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10TH INTERNATIONAL CONFERENCE ON APPLICATION OF INFORMATION AND COMMUNICATION TECHNOLOGY AND STATISTICS IN ECONOMY AND EDUCATION ICAICTSEE – 2020

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ICAICTSEE-2020**

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Dear Colleagues,

*On behalf of the Conference Committees I have the honor and pleasure to thank you all for your true participation in the work of the **10th International Conference on Application of Information and Communication Technology and Statistics in Economy and Education (ICAICTSEE-2020)**, <http://icaictsee.unwe.bg/>, which took place on November 27-28th, 2020 at the University of National and World Economy (UNWE), Sofia, Bulgaria.*

*For a first time **ICAICTSEE** shared experience with the **Recent Trends in Biomedical Technology Conference**, co-organized by the School of Eelectronics Engineering, Vellore Institute of Technology, Vellore, India.*

Due to the COVID-19 pandemic, both conferences were conducted virtually.

I would like specially to express my gratitude to all of the program committee members for their genuine support without which it would never had happened.

Due to the current state of scientific development in all spheres of human activity, the constant knowledge and skill actualization of the academia and researchers in the field of Information and Communication Technology (ICT) is an obligatory necessity, especially when the world is in a global economic and financial crisis. The definition of long-term scientific research tasks in this area has a strategic importance, which is even truer for young researchers, lecturers and Ph.D. students.

The conference aims were conducting analysis of the current problems and presenting results of the ICT application in different areas of economy, education and related areas of scientific knowledge; outlining the existing possibilities for the application of modern ICT tools, methods, methodologies and information systems in economy and education; discussing advanced and emerging research trends with a long-term importance in the field of ICT application in economy and education.

The conference has established an academic environment that fosters the dialogue and exchange of ideas between different levels of academic and research communities.

The conference outcome is 70 published research papers (33 from foreign participants), the explosion of fresh ideas and the establishment of new professional relations.

Dimitar G. Velez
ICAICTSEE-2020 Chair

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A Diagnostic Approach for Osteoarthritis Using Vibroarthrography

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Abstract. Osteoarthritis (OA) is a joint disease very common among old age people and also in sports persons. When any joint starts developing OA, the cartilage near that joint becomes weak and worn out. This restricts the normal joint movement. In order to repair, the muscles around the joint become over-active. This results in changing the structure of the joint which causes acute pain, swelling and difficulty in moving the joint normally. Even a creaking sound called crepitus can be heard while moving the joint. It makes the affected person unable to do their daily activities effectively. This work involves detecting the condition of knee cartilage damage caused by OA by using Vibroarthrography (VAG). It includes the use of knee braces with attached accelerometer for detecting the vibrations generated during knee movement and an electro-goniometer to measure joint angles. The further scope of this device is also discussed in this work as adding the provision for connecting FES to this device so that it can act as both: a diagnostic as well as therapeutic device and can be used by patients in the comfort of their home.

Keywords. Osteoarthritis, vibroarthrography, crepitus, braces, Functional Electrical Stimulus (FES).

1. Introduction

Arthritis, in general, is the inflammation of joints and osteoarthritis is a special type of degenerative arthritis. Osteoarthritis is a joint disease usually very common in people of old age. It can be caused due to age, obesity, joint injury, joint abnormalities and also due to genetic factors. It is also referred to as wear and tear disease. It occurs when the cartilage supporting the joint is damaged. The damaged cartilage then restricts free movement of that joint. Whenever our body is in pain, it tries to heal itself. In this case due to the wear and tear of the cartilage, the muscles become overactive in order to support the joint. This is not good for the joint in the long run. It changes the shape of the joint which causes the patient a lot of pain, the area around the joint swells up and also it becomes difficult for the patient to move the joint or put pressure on it. It is a slowly progressing disease so getting the symptoms also takes time and by the time the patient is diagnosed most of the damage has already been done.

Knees are the joints of our body that take up all our weight and help in balancing it also while walking, running and also while standing. Knee is not only just a joint of bones but a group of bones, cartilages and muscles together supporting each other to make the knee joint. When this cartilage around the knee starts getting damaged, the load on the knee increases. Cartilages help in smooth movement of the joint by reducing friction. Cartilage damage increases friction, there's a lot of rubbing of the bones which causes the wear and tear of the joint. The shape of the joint is also changes due to which there is difficulty in walking due to acute pain. This pain causes hindrance in performing normal daily tasks and the person

ultimately becomes dependent on others for very basic activities also. As this a degenerative disease there is very less chance of reversal of the damage we can only use aids to minimize the pain and symptoms and also prevent from further damage. Some common symptoms of osteoarthritis are:

- Pain around the knee joint. The pain might range from mild to agonizing.
- Decreased Range of motion.
- Grinding or popping sounds and muscle weakness.
- Swelling, locking and giving away of the knee.
- Difficulty in walking, climbing stairs, performing household chores and even sitting upright.
- Decreased quality of life.

All these symptoms make the lives of the patients very difficult. Even doing daily activities becomes difficult so controlling the symptoms and also trying to reduce the damage becomes very necessary. There are some of the suggested things to do which if kept in mind would really help to prevent and control OA:

- Keep a healthy body weight. Being overweight puts pressure on our knees which can deteriorate the condition even more and make it more serious.
- Control blood sugar.
- Be active everyday and do regular exercise. Doing regular exercise makes us active and strong. There are a number of muscle strengthening exercises which are beneficial for providing the correct amount of support to the joint.
- Prevent injury to joints. Joint injuries make the joints weak so if there is a joint injury there are more chances that the person can develop osteoarthritis later.
- Pay attention to pain. Do not ignore joint pain. Today's mild pain can become a major issue tomorrow that could also make one incapable of even moving on their own.

There are generally two types of osteoarthritis- unilateral and bilateral. Unilateral osteoarthritis is when it affects only one leg and bilateral osteoarthritis is when it affects both the legs. People with unilateral knee OA even when only one knee is painful, have 80% chance of developing bilateral disease within 12 years. This is because all of the load is shifted on the other leg and its wear and tear becomes very fast and ultimately the other leg also gets affected. These non-surgical options are great to prevent one from OA but if one has OA already then they might not help in reducing the pain. The first line therapy for OA patients should be unloading the knee joint before any attempts made at tissue regeneration or repair. Unloading the knee off the excessive forces may slow down or potentially reverse osteoarthritis progression.

Initially to diagnose osteoarthritis, X-ray was used to know about the extent of damage and degeneration of the joint. To treat there are a number of methods falling under the categories: non-surgical, electrical stimulation and implants.

The **non-surgical** methods involve:

- **Heat and cold treatment:** heat enhances the circulation and soothes stiff joints and tired muscles. Cold treatment slows down circulation, reduces swelling and alleviates acute pain.
- **Muscle strengthening exercises and weight loss.** So that the muscles support the joints well and there is less weight and pressure on the joint.
- **Orthotics.** Are supportive devices like insoles and knee braces.

Insoles. Also known as foot orthosis or shoe insert thinner at inside and thicker at the heel. They help in daily wear comfort, height enhancement, foot and joint pain relief, reduce

pain by reducing Varus torque i.e. twisting of the knee inward. It isn't enough on its own but may relieve the joints to some extent.

Braces. They help with mobility and function, reduce symptoms, improve gait mechanism and correct knee alignment. This just for support and not treatment so if used after treatment the knee joint can be relieved of the load and gets time to heal.

The most commonly used **electrical stimulation** methods are:

- **TENS (Transcutaneous electrical nerve stimulation).** The procedure is that a low voltage electric current is applied to the area where the pain is i.e. the knee to generate a sensation that blocks the pain signal from nerve to where it is perceived in brain as pain. This is just a temporary pain relief alternative for the patients. This just in a way fools and masks one pain with another.

- **Neuromuscular electrical stimulation.** Here, electrodes are placed on the muscles supporting the joint and not on the joint directly. In case of OA, the current is applied on quadriceps. It causes excessive fatigue in muscles by altering normal motor unit recruitment order i.e. compromising the natural rate of fatigue resistance. This may produce sudden, sometimes uncoordinated, inefficient movement patterns rather than the smooth gradation of force typically seen in human movements

Implants: Extra-capsular medial compartment knee load absorber implants fixed to the medial distal femoral cortex and the medial proximal tibial cortex to achieve offloading of the medial compartment. The device is surgically implanted via a minimally invasive incision. The joint remains fully intact. The procedure is reversible. The medial knee compartment is unloaded sufficient to reduce pain and improve the joint function. But this is an invasive method and may not be feasible for all and it is one of the final and claimed to be permanent solution but there is nothing that can cure OA completely.

2. Literature Review

Osteoarthritis (OA) is a major common joint disease. It is a progressively degenerative process and involves low-grade inflammation, mainly affecting the elderly. It is a highly prevalent disease and causes substantial disability in late life in most developed countries. About 10% of the total world population and more than half of the people aged over 50 years suffer from OA. It causes pain, swelling and difficult and painful motion in joints. Healthy cartilage, which is the tissue that covers the ends of the bones in a joint, absorbs the shock during movements. In OA, there is wear and tear of this cartilage, leading to increased friction between the bones. Knee OA disturbs about 30% of those over 65 years old. Its pathological features include narrowing of joint space, formation of osteophyte and angulation of the joint. It worsens with time and as of now there are no cures. However, OA therapies do exist that can relieve pain and help patients remain active.

The knee is the most common part of the body to be affected by this degenerative disease. Injured knees resulting from a variety of traumatic causes are one of the reasons for the occurrence of OA at an early age. One of the non-traumatic causes of knee OA is chondromalacia patella, in which the articular cartilage is damaged. One of the major problems during the examination of the causes or progression of these conditions is the difficulty in detecting changes in articular cartilage until the situation worsens, either anatomically or symptomatically. Image-based techniques such as X-ray imaging, computed tomography (CT) and magnetic resonance imaging (MRI) are used to detect major cartilage disorders, but they fail to characterize the functional integrity of the cartilage, such as its softening, stiffness or degradation. To diagnose cartilage pathology, arthroscopy is the gold standard method for evaluating cartilage status. The grading system provided by arthroscopy is important for

prognosis and treatment of knee osteoarthritis. It is an invasive procedure and has some risks related to anaesthesia. Also, repeated arthroscopy is not practical in the same patient. Some alternative tools, such as joint auscultation have been used, to overcome the drawbacks of imaging and arthroscopy.

Crepitus is often noted in the knee during clinical examination of OA patients. This physical examination is done with one hand of the examiner being placed on the patella of the patient during a passive range of motion (ROM). However, it is a subjective assessment and cannot be recorded and analysed for comparison as it may not always be due to presence of OA. Moreover, its interpretation is dependent on the examiner and requires a lot of personal experience. The sound signal, generated during knee movement, represents the acoustic and vibrational signals caused by the joint surfaces rubbing against each other. It is associated with cartilage damage conditions such as roughness, softening, breakdown or cartilage loss, and may be a useful measure of the osteoarthritic knee. Many studies have reported the usability of this technique for the non-invasive diagnosis of articular damage via the analysis of knee sounds obtained by an auscultation. Chu et al. devised strategies to reduce skin friction and surrounding noise while recording and to classify the knee sound signals as rheumatoid arthritis, degenerative arthritis and chondromalacia patella, using their autocorrelation function. Kernohan et al. reported that 86% of patients with meniscal injuries produced similar signals and that the changes in the normal joint sound signal could be a useful indicator of early cartilage degeneration.

Rangayan et al. reported that meniscal lesions showed sharp bursts in the sound signal, which appeared as short energy durations in the range of 0 to 200 Hz in the spectral contour plots, while mild chondromalacia showed sound signals as long durations in the range of 0 to 300 Hz. The signals associated with severe chondromalacia were observed to be of relatively low frequencies (0-100 Hz), as expected, due to the loose cartilage tissue existing between the rubbing surfaces. Another report by Nagata et al. discussed the methods for reducing noise in the recordings of knee joint sounds and using frequency analysis of the sound signals using a narrow band spectrum analyser for diagnosing osteoarthritis. Reddy et al. demonstrated that the mean power of the acceleration in the range of 100 to 500 Hz was different for OA patients when compared to rheumatoid arthritis patients. Regarding the signal processing of knee sounds, various techniques have been tested for classifying normal and abnormal knees according to the articular pathology, such as autoregressive, least square, linear prediction modeling, time-frequency analysis and wavelet decomposition.

3. Methods and Methodology

After understanding the seriousness of OA and its impact on the daily life of the patient, a device is proposed in this paper in order to diagnose this painful disease. Considering the pain and discomfort caused to the patient its early detection can be very beneficial as the person can know in advance if he/she has OA or may have it in future and it would also be beneficial for those who are already suffering from this disease. This device has knee braces with an accelerometer and an electro-goniometer. The basic idea behind the device is Vibroarthrography which is a method for assessing the condition of knee cartilage damage during the extension and flexion movements. In this device, a 3-axis accelerometer is used to detect vibrations from all three axes produced while we move the joint. This can tell us the exact location of the tissue where the wear and tear is the most.

An electro-goniometer is used to measure the angle of movement i.e. the range of movement of the knee joint. For this purpose, a potentiometer or a strain gauge can be used. Earlier, a protractor was used for the same purpose. What it actually does is it measures the range of angle formed by the joint when in movement during flexion and extension of the leg.

Measuring this angle can help the person using this device know whether their range of joint movement is in the normal range or not.

The reason for choosing braces is that they are light weight, efficient for unloading purposes i.e. it doesn't put pressure on the knee it rather distributes the weight. Hence it can prevent further damage. They exert exact and effective pressure close to the knee joint. If the frame padding is well cushioned they'll be comfortable to use also. These reasons make braces the suitable candidate for the proposed device. For this device, braces not only act as support to the knees but also are the place for attaching our circuits. Attaching the circuits at right places can help us use the device very easily. It also facilitates easy movement of the leg resulting in accurate measurements.



Fig. 1. Knee braces

The circuits used in this device were made using a Computer Aided Design (CAD) software. The one used in this study was Tinkercad. It is a very useful tool for making a computer based design for any device or design we want to physically make in future. Besides all the basic shapes in 2-D and 3-D, there's also an option to make circuits and not only basic circuit elements but also elements like arduino and some sensors are also available there.

Here we made two different circuits for the two components of our device. Figure 2. is for the 3-axis accelerometer and figure 3. is for potentiometer which works as an electrogoniometer. Both the circuits have connected display screens so that the user can view the real time values. It makes the device very user-friendly.

This can be placed in a knee brace and can easily be operated by the patient himself even in the comfort of his home. To use this device properly, the patient has to sit a chair position and flex his leg from 90-0-90 degrees and the duration of each cycle should be 2-4 seconds with 1-3 minutes break after each cycle to avoid muscle fatigue. Fatigue can alter the actual readings, which is very important to avoid. The output of this device can be used to know the presence or severity of the disease. If the phase angle is more than 90 degrees this is an indication that the person is suffering from OA.

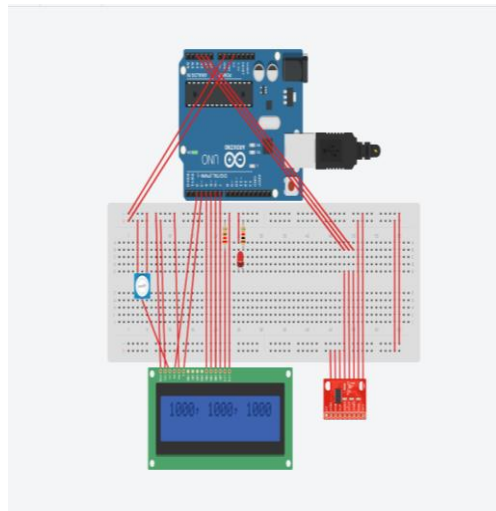


Fig. 2. Circuit for accelerometer

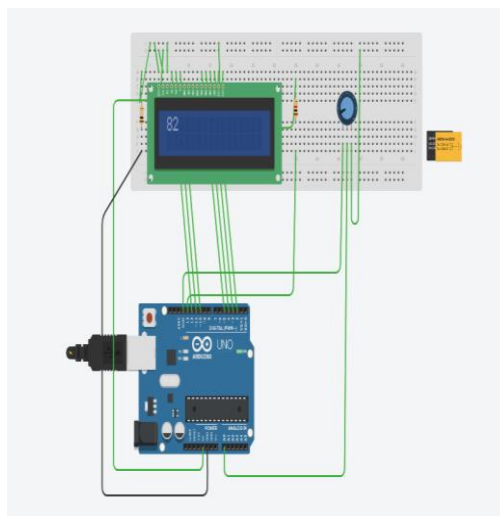


Fig. 3. Circuit for potentiometer

4. Results

Using the device the exact location can be known by knowing the coordinates of the three axis accelerometer and the potentiometer acting like an electro-goniometer tells about the angle of the joint. The braces used give the right amount of support to the leg and can prevent further damage to the joint. By unloading the joint it also prevents the unilateral OA that is a condition when a person has OA in only one leg from being converted into bilateral OA, a condition with both the legs involved. Figure 4 is the prototype of our proposed device. The placement of the accelerometer and electro-goniometer is shown in the figure. The placement is always near the knee so as to get the accurate results. Both the circuits are placed near the center of rotation of the joint. The values for both the circuits are displayed on the screens in real-time.

These results can be used to identify if the person using it is suffering from osteoarthritis or not and if yes then what is the progress of damage to the joint. Even those who don't have any of the symptoms can know their chances of getting the disease as its symptoms take years to show up. Since osteoarthritis is a slow progressive disease it is very difficult to diagnose at a very early stage. If diagnosed at an early stage, the person can do regular exercise and maintain their body weight to put least load on the joint and prevent the situation from worsening. Anyone can use this device at their home by themselves. It eliminates the need to go to a doctor or a diagnostic centre again and again to check the progress of the disease. It saves a lot of money in the long run and also we know that X-rays are not good for our health. So we can't go every time to a doctor and get X-ray scan done. It is hazardous as they slightly increase the risk of cancer on being overexposed to them.



Fig. 4. Final device

5. Discussion and Conclusion

With increasing age there are a lot of disease and issues that people face. Ranging from heart diseases to neural diseases to decrease of bone density and many other degenerative diseases as ageing is a degeneration process of our body. After a certain age the growth of our body stops and starts degenerating. The age and the speed of degeneration may be different for different people. Women more than men are more prone to osteoarthritis as after 30 years of age their bone density starts decreasing. Also people with obesity issues are also prone to have OA. So there is a huge need for a device that people can have at the comfort of their own space which also ensures that they don't have to go to the doctor or the diagnostic centre everytime they have symptoms of OA. This device can be very useful for people with even the slightest symptoms of OA and also for those who are already suffering from it. Braces give a great support to our knees and can unload the joint from our body weight and hence decrease the amount of pressure on the knee joint which is beneficial for the joint health. Braces prevent further damage and give the body a fair chance to heal itself. This device would make the person aware of the severity of the disease and also if there's any chance they would have OA in future.

In addition to the two circuits used in this device i.e. accelerometer and an electrogoniometer, a functional electrical stimulator (FES) system to this device. FES is used to train muscles for movement. FES when used with muscle strengthening exercises can help in strengthening the muscles around the knees which would provide a better support to the joint. Adding FES to the proposed device would make it a diagnostic as well as treatment device which can be used by the patients by themselves also or with the help of anyone in their home. There can't be anything better than having a diagnostic as well as a treatment device at home. This makes the whole treatment process very convenient for the patient. This device is a one-time investment for those who have to visit doctors regularly after an interval of time for their basic routine check-ups. It can save a lot of time and money in the long run. Being able to diagnose and treat themselves at home can give people confidence and uplift their lifestyle by bringing positivity in their lives by seeing positive results and that too on their own without depending on others.

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A LabVIEW Based Design for Detection of Heart Diseases, ECG Abnormalities and Measurement of SAO2

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Abstract. Detection of ECG parameter variations in early stage is necessary as it may, even cause death if not detected at an early stage. The rate and rhythm of heart beat is measured using ECG and is also helpful in implementing human heart abnormality diagnostic. The proposed system mainly consists of five steps. They are acquisition of ECG signal from the physionet, preprocessing, ECG feature extraction to estimate diseases, Calculation of heart rate and Measurement of SAO2. LabVIEW provides a simple and fast platform to detect ECG abnormalities, heart rate and measurement of SAO2 which is a respiratory parameter. The blinking LEDs in the front panel indicates the ECG abnormalities. Also this virtual instrument is efficient for the detection of censorious diseases in early stage and thus can save a patient from suffering. By using Hilbert Transform datas, located the R wave peaks in the ECG waveform to calculate the heart rate and the heart abnormalities are detected by extracting the features of the ECG and measurement of SAO2 by inferring the number of pulses from ECG waveform. Also LabVIEW aids in the remote transmission of the ECG signal from the bed to the control room for diagnosis and to take corrective action at the right time.

Keywords. ECG, ECG abnormalities, LabVIEW, Heart rate, SAO2.

1. Introduction

ECG is a measurement of the electrical activity of the heart muscle obtained from the surface of skin. The rate and rhythm of heart beat is measured using ECG and is also helpful in implementing human heart abnormality diagnostic. Electrical activity appearing as a periodic signal of myocardium is shown in ECG.

As world population is increasing day by day, age related diseases are also being increased. These diseases include heart failure, dementia, step apnea, cancer, diabetes and chronic obstructive pulmonary disease. For past few years, studies shows that heart diseases are increasing rapidly and became the major cause of death.

Heart being one of the most important and censorious organ in our body. It is much important to establish systems for heart examination. ECG is used for measuring and recording electrical signals of heart. It is done with an electrode placed on the patient's body. Then the cardiac muscles are stimulated by current passing through the electrode which results in heart contraction and relaxation. Then these signals are denoted by peaks and valleys.

Usually P, Q, R, S and T are used to denote ECG cycle and often U wave for individual peaks when R is always a positive. In accordance with the extracted features from morphology and timing of these points, the diagnosis is carried out. Mainly QRS detection is tough because of some problems like noisy ECG signal, power line interference, baseline wandering and T

wave amplitude similar to QRS complex. These issues mainly affect in getting the proper information from the ECG signals.

To detect ECG parameters we use easy and rapid techniques like QRS complex detection, P or T wave by using digital filters, wavelet analysis and biomedical module in Lab VIEW. This equipment is having three stages, first is employed with acquiring ECG signal and the signal is from the physionet. To limit the range of frequency and then to detach baseline noise and Power line interference, we pass this ECG signal into a filter and de-noises with the help of WA analysis. The next stage is to extract ECG parameters, in order to do this, we pass the de-noised, filtered signal into an ECG feature extractor. In the final step the ECG signal parameters are compared with respective normal parameters, and we could find the abnormality of ECG by identifying mismatch in parameters.

Oxygen Saturation is denoted by SAO₂. Maintaining optimum level of SAO₂ is important. For measuring oxygen saturation, the currently followed idea is pulse oximeter. In pulse oximeter SAO₂ level is measured by light transmission reflection method. But it is very difficult to maintain the intensity of light at a constant level to measure oxygen in the haemoglobin. So it must be taken as a drawback of current technique. And one another reason for the drawback is that the pulse oximeter is unable to distinguish between oxygen and carbon monoxide. So to solve these problems, we have used ECG signals for the measurement of SAO₂.

2. Methodology

ECG data taken from physionet is obtained using Lab VIEW software and exhibited the raw ECG. ECG waveform that is given to Express Virtual Instruments for signal processing after acquiring the data. In this part it contains process like digital filtering, digital smoothing, wavelet de-trend and wavelet de-noise. As a part of Advanced Signal Processing Toolkit, the wavelet de-trend and wavelet de-noise is much useful in the processing of ECG signal. Thus problems like noise artefact is detached using signal processing. These noises include power line interferences and white noise from the signal. Then ECG parameter of the wave is obtained by passing the wave through ECG feature extractor. For finding the heart rate, the threshold value and valley detection is found using maximum and minimum values of the processed signal. Heart rate depended on peak and valley is found out with the help of period from peak and valley given by the virtual instrument. This signal is thus passed into disease detection module after the computation is done, here it compares the ECG parameter to normal parameter based on some specified rules and get to know the disease by indicating it on the front panel display. Result of each stage of processed signal is also being displayed on the front panel. The process is continued until being completed the data processing or being stopped by the user in order to display the result.

To measure the heart rate and to divide it as normal and abnormal, R wave peak is located in the ECG wave using Hilbert Transform datas. There are five subdivisions for abnormal waveforms. They are Bradycardia, Tachycardia, Atrial tachycardia, atrial flutter and Atrial Fibrillation. We use ECG signals generally for calculating cardiac parameters but here it is measured SAO₂ which is a respiratory parameter. By satisfactory computations SAO₂ level can be calculated by the method of judging the number of pulses from ECG signal. And thus obtained ECG from Lab VIEW is of higher accuracy. Also it provide assistance to transmit the signal from patient bed for detection and to take preventive actions at the correct time.

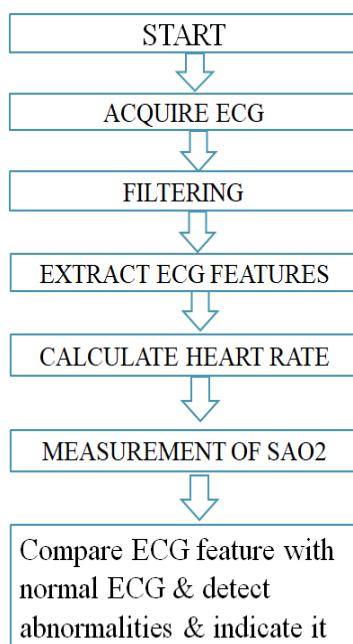


Fig 1. Flow Chart on Application Procedure in LabVIEW

In Figure 1 the flow chart explains about the major five parts of the frame work used. They are acquisition of ECG signal from the physionet, preprocessing, ECG feature extraction to estimate diseases, Calculation of heart rate and Measurement of SAO2. The given rules are followed in detecting the diseases with respect to heart beat rate and deviation in variables:

1.If heart rate in between 60 & 100 beats per minute, then it will normal ECG otherwise Abnormal ECG.

2.If heart rate is less than 60 bpm then it will indicate bradycardia.

3.If heart rate is in between 100 & 170 bpm then it will show tachycardia.

4.If heart rate is in between 160 & 200 bpm, then it indicate Atrial Tachycardia.

5.If heart rate is in between 170 & 350 bpm then it will show Atrial Flutter.

6.If heart rate is greater than 350 bpm then it will show Atrial fibrillation.

7.If PR interval is lesser than 0.12 sec then it will indicate pre-excitation syndrome.

8.If PR interval is greater than .20 sec then it will indicate av block.

9.If QT interval is greater than 0.45 sec then it will indicate long QT syndrome (hypercalcemia).

10.If QT interval is lesser than 0.32 sec then it will indicate short QT syndrome (hypercalcemia).

11. If QRS interval is greater than 0.12sec then it will indicate Bundle branch block.

3. Result And Discussion

ECG signal database is collected from physionet for the approximation of different diseases. When this signal is passed through the Butterworth filter, it accepts ECG signals with an upper limit of 150 Hz and a lower limit of 0.05 Hz frequency. In order to eliminate the power line interferences, a notch filter is used. Then the signal gets rid of wideband noise and

renovates the original signal which corresponds to db6 wavelet of the ECG signal, it is passed through wavelet de-noise and multiresolution analysis module respectively. Hence the signal is passed through the ECG feature extractor, as a result we receive various parameters corresponding to P onset, P offset, QRS onset, QRS offset, amplitude, iso level and ST level.

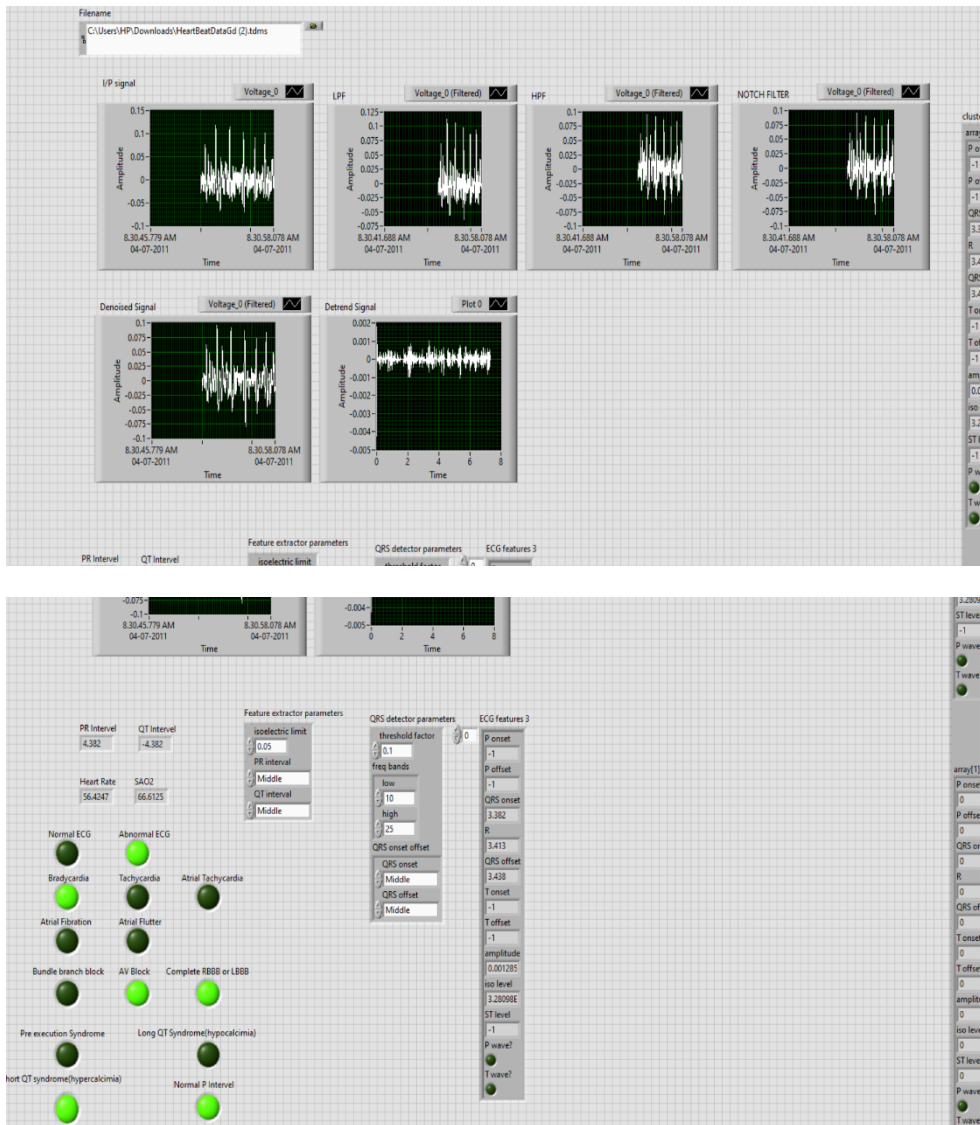


Fig. 2. Front Panel of the proposed system

There after by comparing it with the normal ECG parameter, it specifies the disease with the patient by checking for abnormalities in the wave. In order to approximate the heart rate and to classify the wave into normal and abnormal, R wave peaks in the ECG is detected using Hilbert transform datas. There are five subdivisions for abnormal signals namely Bradycardia, Tachycardia, Atrial tachycardia, atrial flutter and Atrial Fibrillation. ECG Signals

is usually used to measure Cardiac Parameters, but here it measures SAO2 which is a respiratory parameter. By inferring the number of pulses from the ECG waveform, the SAO2 level can be measured by suitable mathematical computations. The ECG signal is obtained by using the LabVIEW software for better accuracy. Also LabVIEW aids in the remote transmission of ECG signal from the patient bed to the control room for diagnosis and to take corrective action at the right time.

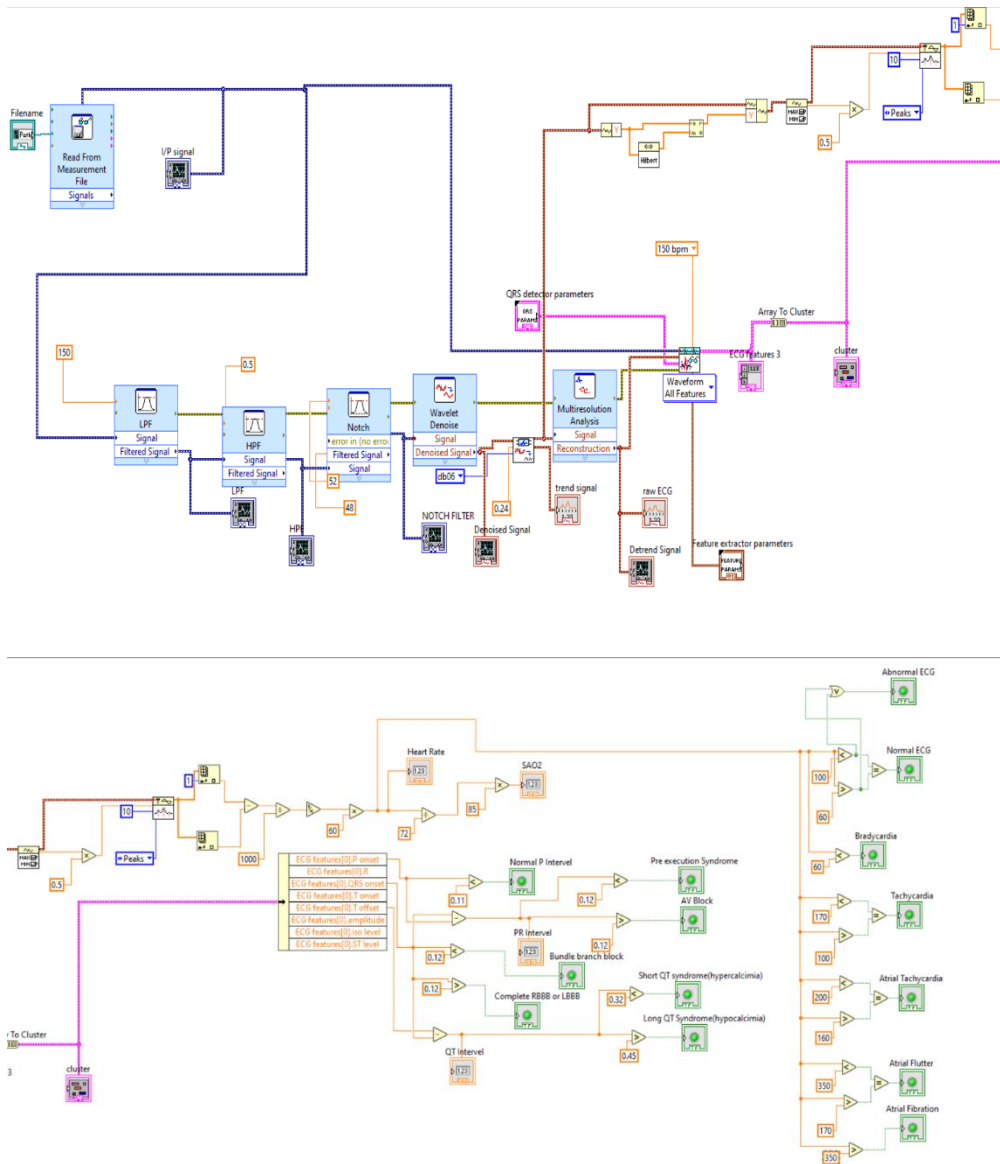


Fig. 3. Block Diagram of the proposed system

4. Conclusion

The system for ECG signal gain and process is set up using Lab VIEW software. The system provides for finding changes in heart rate to detect the related types of diseases. The designed algorithm is capable of acquiring measured file data or simulate the ECG signal, processes the data, displays ECG waveform, displays heart rate and its abnormalities. The blinking LEDs in the front panel indicates the ECG abnormalities. Also this virtual instrument is efficient for the detection of censorious diseases in early stage and thus can save a patient from suffering. Here the heart abnormalities are detected by extracting the features of the ECG and measurement of SAO2 by inferring the number of pulses from ECG waveform.

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A Novel Diagnostic Tool for Obstructive Sleep Apnea using LabVIEW

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Abstract: The physiological activity of sleep achieves the resting of major bodily functions and recuperates energy spent during the day's activities. One of the most underdiagnosed and undetected disorders pertaining to sleep is Obstructive Sleep Apnea. The repercussions of Sleep Apnea include reduced cognitive awareness, extreme tiredness, hypertension; and in exacerbated situations, cardiovascular diseases, respiratory illnesses, and lifestyle diseases like Diabetes Mellitus. A diagnostic procedure for Sleep Apnea include a Polysomnograph, which involve trained personnel and institutional processes; which can be gruesome and inaccessible to a larger community. The development of a real-time Apnea detection system is beneficial for a larger strata of people, which can solve the underdiagnosis paradigm. This research focuses on the development of a detection and monitoring system for Obstructive Sleep Apnea using a powerful and user-friendly platform, LabVIEW. The paper elucidates a software model for the detection and diagnosis of Obstructive Sleep Apnea, which is enhanced with multiple sensor data analysis.

Keywords: LabVIEW, Virtual Instrument, Obstructive Sleep Apnea, Gyroscope, MathScript, Graphical User Interface.

1. Introduction

The activity of sleep is a major regulatory action in the functioning of the human body. The body recuperates energy after the continuous expenditure of energy. A major disorder that correlates with the conditions of sleeplessness or insomnia is Sleep Apnea. Sleep Apnea is one of the most underrated diseases which degrade the qualities of the patient's life. It is a condition when the patient is unable to sleep properly through the night due to certain physiological events. The patient will suffer on a daily basis; as it leads to less energy, more lapses in concentration in tasks, Co-morbidities like high blood pressure, diabetes, and in severe conditions; anorexia and cardiac diseases. The most alarming fact about this disease is that it goes neglected and under-diagnosed within patients; and the risk factors for the comorbidities increase as the disease progresses.

Sleep Apnea is classified into Obstructive Sleep Apnea, Central Apnea and Mixed Apnea. Central Apnea is characterised when the basic respiratory neurological controls malfunction; thereby the signaling for inhalation and exhalation will be missed during certain cycles. The most common condition is the obstructive sleep apnea. OSA would include all the conditions where there is an obstruction in the airway, which leads to the pressure drop in the airway which further causes the lapses in breath cycles. The clinical conditions leading to the obstructions would include large tonsils, obesity, kidney failures, premature birth, and neuromuscular disorders. Mixed Sleep Apnea is the condition where the factors leading to cessation of breathing is contributed by both central as well as the obstructive sleep apnea.

The major symptoms of Obstructive Sleep Apnea include loud snoring, episodes of breath cessation, gasping for air during sleep, dry mouth, morning headaches, insomnia, and excessive daytime sleepiness. These conditions will hinder the patient's productivity as the cognitive skills of the patient will be limited due to the lack of energy. A sleep deprived patient will be averse to all physical activities and there would be lapses of concentrations in the tasks that the patient would involve. These conditions could prove fatal if the patient would carry out complex tasks like driving; which requires multiple cognitive skills to work in the maximum capabilities.

The diagnosis protocols that are followed to diagnose Sleep Apnea include the patient to undergo a Polysomnograph (PSG). It includes the monitoring of ECG, EEG, EMG and also vital parameters like Oxygen Saturation, Blood Pressure Measurements, etc. A cumulative study is conducted to evaluate the posture of sleep as well. The comprehensive estimation is considered to be the gold standard of measurement and diagnosis of Apnea. However, the system requires institutional support along with the guidance of a technician; who monitors the data for the whole period. So, there are limitations to adopt these methods to a much more generalised strata.

Research has been done proactively to estimate the parameters leading to the causes of sleep apnea and for its accurate diagnosis. Approaches involving the measurement of ECG, Photoplethysmography, Oxygen Saturation are employed to detect Apnea events in the patient's breathing patterns. The lower saturation of oxygen is one major parameter that is correlated with the apnea event. Various approaches which involve Near Infrared sensors, smartphone sensors, cameras and feature extraction techniques have been extensively researched and documented for the detection of apnea.

Negative intrapharyngeal pressure[1] is the driving force for inspiration and expiration. The collapse of the airway is prevented by pharyngeal abductor and dilator muscles. During sleep, the muscles become hypotonic, hence the pressure is dependent on the pharyngeal size and the pharyngeal tissue compliance in the nasopharynx, oropharynx and hypopharynx. The compliance and the intrapharyngeal pressure is not in equilibrium, obstruction occurs. The treatment procedures suggested in this paper is uvulopalatopharyngoplasty, and other related surgical procedures, in the case of an anatomic disorientation. For a non-surgical operation, Continuous positive Airway Pressure Therapy (CPAP) is suggested.

The phone's accelerometer could be used to classify body posture during sleep. A microphone could be used to detect the snoring sounds, to analyse the degree of apnea; and a pulse oximeter is interfaced to correlate the findings of the processed sound wave to an apnea event[2]. The availability of multiple sensors in the smartphone device enables devices to be robust and cost-efficient for implementation.

The PPG, the R-R interval times and for features of age, height and weight of the patient could be compared to estimate feature extractions[3] with references of standard ECG, blood pressure and oxygen saturation measurements. The issues faced by these approaches include initial calibration of the BP values for each measurements, the disability to synchronise the readings of the PPG and ECG acquisition to better correlate the R-R time differences. The system can provide a fast alternative to health monitoring, but cannot conclusively replace the standard health monitoring setup for ECG, Heart Rate and Blood pressure Measurements.

A wearable, accurate embedded systems sensor with Internet of Things Capability could be another design approach, which measure the ECG. The ECG's spectrogram provides a difference in the normal condition and an oxygen deprived condition. The frequencies of the oxygen deprived signal and the normal condition introduce a shift in the RR interval and also to the amplitude of the series of R-R peaks and the R-S intervals[4]. These are illustrated to be the classifier of the SVM model.

The estimation of Apnea-Hypopnea Index[5] which is an important marker to classify the nature of apnea the patient would be experiencing is a major upgrade to the present apnea classifiers. The AHI should be lesser than 30 to essentially classify the patient's condition to be medium-risk. The data obtained can be complemented with the actual monitoring of rPPG in a Polysomnographic test condition; and can be evaluated further to develop another suitable mechanism that utilises a homecare solution.

The heart rate measurement system[6] using Arduino Nano and LabVIEW development system is an established cost-efficient parallel to the design of the sleep apnea monitoring solutions. The Arduino is interfaced into LabVIEW and the data acquired is calibrated into a system which measures the time between peaks. The time difference between peaks is calculated with the minute to obtain the heart rate.

A method to calculate vital signs from the patient using a smartphone device based camera and the rPPG value is estimated using the standard color conversion algorithm[7]. The data extracted from the obtained signal can be compared with Peak-Peak intervals to obtain the Heart Rate Variability analysis(HRV). The data obtained was compared with the standard error comparisons and could obtain efficient results. As mentioned earlier, this approach can complement the development of the system using smartphones and carry forward the same benefits of frugal development. A research algorithm to extract rPPG signals to estimate pulse oximetry in a sleep environment; where there is a dark background, which acts as a noise in the normal methods of oximetry[8]. To find the static living pixels using their algorithm to estimate the differences in the values obtained; when the subject moves. The data was extracted from a hybrid approach of various algorithms that were initially available for discussion in the same domain.

The ECG can be acquired and sent via Bluetooth to the module which processes features of ECG with algorithms to extract apnea features[9]. The system estimates whether the person used had obtained a good sleep or not. The OSA estimation is carried forward by the analysis of the R peak detected using the common Tompkins Algorithm, then subject the extracted data to a cluster analysis with t-test with certain parameters of the HRV analysis. The extracted features can be analysed by a ROC curve(Receiver Operating Characteristic Curve).

The concepts of wireless transmission for vital parameter monitoring is of paramount importance to forward the idea of home healthcare monitoring; It can uphold features which can further be extrapolated to estimate the quality of sleep of the user[10]. The data taken from the patient was the ECG, the Oxygen Saturation, the chest effort using a piezoelectric sensor, the body position using a gyroscope. Zigbee mode of transmission is beneficial in order to achieve low power. A WiFi transmission protocol will be an addition to the system to achieve wider range.

2. Realization of the Virtual Instruments

The application is designed using three separate Virtual Instruments. The first VI will generate the respiratory rate measurements from the pressure sensor that is placed in the Pharyngeal path. The data acquired from the pressure sensor is simulated using a Mathscript structure. The data acquired from the pressure sensor is further processed and analysed for the peaks. The apnea condition will be separated using the thresholding function; and a suitable alarm will be triggered when the apnea condition is detected on the graph. The number of instances is also detected; which provide quality to the data that is analysed from the Apnea monitoring. The lock diagram design of the virtual instrument is illustrated in Figure 1.

The gyroscopic data is obtained from the smartphone sensor; and is captured using the Phyphox app. The data acquired is processed using a separate VI. The integrated waveform is then provided to the display mechanism to illustrate the results.

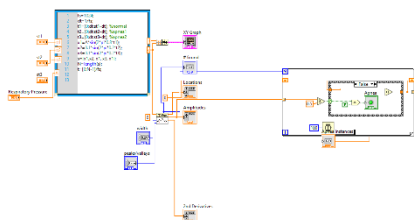
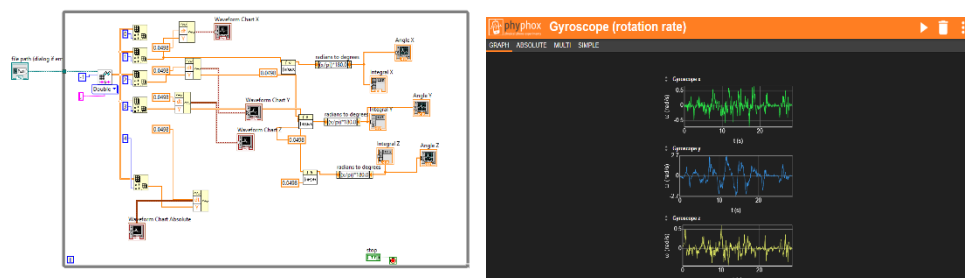


Fig. 1. Block Diagram of the Apnea Detection System

The gyroscopic data is captured with the motion of the phone resembled to the sleeping position. The angular velocity of the phone could be correlated to the sleeping posture of the patient during the measurement phase. The data obtained is undergone integration to obtain the angular position over time. The data obtained is then plotted and indicated over as a separate value in the second Virtual Instrument. The block diagram of the Virtual Instrument and the signal acquisition interface of Phyphox App is illustrated in Figures 2 and 3 respectively.



Figures 2 and 3. Gyroscope Block Diagram and the Acquisition Windows.

The obtained gyroscopic data is then processed to obtain the suitable angular data in the 3 axes of X,Y and Z; the data is converted from radians/sec to angles per second. The angular data is then fed into a Graphical User Interface which shows the angles in 3 dimensions; which rotate to indicate the posture of sleep of the patient during the particular instant. The data could be visualised and annotated for a better diagnosis of the apnea conditions. The block diagram of the graphical user interface is illustrated in Figure 4.

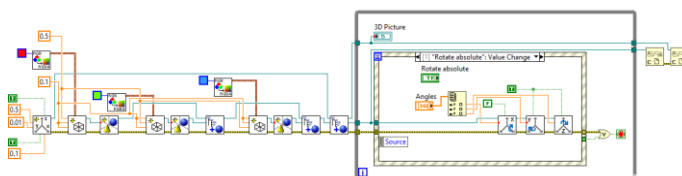


Fig. 4. Block Diagram of the Graphical User Interface.

The interface is designed with the creation of the 3D axes; along with the creation of 3 objects with different colours depicting of the 3 axes. The objects created is rotated using a logic which is powered by an event structure; which responds to the events happening in the front panel. The data is entered for the angles in the front panel; the Rotate Absolute button; when triggered rotates the object created into the angles entered using the array function. The reset button resets the object to the initial position. The rotation among axes is obtained from the Mathematics toolbox in the block diagram.

3. Virtual Instruments

The apnea monitoring system is realised using LabVIEW programming; and the alarms are suitably triggered with the initialisation of the apnea alarm given as an indicator in the form of an LED. The apnea wave is created using the pressure control to the right of the graph; with the apnea conditions are simulated with the inputs to the parameters st1, st2 and st3. The number of apnea events are indicated in the application and obtained during the running of the pressure data in the Virtual Instrument. The front panel of the sleep apnea instrument is illustrated in Figure 5.

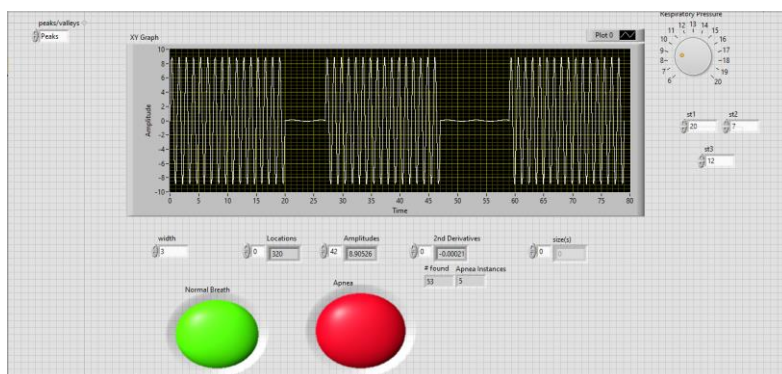
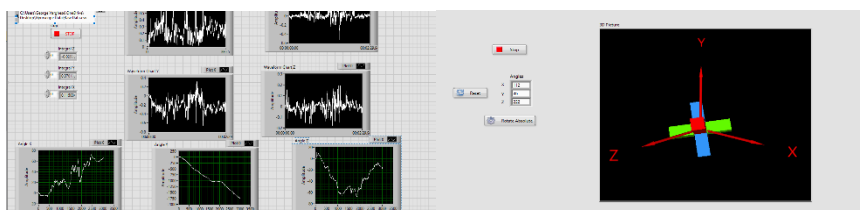


Fig. 5. Front Panel of the Sleep Apnea Instrument.

The gyroscopic data is obtained and displayed in graphical form as the measurement is carried forward. The data obtained is converted into the pure angles which indicate the position of the patient wearing the sensor. The graphical representation of the front panel of the instrument is carried out in Figure 6. The graphical user interface is illustrated in Figure 7. The angular data which is obtained from the gyroscope is inputted into the GUI manually by the user to obtain the visualisation of the patient in the particular time.



Figures 6 and 7. The Gyroscopic Data and the Graphical User Interface of the Patient Position Visualisation System

The research indicated that the apnea could be illustrated as a function of the frequency of breaths. It will vary in cases of obstructive apnea. The detailed relationship of apnea with the frequency could be examined with the inclusion of real data from patients. The estimation of the apnea parameters could be fine tuned on the basis of a control system approach. The research also throws light into the consideration of more data as a part of the analysis; to better estimate the relationships of the apnea conditions; which could prove indications of classifying the apnea episode to be of OSA, central or mixed apnea. The full scaled model is encouraged with this particular estimation of the apnea detection function.

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Acceleration-Based Ambulatory Monitoring in Knee-Osteoarthritis Patients Using LabVIEW

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Abstract. To support the rehabilitation pathway and to identify different perspectives of the Knee Osteoarthritis, a particular design is required according to the mode of use and the technology supported. In the proposed work, we developed a sensor to be implemented in a knee brace which would be beneficial to measure the acceleration and other physical parameters during daily activities. In this context, I have developed a sensor using LabVIEW, a graphical programming interface, for measuring, and also to monitor the acceleration in real-time through NI-DAQ assistant and Makers-Hub using an Arduino UNO monitoring board. A single-axis and a triaxial accelerometer will be used for static and dynamic measurements in a knee brace which along with an inductive sensor which would allow long-term and real-time ambulatory monitoring, by detecting the change in mutual inductance by altering the flexion and extension(f/e) of knee joint, and hence, would predict the above-mentioned activities with an admissible performance. Furthermore, this user-driven development approach is going to develop a rehabilitation tool for patients with Knee Osteoarthritis.

Keywords. Accelerometer, Knee-Osteoarthritis, LabVIEW, acceleration, Arduino, Rehabilitation-Engineering, Braces

1. Introduction

Knee osteoarthritis (OA), or most commonly known as degenerative joint disease, is generally because of the continuing disappearance of the articular cartilage. It is mostly seen in elderly people. It can be either Primary or Secondary. There is no underlying reason for Primary osteoarthritis, while secondary osteoarthritis results in an abnormal amount of pressure across the joint such as in the case of post-traumatic causes or autoimmune diseases, such as rheumatoid arthritis (RA). Typically, it would gradually lead to disability and the intensity of the symptoms may differ from person to person. However, over time, it becomes more acute, more recurring, and enfeebling. Some of the common clinical symptoms include knee pain, stiffness, and swelling, which are gradual in the very beginning but get worse further activity. Non-surgical treatment for knee osteoarthritis comprises conservative methods, biomedical engineering, etc., and eventually progresses to surgical methods if the former treatment fails. There are some medications available that can help to slow the progression of Knee-osteoarthritis to some extent, but to modify the disease, there is hardly any treatment known.

Even though practice treatment may improve side effects, it doesn't diminish the knee adduction second, a key marker of OA illness movement [1]. Individuals suffering from knee OA get practice treatment through a arrangement of restoration programs that are valuable to joint versatility and body digestion

2. Related Work and Importance of wearable sensors

Physical activities have always played a crucial part in everybody's life, especially keeping in mind the current scenario, the Coronavirus pandemic, it is important to stay healthy by maximizing physical activities. It not only helps us to stay fit but also helps us to overcome health issues like obesity, diabetes, severe heart diseases, anxiety, and depression. Therefore, by motivating the idea of more and more physical activities, it would be helpful in certain rehabilitation training programs and therapy sessions.

Over the last ten years, there have been ample efforts put forth in the research and engineering sectors to develop small, cheap, and error-free wearable sensors. At present, wearable sensing devices can be used for various clinical applications [2][3]. Even in the case of gait-analysis these devices are used to estimate motion and are worn at different parts of the patient's body. Force sensors, strain gauges, potentiometers, ultrasonic sensors, accelerometers, etc. are some of the commonly used wearable sensors [4]. The monitored signals which were processed first, obtained from these devices are used to detect locomotion and to perform gait analysis.

Some well-furnished gait laboratories can precisely estimate parameters such as knee joint angles during rehabilitation training and various medical analysis. Additionally, these measurements are constrained to the laboratories. This shows that the patient or the subject performs the required day-to-day activities by asking the people whether the outcome can generally be shown for daily activities.[5]

There are many limitations and drawbacks related to gait laboratories, and various efforts are defined here in the literature to use precise wearable sensors for real-time monitoring such as flexion/extension knee monitoring by conductive elastomeric complexes combined in a fabric band and wearable kinematic monitoring devices.[6]. Another device that was reported was a wearable joint monitoring scheme including accelerometers and a rate gyroscope with small size, low power consumption, and radio data transmission [7]. [8] An altered Intelligent Device for Energy Expenditure and Activity (IDEEA) for measuring the knee f/e angles with utmost accuracy, was proposed with a slight drawback as it cannot be used for long-term ambulatory monitoring. Lastly, various methods [9] were put forth for identifying walking activities using on-body radio nodes equipped with inertial and positioning sensors. The results show that the magnetometer shows the best performance. It was also concluded that it significantly outperforms the accelerometer and potentiometer.

Today, available wearable devices with high precision majorly exist as numerous and intricate wired electronic systems that are most likely used for correct placement on the body. While using an accelerometer and gyrostats one should keep in mind that initial joint angles and accretion of the integral error are important problems especially when it comes to long-term monitoring. For the long term and real-term, a new device is proposed in this work which can be further implemented in a knee brace consisting of an inductance sensor and accelerometers, which are used for measuring f/e of knee joint [10][11].

Speaking about the inductive sensor technology, it has various advantages as compared to present activity monitoring. The sensor consists of a coil which can be combined in, or worn below. Besides, the output signaling is in one dimension and is directly proportional to the joint angle. For this very cause, it is forthright to process compared to other complicated signals as in the case of triaxial accelerometers. These triaxial accelerometers have an ability to perform lesser under dynamic conditions as the gravitational component overcomes the actual movement. Finally, no complex filtering or fusing algorithms are essential to development the self-inductance data. This will eventually ameliorate the viability for long-term ambulatory monitoring and can be a primary step as to how activities such as walking, running, ascending and descending are performed with better accuracy.

Based on the idea of inductance and acceleration, we developed an accelerometer on LabVIEW and an inductive sensor on Arduino/Tinker CAD to monitor the accelerations in real-time and help in improving the physical activities for patients suffering from Osteoarthritis.

In this paper, we have measured acceleration sensor using a single as well as a triaxial accelerometer and an inductive proximity sensor technology to monitor the above-mentioned parameter for different activities in real-time.

3. Knee Brace with Inductive Sensor Technology

In order to monitor activities in real-time circumstances we need a device which is easily worn and could measure the angle of the knee joint. Furthermore, this device should be comfortable to wear, and no severe placement should be required as the subject needs to put it on without help. Furthermore, to improve the possibility for real-and long-term monitoring the output should not be compound and may not be disposed to any noise or external factors. Therefore, in order to quantify f/e of the knee joint in an ambulatory situation during day-to-day activities, Biomedical engineering, or training sessions, a knee-brace can be used with the above-mentioned sensors. TNO medical devices developed a device with two accelerometers and a coil which was easy to wear and accurately designed. [10]

The electrical inductance of the coil changes, because of the change in knee f/e. As the knee brace bends, the acceleration within the brace changes and the inductance of the coil changes. It means that the inductance of a coil is altered according to a change in its form.

To corroborate the above experiment, Gransier et al. [26] and Meijer et al. [27] performed an experiment where a sensor and calibration technique was compared to a lab reference system, the optical movement capture system. Using Root Mean Square Error of and Mean Absolute Error regarding knee angles and came to a conclusion that the measured precision is within clinically accepted standards.

4. Materials and methods

A) Measurement of a single axis accelerometer using LabVIEW-LabVIEW is a visual programming language that creates a development environment that is aimed to enable all kinds of data processing functions. It can be used for creating equipment control and a variety of data acquisition applications.

Here, we have used LabVIEW to design a VI for a single axis accelerometer and a triaxial accelerometer. In the block diagram, a DAQmx assistant is used to simulate voltage parameter followed by measurement of Raw accelerometer voltage and acceleration voltage values in the beginning. DAQ samples voltage sends the information of these variables to the software in order to perform the further data processing required. Different DAQ devices have different channels, for instance, The DAQ card NI-9205 from National Instruments NI is composed of 32 channels of data type analog input with an input voltage signal of $\pm 10V$ range. This card must be inserted into a frame of National Instrument NI USB-6008 which is connected to the computer via a USB cable in order to process the data on LabVIEW. The choice of working with this card is due to the reason that it admits a high sampling rate in order to revive the proper shape of the signal voltage and current at the terminals of the stack, besides its small size and simplicity connection with the computer. The data collected was stored in a separate file using the Write to measurements file block. A block diagram using LabVIEW is shown in Figure 1 with a design of a single axis accelerometer

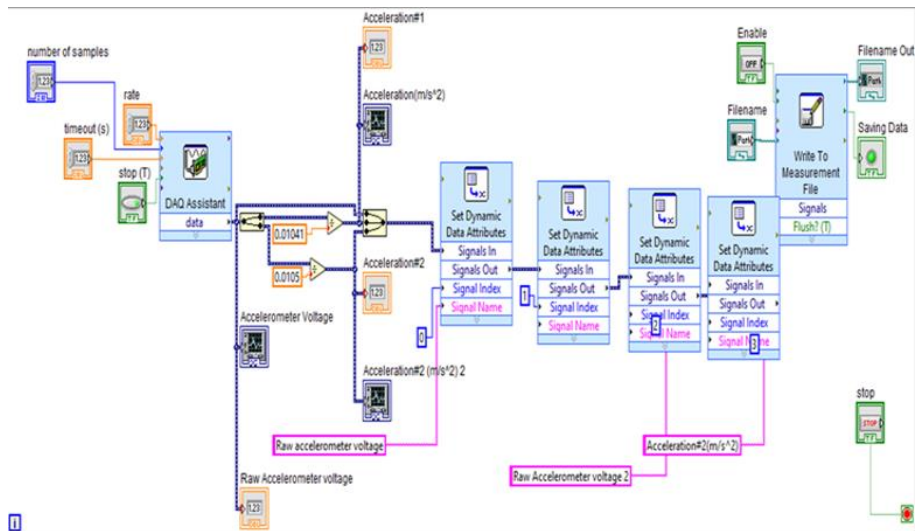


Fig. 1. Block diagram of LabVIEW showing a single axis accelerometer.

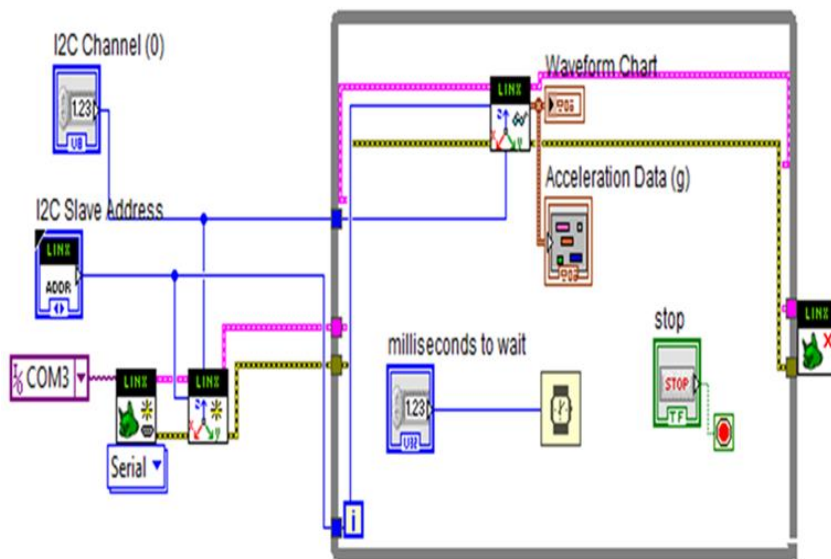


Fig. 2. Block diagram of LabVIEW showing a triaxial accelerometer

B) Measurement of a triaxial accelerometer using LabVIEW- Using the Makers-HUB Arduino interface on LabVIEW, we developed a triaxial accelerometer for dynamic measurements in real time. An Arduino UNO# chip is connected as an external device and ICOM3 is selected at the import device. Using the LINX blocks, the acceleration data is recorded. Figure 2 shows the measurement of acceleration using a triaxial accelerometer.

C) Design of an Inductive Sensor on TINKERCAD- Tinkercad is a free online assortment of programming instruments that help individuals everywhere in the world think,

make constantly. It is the ideal prologue to Autodesk, the pioneer in the 3D plan, designing, and diversion programming.

Tinkercad utilizes a streamlined helpful strong math technique for developing models. A plan is comprised of crude shapes that are either "strong" or "opening". Consolidating solids and openings together, new shapes can be made, which thusly can be relegated to the property of strong or hole.[12] notwithstanding the standard library of crude shapes, a client can make custom shape generators utilizing an implicit JavaScript editorial manager.

Shapes can be imported in three arrangements: STL and OBJ for 3D, and 2-dimensional SVG shapes for expelling into 3D shapes. Tinkercad sends out models in STL or OBJ designs, prepared for 3D printing.

Tinkercad additionally incorporates an element to trade 3D models to Minecraft Java Edition,[13] and furthermore offers the capacity to configuration structures utilizing Lego blocks Apart from the design of an accelerometer, an inductive sensor with an activated relay lamp was designed. We used Tinker CAD for the design. It used basic electronic circuits to construct a sensor and operate it using an Arduino code. It is designed in such a way that the change in inductance shows an alert and a lamp will be generated.

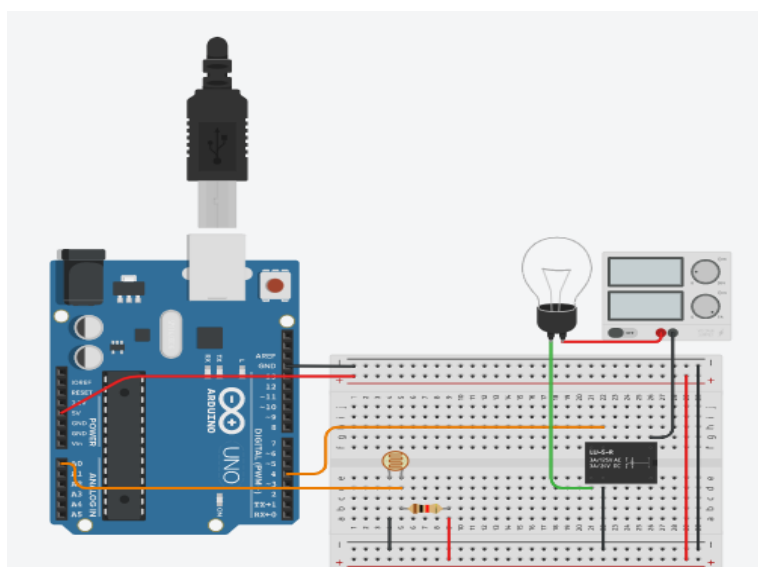


Fig. 3. Inductive sensor with an activated Relay Lamp on TinkerCAD

5. Results and Discussions:

The propose design on LabVIEW was executed and the results were shown in the front panel. Figure 4 shows the front panel showing a single axis accelerometer.

Based on the results obtained in a single axis accelerometer, we obtained the values of acceleration in single axis as 18.0163 m/s^2 and raw accelerometer voltage was detected as -0.73 V . We developed a triaxial accelerometer using an Arduino interface and the results were shown in Figure 5. In the ICOM3 serial port, the acceleration values were recorded as 0.18 , -0.33 and 0.79 m/s^2 in X, Y and Z axis respectively. As the Arduino chip moves, the acceleration values are shown with a slight deflection. Based on the results obtained in the triaxial and single axis accelerometer, we designed an inductive activated relay lamp and simulate it. Figure 6 shows a simple Tinker CAD model for the same.

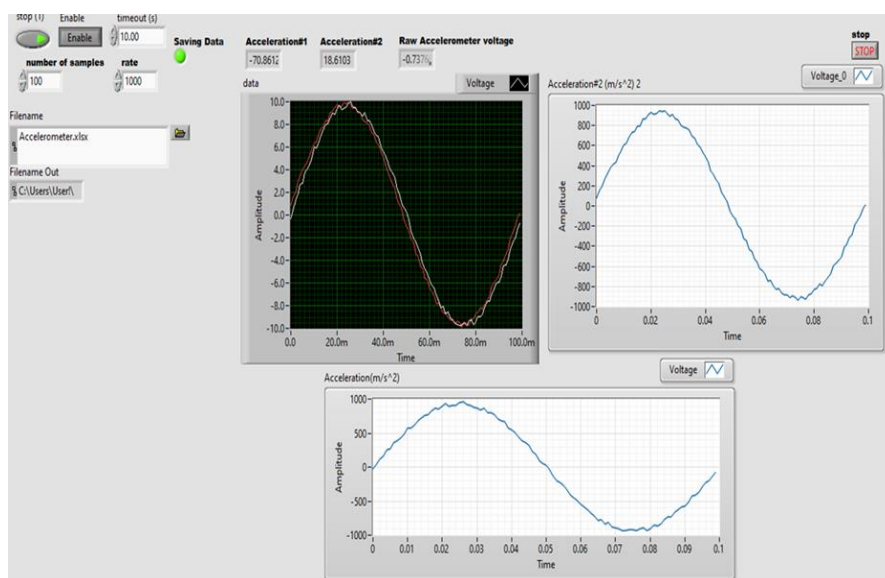


Fig. 4. Front panel of LabVIEW showing a single axis accelerometer

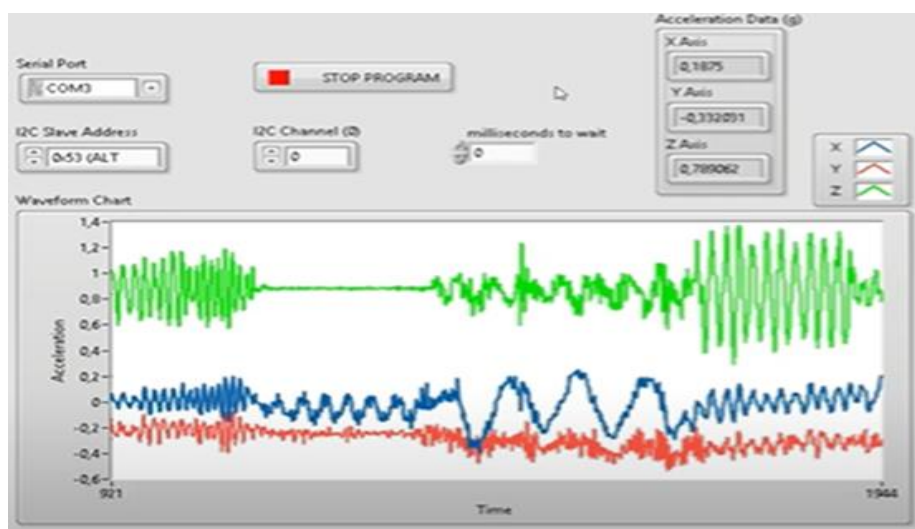


Fig. 5. Front panel showing the results of a triaxial accelerometer

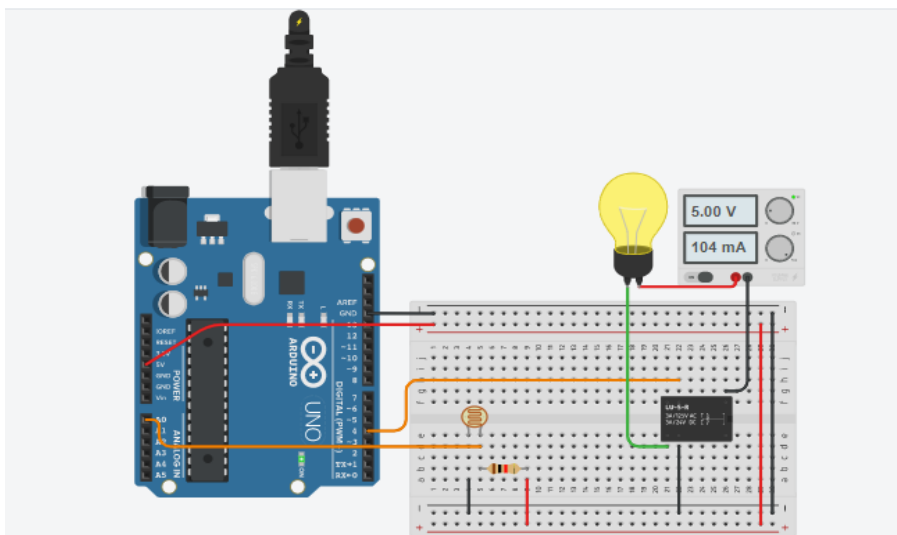


Fig. 6. TINKERCAD model showing an inductive sensor with activated relay lamp

6. Conclusion

In this study we measured the acceleration using an accelerometer in real-time circumstances and can be used to measure for different activities such as walking, climbing, ascending and descending of stairs. Therefore, we developed a sensor, which could be incorporated in a knee brace and can used to measure the inductance along with the flexion/extension of knee joint. Figure 7 shows a Tinkercad model of a knee brace along with two sensors, one accelerometer and an inductive sensor.

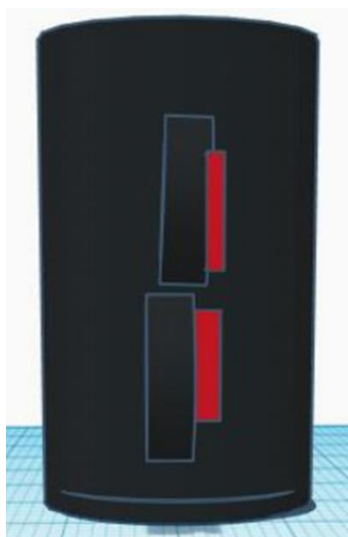


Fig. 7. TINKERCAD model to show a Knee brace and two sensors (labelled in Red)

We concluded that knee movement angles of flexion and extension, can be measure using the inductive sensor used in a knee brace such as in the case of an electrogoniometer. Generally, a knee joint consists of four parts namely menisci, cruciate ligaments, collateral ligaments and joint cartilages which play a very crucial role in moving the knee joint. The normal knee joint flexion angles are between the range of 50°-120°, while if extension goes beyond 5°, it would prove pathological. The inductive sensing device or the coil technology can be used to measure the f/e angle of a knee joint. The situating of the support fairly impacts the exactness of the course of action yet at the same time a reasonable execution is reached.

Contrasted with the current age thoughts, we built up a sensor and planned a model for executing in knee support. This induces that the subject can put on the gadget without help from anyone else which is significant for the long haul and ongoing checking. Particularly when the gadgets must be utilized for long haul checking no perplexing or intertwining calculations are needed to deal with the sensor information.

At long last, this examination is acted in the field where subjects were allowed to walk the track. We accept that this disposes of impacts in estimations acted in a research facility or under lab conditions. This tale innovation will empower fitting treatment and recovery procedures to the requirements for people remembering competitors for singular preparing plans. A bit of leeway of the inductive sensor utilized here is that it can undoubtedly be incorporated in, or worn under, attire which makes it agreeable to wear during restoration, sports exercises, and day by day exercises in wandering conditions.

In our future work, we will be including knee OA patients of various stages to affirm the proposed component in a clinical circumstance. Besides, we will explore how the wearing places of the sensors influence the framework execution and the issues on security and its intrusion

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Analysis and Diagnosis of COVID19 Symptoms Using Ultrasound Image Processing

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Abstract. The paper reviews multiple ultrasound image processing techniques for patients affected by COVID19. Extensive research of both COVID19 patients, as well as patients infected by other diseases, have been done in this regard. The approach towards this issue has been taken by using MATLAB analysis techniques; to classify the infected areas with various colour mapping as well as classify them based on the severity of the infection. This paper also strives to filter out only the infected lung areas so as to ease the process of diagnosis. Promising areas of development and future scope have also been discussed in detail.

Keywords. Ultrasonography, COVID19, Pleural lines, Colour mapping, Feature extraction.

1. Introduction

Ultrasonography is a diagnostic imaging technique that creates images of internal body structures or parts such as the tendons, ligaments, muscles, joints, blood vessels, and internal organs. It aims to find the source of any disease. Ultrasound waves are generally referred to as sound waves with frequencies which are higher than those audible to humans ($>20,000$ Hz). The ultrasound pulses echo off tissues with different reflection properties and are recorded and displayed as an image. Use of ultrasonography (USG) in emergency departments, critical care and cardiac care units is becoming very popular nowadays, especially with the ongoing pandemic. This imaging technique is easily available at bedside, real-time and free of radiation hazards in comparison to the conventional imaging methods of lung (chest radiography and lung computed tomography) in critically ill patients. Lung Ultrasonography (LUS) has been proven to be superior to chest X-ray and equal to chest CT in diagnosing many pleural and lung pathologies. Growing applications of LUS in different settings have led to a difference in approach and nomenclature.

2. Literature review

Role of point-of-care ultrasound during the COVID-19 pandemic: our recommendations in the management of dialysis patients: Evidence that ultrasound can be potentially used to detect the novel COVID-19 that had affected the whole world, especially for the lung ultrasound. In this review, the experience in using point-of-care ultrasound, particularly lung ultrasound, to indicate the probability of COVID-19 in patients with end-stage renal disease treated by hemodialysis is shared. Sonographic signs and patterns of COVID-19 pneumonia: The novel CORONAVIRUS SARS-CoV-2 has a specific tropism for the low respiratory airways, but causes severe pneumonia in a low percentage of patients.

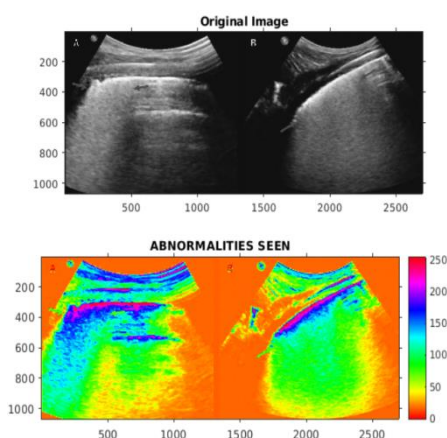
Pneumonia in COVID-19 has peculiar features and can be studied by lung ultrasound in the early approach to suspected patients. The sonographic signs are non-specific when considered alone, but observation of some aspects of vertical artefacts can enhance the diagnostic power of the ultrasound examination. The combination of sonographic signs in patterns and their correlation with blood exams in different phenotypes of the disease may allow for a reliable characterization and be of help in triaging and admitting patients. Ultrasound Imaging and Muscle Function: Paper suggests that conventional grayscale B-mode USI provides information about the echogenicity or reflective properties of a tissue, as well as the architectural characteristics (eg, size and shape) of a structure. Alterations in muscle echogenicity can assist in the detection of muscle trigger points and fatty fibrous infiltration. Lung ultrasound in children with COVID-19: Preliminary findings: Studies about Lung US, reveals signs of lung involvement during COVID-19 infection. In particular, vertical artefacts, pleural irregularities, areas of white lung and subpleural consolidations were the main findings in patients with COVID-19. According to the studies, the routine use of LUS in the evaluation of children with suspected or confirmed COVID-19, when performed by clinicians with documented experience in LUS, was useful in diagnosing and monitoring pediatric COVID-19 pneumonia, reducing unnecessary radiation/sedation in children and exposure of healthcare workers to severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). Advances in Lung Ultrasound: Talks in detail about the types, procedure and advantages of lung US 2. A,B,C, false B(E & Z) lines 3. Sonography is thought to have high accuracy in diagnosing pneumothorax and may outperform radiography in detecting small localized pneumothorax. (but can be masked if B lines present). 4. Lung consolidation 5. US scanning protocols(FALLS, CAUSE).Point-of-Care Lung Ultrasound findings in novel coronavirus disease-19 pneumonia: A case report and potential applications during COVID-19 outbreak 1. 2 case studies of performing lung ultrasound in COVID19 patients. 2. For normal cases-normal pleural line with A-lines regularly reverberating and only one, regular vertical artefact (B-line) noted in a single area 3. For abnormal cases-anterior and posterior EMI-thorax bilaterally, an irregular pleural line with small subpleural consolidations, areas of white lung and thick, confluent and irregular vertical artefacts 4. 6 merits of US over CT(user-friendly, contactless etc). Lung ultrasound early detection and monitoring in COVID-19 pneumonia: fact and fiction: 1.B-lines were observed in US but not that prominent in CT 2. B-lines are visible where the proportion of air/liquid film changes: this happens in pulmonary oedema, pneumonia, atelectasis, acute lung injury/acute respiratory distress syndrome, pleural effusion (also minimal), acute exacerbation of chronic obstructive pulmonary disease, neoplastic lymphangitis, pulmonary fibrosis. 3. impracticable and naïve assertion, suggesting an approach unacceptable when faced with the overwhelming surge of patients calling for optimizing workflows for rapid diagnosis and care. Lung ultrasound findings in patients with COVID-19 pneumonia: 1. A total of 20 patients of COVID-19 pneumonia were categorized as 4 moderate, 5 severe, and 11 critical cases. 2. Most of the moderate and severe cases could show both separated B-lines and confluent B-lines during admission. 3. The predominantly involved areas in moderate patients were on the back, i.e., the interscapular and infrascapular areas. 4. and critical patients, all 5 areas could be involved. Consolidations were not detected in moderate cases and distributed mainly on the posterior areas in severe and critical cases. Pleural effusion (18%, 2 cases), pericardial effusion (9%, 1 case), and deep vein thrombosis (64%, 5 cases) were only found in critical patients. 5. The extent of disease demonstrated by ultrasound findings seemed to reach the peak at the 2nd week and recover gradually thereafter.

3. Working

The following two methods were applied for the diagnosis of Lung Ultrasonography of Covid19 patients using MATLAB-

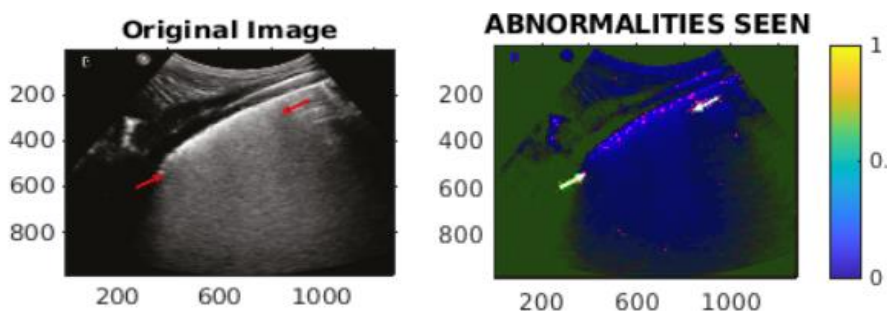
i.) Sharpening the image and adding the colour map based on pixels of the intensity of the image and concluding the results based on different colours being the indicators of the severity of the symptoms.

After the image is loaded, the image is sharpened based on the pixels. After that intensity of pixels is determined by adding a color map to it. The more denser the image the more darker the shade of the colour will be on the inflamed area of concern. A colour bar is also added which indicates the intensities of different colors based on the pixelated values for reference.



ii.) Extraction of h,s,v components from the LUS images and comparison of its intensity separately to get a more detailed idea about the infected section of the lung.

After the ultrasound image is loaded, it is converted from RGB to HSV coloured format using colour map. The abnormalities are highlighted as shown in the images below.



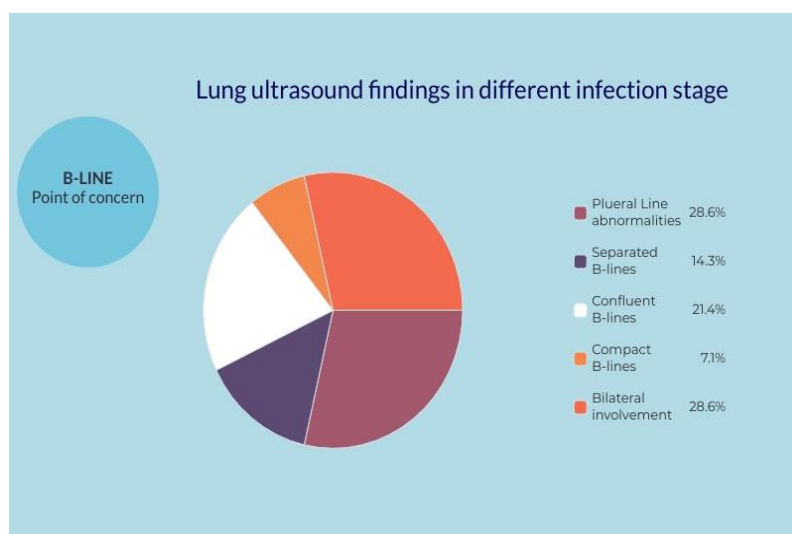
The second part of the code extracts the hue, saturation and brightness (h,s,v) components from the HSV image and displays them separately.



Further improvisation of the code has been performed by adjusting the intensity levels of the ‘v’ image and filtering out the rest of the lung image.

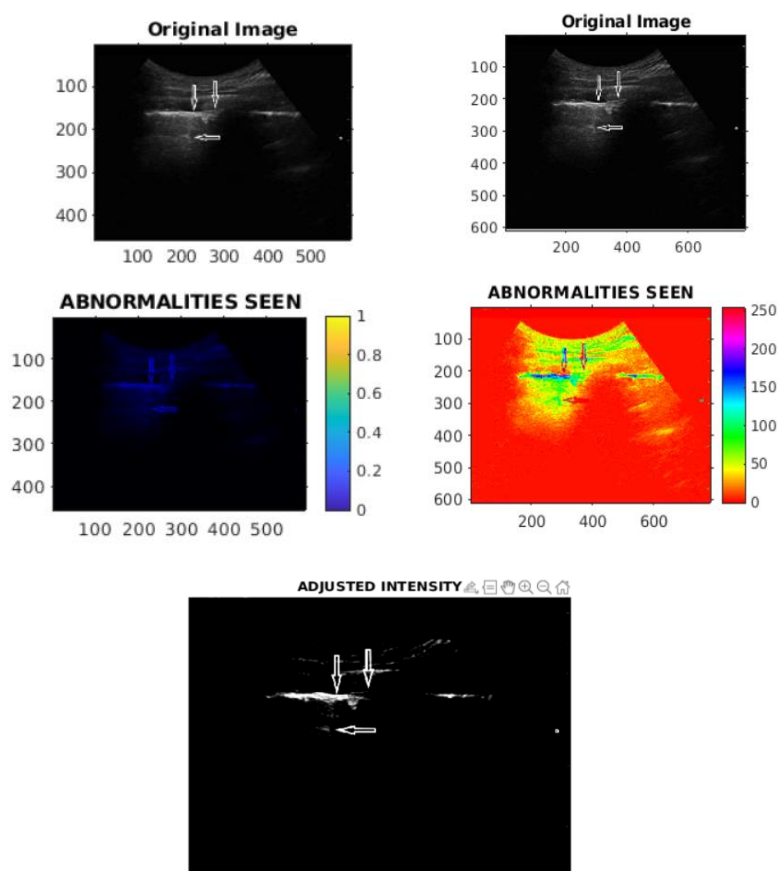


4. Result and Discussion

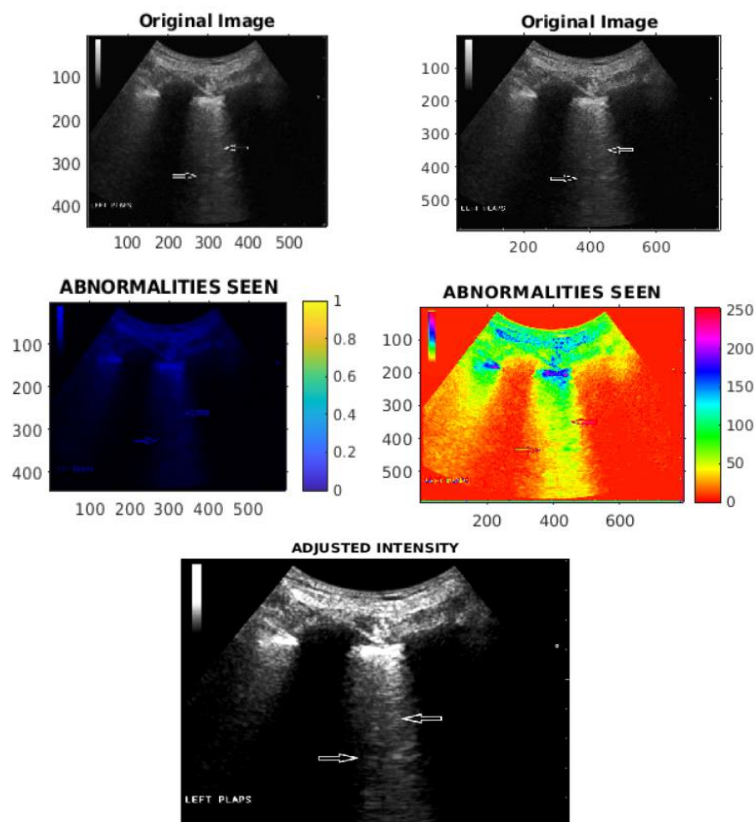


Apart from this, a detailed analysis of LUS of four COVID19 patients, belonging to different age groups have been performed. The results displayed similarity to the predetermined ones.

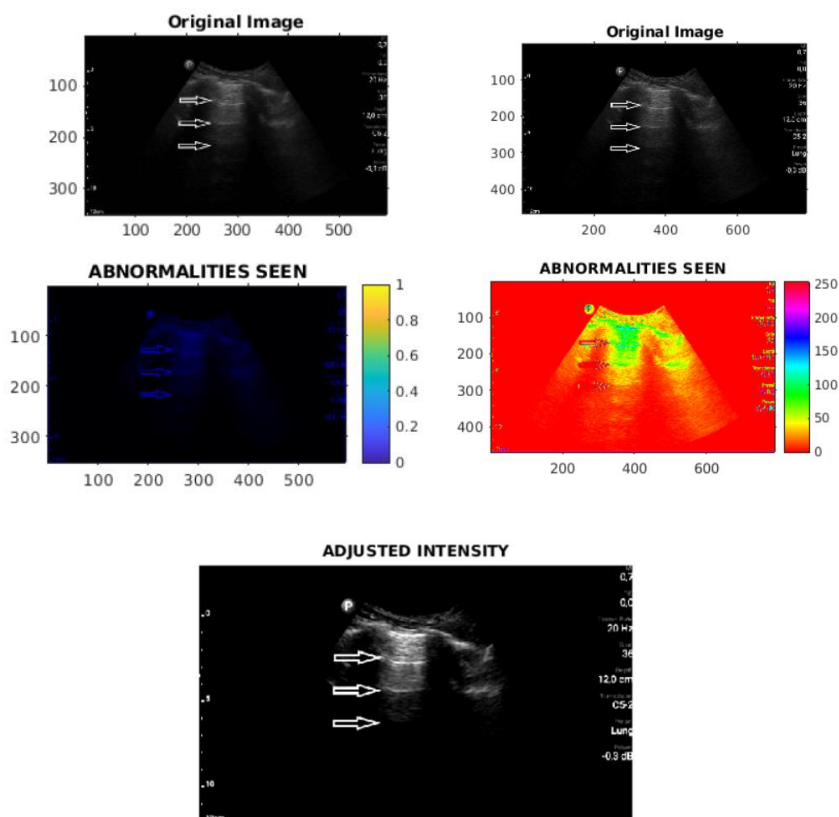
CASE 1: A 25-year-old male without previous medical history, complaining of fever of 39.2 °C and cough for 2 days. Because of inconclusive results of the other tests, LUS was performed, revealing multifocal minor subpleural consolidations accompanied by strengthening behind the lower margin of the lesion (the so-called C-line artefact), short vertical artefacts (the so-called Z-lines) and segmental pleural irregularity. Considering all information obtained and clinical data, a suspicion of COVID-19 infection was put forward, confirmed by the RT-PCR test.



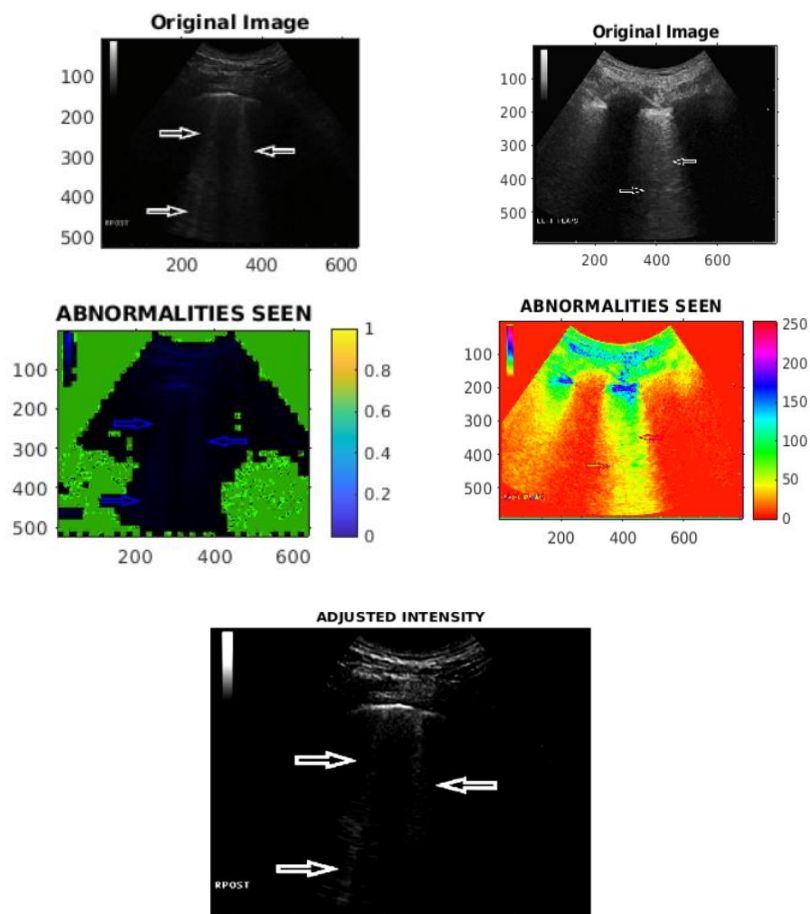
CASE 2: An 84-year-old man with many comorbidities involving the cardiovascular system, including persistent atrial fibrillation and pulmonary hypertension, admitted to hospital due to fever of 38.4 °C. An ultrasound examination of the lungs was also performed, revealing the following abnormalities: segmentally irregular pleural line and single focally located B-lines. COVID-19 was suspected and then confirmed by RT-PCR.



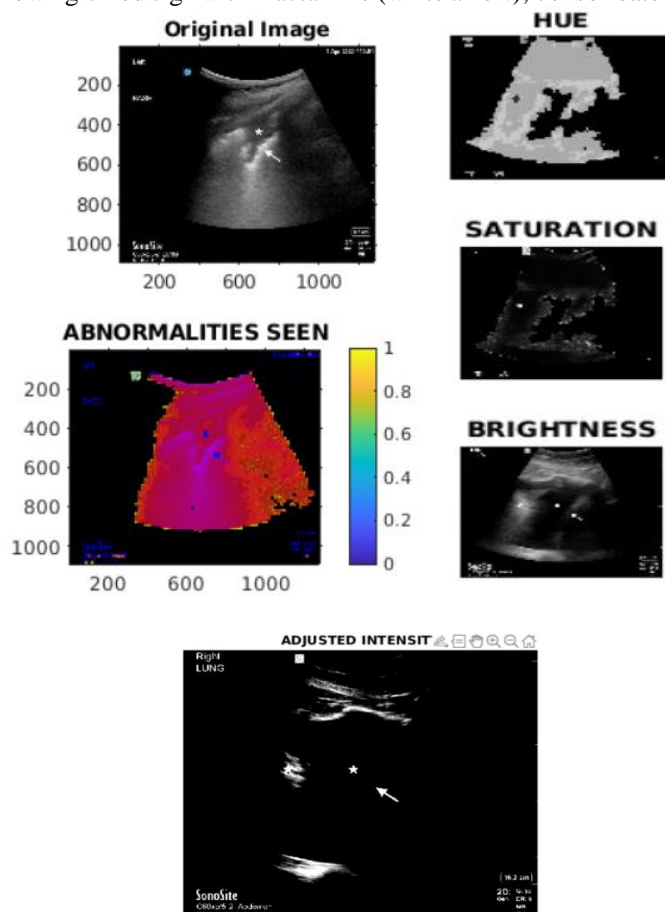
CASE 3: An 80-year-old female with many comorbidities, including cirrhosis and chronic kidney disease (CKD G3), and a history of ischemic stroke and episode of deep vein thrombosis, was admitted to the clinic due to acute dyspnea. A bedside LUS examination was performed. Pleural line A was found in the upper fields of both lungs; in the middle field on the right side, the alveolar-interstitial syndrome (the white lung) and the blurred pleural line were visualized.



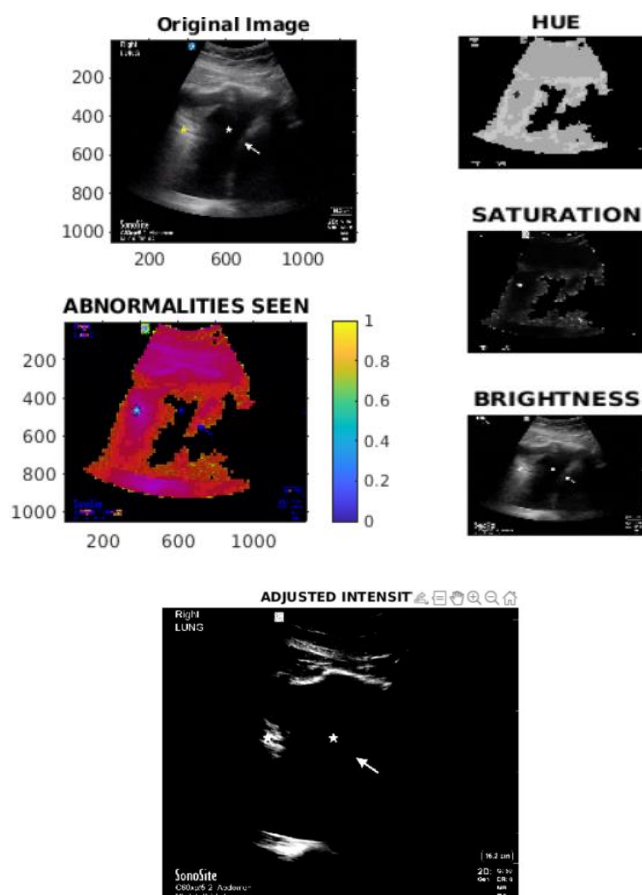
CASE 4: A 52-year-old female admitted to the emergency department due to fever, cough and dyspnea. The patient had no previous medical history of comorbidities. Fever and cough started 4 days earlier. LUS was performed, revealing confluent B-lines in anterior, lateral and posterior regions in the lower and upper fields and small consolidations in both lower fields. Unfortunately, the patient's condition worsened, in a control arterial-blood gas test pO₂ was low (approximately 60 mmHg) despite the oxygen therapy.



Following are the 2 more ultrasound reports collected from a local diagnostic centre:
USS image showing shred sign with fractal line (white arrow), consolidated lung (white star).



USS image showing right lung effusion (white star), atelectatic lung (yellow star) and diaphragm (white arrow).



5. Conclusion

In normal people, the lung shows a thin pleural line whereas the thickened pleural line is a major symptom of infection of COVID19. The same can be differentiated in the images. The inference can be deduced that the blue line thickening (i.e. the pleural line) in the coloured image, is the point of concern for us; following the light-cloudy matter which can be noticed below, is the confluent B-lines. Since it is a domain of ongoing research, a lot of inference is yet to be deduced from it, such as further filtration to detect the B lines perfectly.

6. Future scope

With more research in this new domain, the image of the virus activity will get clearer and hence the symptoms will be definite in the patients of various age groups and with different medical conditions. This will be the next step for this project, the symptoms database will be expanded based on the further research.

However, to make a user-friendly interface, the MATLAB code can be incorporated in a website or to enhance more, an app. To make the task smooth, in the app or website only the LUS image of the patient could be uploaded and the result will be shown in just a matter of seconds with all the severity of symptoms highlighted in a colour-scale fashion while maintaining the efficiency of the results. Interfacing the project with a UI will make the experience better and can be made available for public use with proper guidance and assistance.

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Analysis of P300 Component and its Spectral Density for Detection of Certain Neurological Disorders and their Effects on Perception

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Abstract. Most of the neurological disorders prove to be devastating for the patients suffering from them, which the primitive methods lack to detect, and with evolving methods, it is gradually becoming possible by sophisticated technologies which then proves to be extravagant. So, this paper focuses on the economical solution for the detection of different neurological disorders just by undergoing a P300 event-related potential (ERP) test and analyzing the spectral density of the recorded test data. The analysis could be done using various available inexpensive Electroencephalogram (EEG) & ERP analysis software and toolkits.

Keywords. Electroencephalogram (EEG), Event-related Potential ERP, P300, Neurological disorders, EEGLAB, ERPLAB.

1. Introduction

An electroencephalogram is the record of the electrical activities taking place inside an individual's brain. It consists of numerous components which include N100, P100, N200, P200, N300, P300, etc. This paper focuses particularly on the P300 component of the EEG signal.

P300 is an Event-Related potential which is evoked in response to certain types of stimuli. The name "P300" is given to this ERP is because it occurs as a positive deflection in EEG at about 300 milliseconds. It is also called "P3" or "Late Positive Component" (LPC). Range of its latency is from 300 milliseconds to 600 milliseconds. It has two sub-components known as "P3a" and "P3b". The Distracter in the P300 test elicits the P3a subcomponent, while target elicits the P3b subcomponent as explained by John Polich [2].

While undergoing a P300 ERP test, the subject is stimulated with specific types of stimuli that generate the P300 signal. The type of stimuli can be auditory or visual depending upon the problem. The dataset used for this study is of a P300 speller provided by Kabbara A. [4]. A P300 test can be performed using three different paradigms: 1.) Single stimulus, 2.) Oddball, and 3.) Three stimuli Paradigm [1].

In the single-stimulus test, only Target is presented at random intervals without the presence of any other stimuli. In Oddball test, two different stimuli (Target and Standard) are used with different frequencies. Three stimuli task is similar to oddball but it uses three stimuli with the infrequent third stimuli being the Distracter. In all of the tests, the subject is asked to respond only to the Target stimuli as stated in an article by John Polich [2]. The power spectrum of the Event-Related Potential shows the distribution of power of frequencies. This aids in identifying the mental state of the patient.

2. Flow of Process

The EEG of the patient is acquired and the data is collected in a file. These recordings are taken from the electrodes placed at the area where the activity is supposed to occur. These files are imported in the EEGLAB which is a MATLAB toolbox and are then converted to .set extension. These signals are then filtered and processed to get the desired P300 component. The final signal is presented in the graphical form along with its Spectral Density. These outputs are then analyzed by comparing them with the characteristics of a standard P300 ERP.

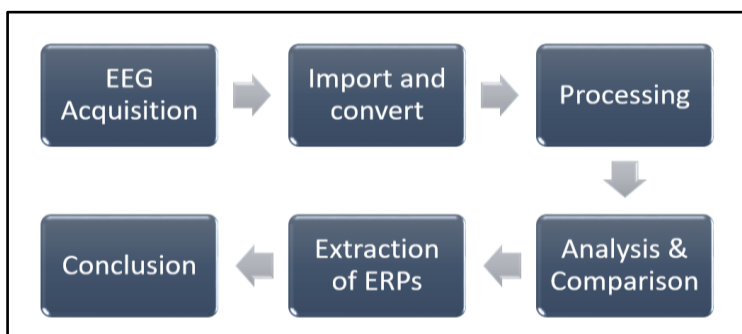


Fig. 1. Flow Diagram

3. Methodology

i) EEG Acquisition:

The Electroencephalogram of the patient is acquired with the help of multiple wet electrodes made up of Ag/AgCl placed on the area of the scalp according to the activity that is to be recorded. The recorded data can be in various file formats such as .dat, .EEG, .CNT, .bdf, .edf, etc.

- ⇒ For Auditory Evoked Potentials; Central and Temporal electrodes can be used.
- ⇒ For Visual Evoked Potentials; Parietal and Occipital electrodes can be used.

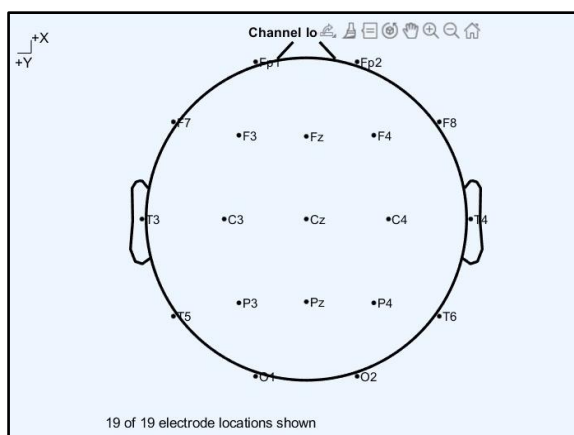


Fig. 2. Image acquired from EEGLAB

ii) Importing and conversion of raw EEG data

The raw data is imported in the EEGLAB toolbox of MATLAB and is converted to .set file, the only acceptable file format to process the EEG with this toolkit. After this, the EEG can be plot using the 'scroll channel' function as shown in Fig.3.

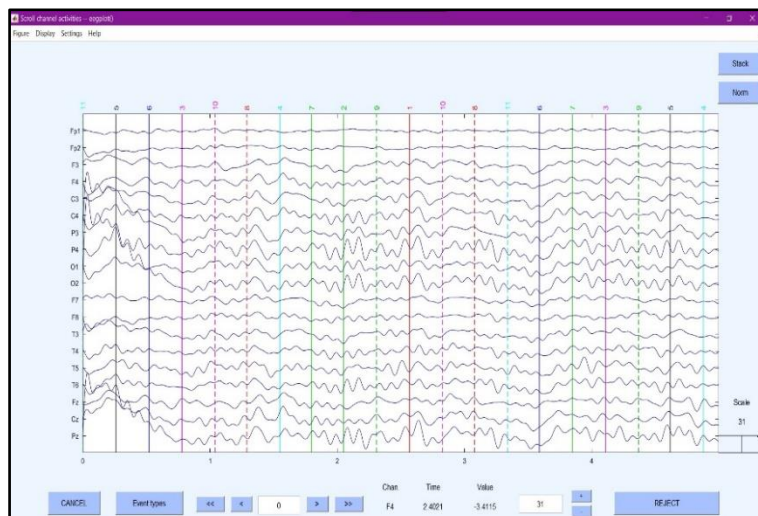


Fig. 3. Plot of EEG data from 0 to 5 seconds using EEGLAB

iii) Processing

The first step includes the assigning of channel locations. This step is necessary for the identification of channels. This also helps in viewing the placement of the electrodes in 2D and 3D modes. Then the signals are re-referenced with the mastoid or ocular or ear lobe electrodes and then it is average referenced for the removal of the physiological artefacts. This data is then re-sampled by down-sampling it to reduce the size of data and the time for processing. The data is filtered using Linear Parks-McClellan Notch filter with the stop-band of 50Hz/60Hz with the help of ERPLAB Toolbox to remove the mean value of DC bias due to the power-line interference this can also be removed using the 'Baseline removal' feature in EEGLAB.

Also, the data is filtered using EEGLAB with the lower cut-off frequency of 0.5 Hz to the higher cut-off frequency of 50Hz with the help of basic Finite Impulse Response filter for removing large amplitudes or drifts or phase shifts, it also displays the frequency response of the filter. This step is required for performing the independent component analysis (ICA). Now, the event list is to be created in the form of EEG.event using the ERPLAB.

In this process, the event codes must be numeric to assign them using ERPLAB. In case they are Alphabetical/Alphanumeric, they must be converted to numeric codes before being assigned. The event labels can be alphanumeric and are used for understanding the event codes. Bin values are allotted for the epoching of the signals using bin numbers. They can also be allotted using the BINLISTER tool in ERPLAB and the bin description are used for a similar purpose as event labels. For epoching, bin based epochs are created using the 'Extract bin based epochs' tool in ERPLAB. The time range of each epoch is set 700 milliseconds because the latency of P300 component is 300 milliseconds to 600 milliseconds and along with that the baseline correction is set approximately 10% of the time frame for identifying a part of the waveform before the occurrence of the evoked potential.

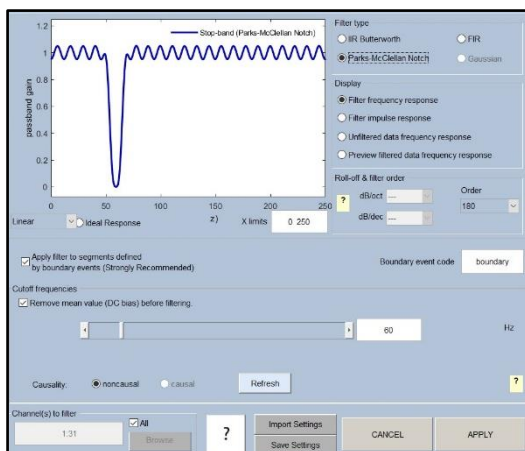


Fig. 4. Notch Filtering using ERPLAB)

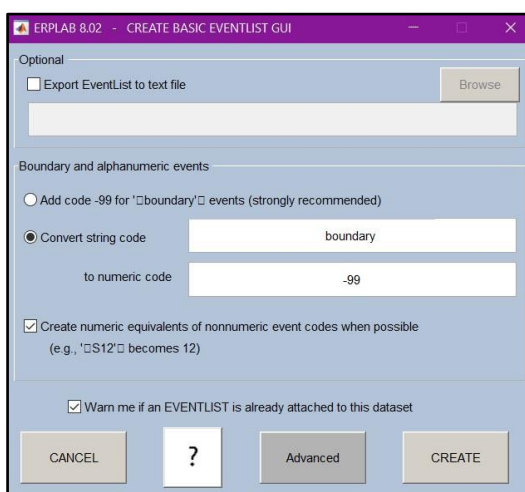


Fig. 5 Creating Basic Eventlist using ERPLAB

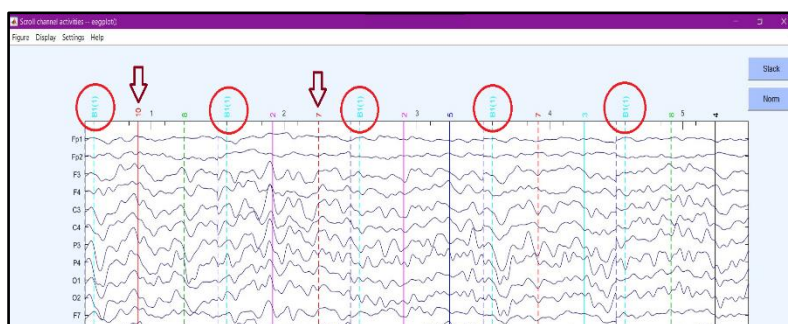


Fig. 6. Bin 1 assigned to ERPs of a specific type of target stimulus (encircled) and others are not assigned with bins (some are indicated by arrows)

ERPLAB provides many artefacts detection techniques, of which, ‘Simple voltage threshold’ is used in this process. Here, the extreme voltage limits are taken as -100 microvolts and 100 microvolts with the test period of -50 milliseconds to 250 milliseconds. Now, the data will be marked and can be rejected using ‘Reject data by eye’ option.

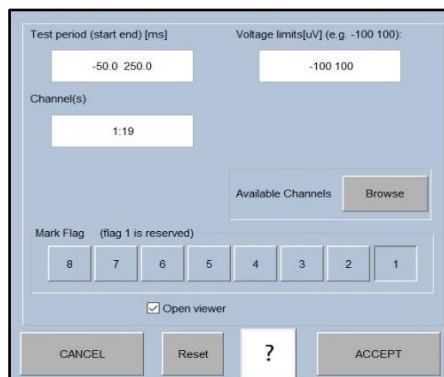


Fig. 7. Artefacts Rejection using voltage threshold in ERPLAB

This follows the filtering of data using the ERPLAB’s 2nd order linear Infinite Impulse Response Butterworth band-pass Filter with the pass-band of 1Hz to 30Hz.

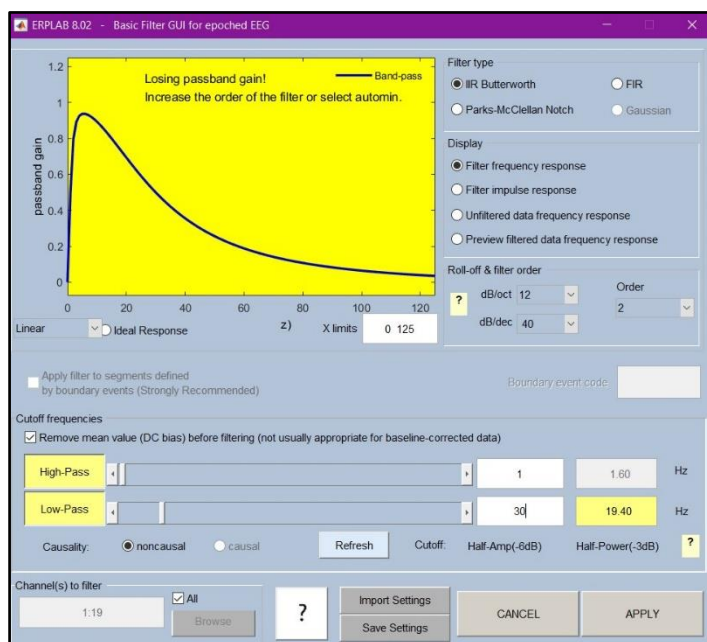


Fig. 8. Band Pass Filtering using ERPLAB

This process filters all the epochs individually. To get the different bins, all the epochs should be averaged using ‘Compute Averaged ERPs’ tool of ERPLAB. In this process, it is highly recommended to exclude the epochs that were marked in the process of artefact detection. This will follow the creation of ERPset which is the collection of ERPs extracted

during the process. These ERPs can be plot using the ‘Plot ERP waveforms’ function of ERPLAB and selecting the required channel for plotting. There are many different plotting layouts available but with the ‘Topographic’ style, the ERPs will be plotted at the site of their acquisition. It also helps in setting the scale of graphs such as negative up or positive up, selecting the type & colour of legends and selecting the bins to plot according to the requirement. On selecting the site/electrode placement, the ERP of that electrode will be displayed in the new window. By using the ‘Compute Evoked Power Spectrum from current averaged ERP data’ function of ERPLAB along with the ‘Plot waveform’ tool, the spectral density of all the ERPs can be plotted in the same way as evoked potential. The plots can then be transferred to MATLAB as figures where it is possible to make few changes with legends and highlighting the bins for further analysis.

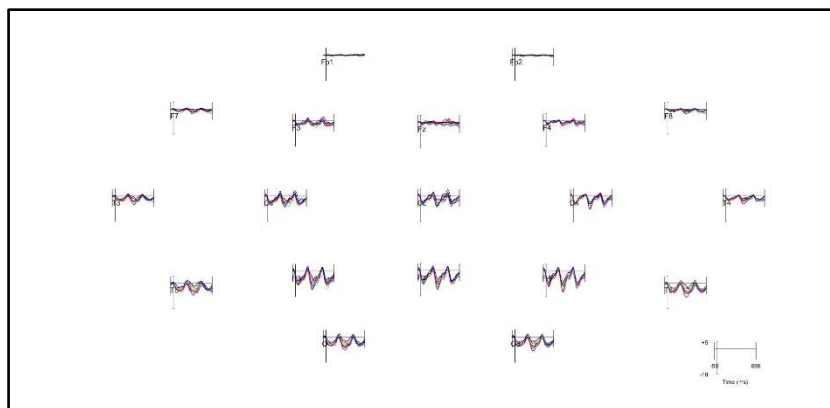


Fig. 9. Topographic Plot by ‘Plot ERP’ function of ERPLAB

iv) Analysis:

The output is observed and compared with the standard P300 characteristics and the observed variation or anomalies are then used for shortlisting and concluding the disorder(s).

4. Results

The figures given below (Fig.10 & Fig.11) displays the Evoked Response and its Spectral Density. The dataset used in this paper is of a healthy subject so, all the characteristics are matching to that of standard ERP. But if the subject was a neurological disorder patient, the characteristics would have been varied.

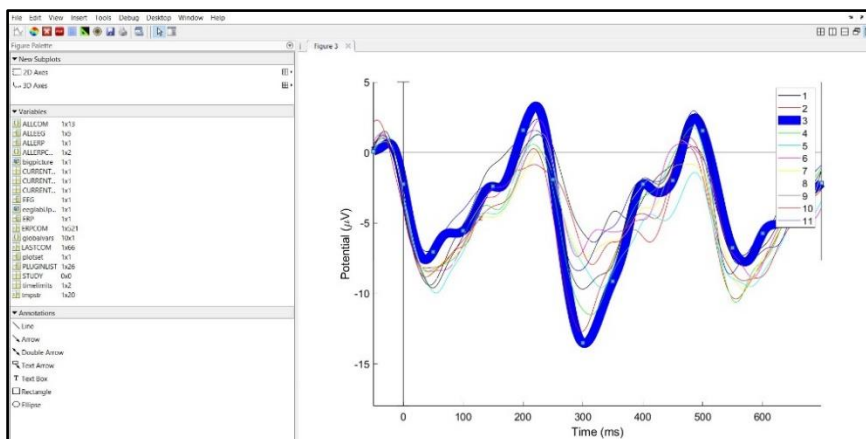


Fig. 10. Highlighted ERP

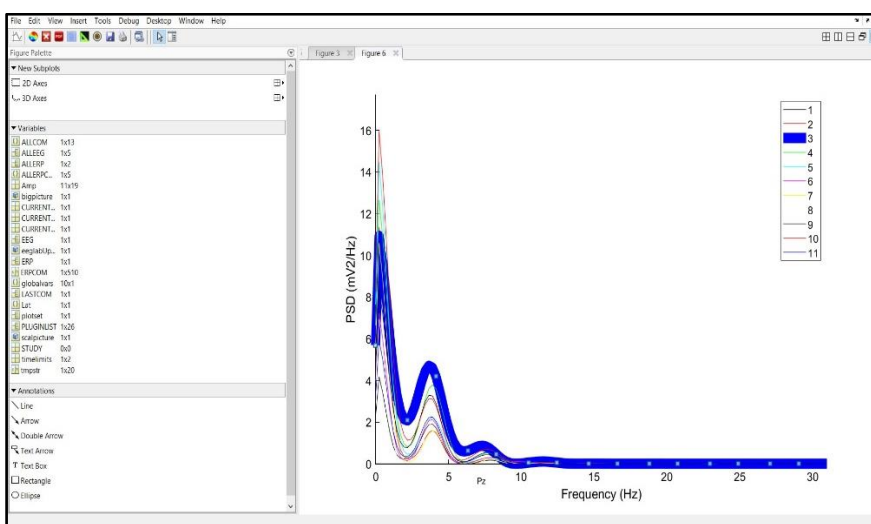


Fig. 11. Highlighted Spectral Density of ERP

5. Discussions

Use of self-acquired data can be more beneficial for study purposes in this area of research as all the datasets that are provided online are not supported by these Toolboxes and may prove to be incompatible at certain steps of processing.

Future scopes may include the use of other components of ERPs along with the real-time processing of Electroencephalogram. This will provide more accurate results and may prove to be more efficient and less enervating to perform all the steps. Use of other software that is more compatible, support various file formats and have multiple user-friendly tools for processing can also provide better results.

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Analysis of Positron Emission Tomography Images with Effective Segmentation and Slicing

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Abstract. The most widely used technique in the study of anatomical and metabolic processes is positron emission tomography. In this paper we proposed a suitable method to analyze the PET images with substantial image processing tools which helps in efficient and error free diagnosis. The images used are in nrrd format that gives n-dimensional raster data after applying various image processing modalities from Jupyter Notebook. We used the 3-D slicer kernel, which is specially used for medical image processing. By using the proposed method, the image can be visualized in all 3 dimensions, can be sliced thorough, the color contrast can be changed considering more than one slice at a time, if there is an abnormality found in the image, for example a brain tumor, it can be segmented and highlighted. Thus, the proposed method helps in easy diagnosis by analyzing throughout the volume of the image.

Keywords: Positron Emission Tomography, Slicing, image segmentation, Brain tumor.

1. Introduction

A brain tumor can directly kill or by implication, it may hurt the solid cerebrum tissue by swarming different regions of the cerebrum and actuating irritation, brain tissue expanding and may strain inside the skull. Picture testing assumes a significant function in investigating and diagnosing tumors in the brain [1]. PET outputs [2] are likewise used to give data about potential tumors and metastasis of malignancy, correspondingly to Computed Tomography pictures (CT), Magnetic reverberation imaging (MRI) and so on Generally, PET gets the pictures of physiologic capacity as indicated by the glucose metabolic action as the work standard so it can show some tumor that can't be found in a structure picture. The upside of utilizing the PET picture is that it can distinguish unpretentious practical changes at the beginning phases of a sickness [2].

Through assessing PET, a specialist can likewise figure out where the tumor is, in the event that it is kindhearted or dangerous, and if the chemotherapy treatment is working. Concerning specialist activity, accurately finding the cerebrum tumor and assessing its size in the skull is significant.

In this paper, we propose a method of detecting brain tumor in a PET scan using 3D Slicer in a python Jupyter notebook. The image can be visualized in all 3 dimensions viz. Longitudinal, transverse and sagittal view ,it can also be sliced ,the color contrast can be changed considering more than one slice at a time, If there is an ambiguity or abnormality found in the image , as in the case of a brain tumor, it can be segmented and highlighted.

2. Literature survey

The low resolution and similarity between textures of different images made it must for image pre-processing and also made the interpretation process difficult for diagnosing a person. The nearly raw raster data (.nrrd) file format of the image gives a much deeper and clear insight in anatomical perspective when compared to DICOM format which is generally used. NRRD records can store a medical scan in a solitary document, while DICOM data sets generally include directories that contain handfuls if not many individual documents. NRRD is subsequently a decent record for moving medical scan information while ensuring persistent protection.

The existing methods for slicing does not provide room for continuous view of getting sliced through volume of the obtained file while in this paper we proposed a method with an aid slider, where in the user will be able to continuously get through the volume of the image obtained in all 3-dimensions by adjusting the offset value in the slide bar.

After pursuing various research and review papers, we closed the vast majority of the papers and extracted the ROI manually which led to human errors and reduced efficiency. To mask out the ROI from other surrounding tissues, various features such as edge size, node size, voxel number and several other parameters were considered. The gist of our work focused on reducing the amount of image processing and made the diagnosing process easier as well as efficient.

3. Methodology

Biomedical pictures are a focal bit of clinical science, these photos are depicted as the photos of the human body that guide the cognizance of nature of the human natural system. The path toward making visual portrayal of within fragments or inside bits of a body for clinical investigation, therapeutic intercession and visual portrayal of capacity of few organs or tissues is called Medical imaging. The methods accessible for division of clinical pictures are explicit to application, imaging methodology and kind of body part to be examined. For instance, necessities of mind division are not the same as those of thorax [3]. Thus while selecting a segmentation type one is required to consider all these aspects. Here, we have used 3D slicer and python Jupyter notebook to slice and segment.

3D Slicer is a free open source programming that is an adaptable, measured stage for picture examination and perception and can likewise be stretched out to empower advancement of both intuitive and cluster preparing apparatuses for an assortment of uses. Python is utilized to import and access the highlights of 3D Slicer. We utilized 3D Slicer to introduce the information of the clinical image (nrrd) in a definite and intuitive way. Utilizing 3D Slicer we did different picture handling, for example, Slicing, Cropping, and 3D revolution of picture, improving shading difference of the picture for better recognizable proof, Segmentation and checking of tumor. We utilized Python to get to the highlights of 3D Slicer. Python is a deciphered, significant level and broadly useful programming language. It is amazing and simple to work with 3D Slicer. Our Project was coded and gathered in a web application called Jupyter Notebook. Jupyter Notebook is an open-source web application that permits you to make and share reports that contain live code, conditions, perceptions and account text. Jupyter Notebook gave an amazing, adaptable, shareable and the capacity to perform information representation in a similar climate. It helped us facilitate the manner in which we program and offer our undertaking.

4. Result and discussion

In the model we developed in the Jupyter notebook, with the image in nrrd format it is possible to visualize the organ or tissue in all three dimensions. This feature gives a clear insight for the initial diagnosis process. Anyone who uses our model will be able to guess the area of abnormality and the extent of spread it has with this feature. For this case we have considered a brain image with a tumor in it. The 3-D view can be seen in the Fig.1 below.

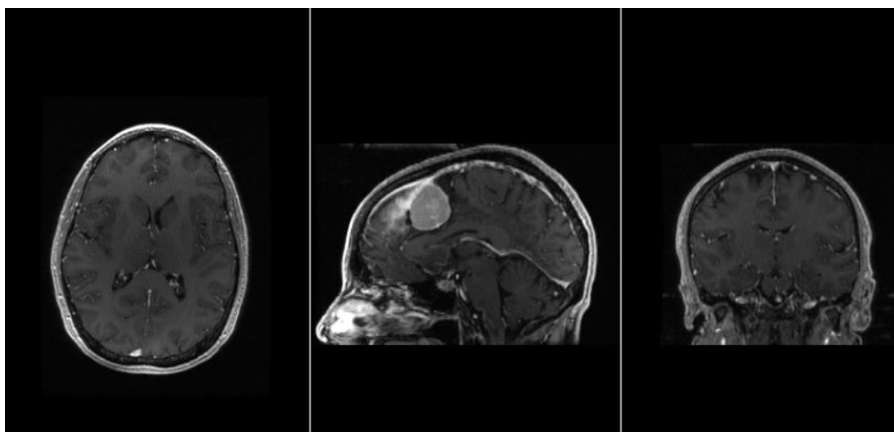


Fig. 1. Visualization of data.

The change in contrast is an important feature that gives the details about the coordinates of the tumor if any. The exact location of the tumor or any ROI that has to be examined can be located and visualized more clearly with a higher contrast. At this stage the diagnosing person will be able to get a clear cut idea of the tumor, the size, the exact location and other required details [13]. The Fig.2 above illustrates this case. The visualized image has been fed into the contrast changer, and we can see that the bright spot in the middle image clearly represents the tumor.

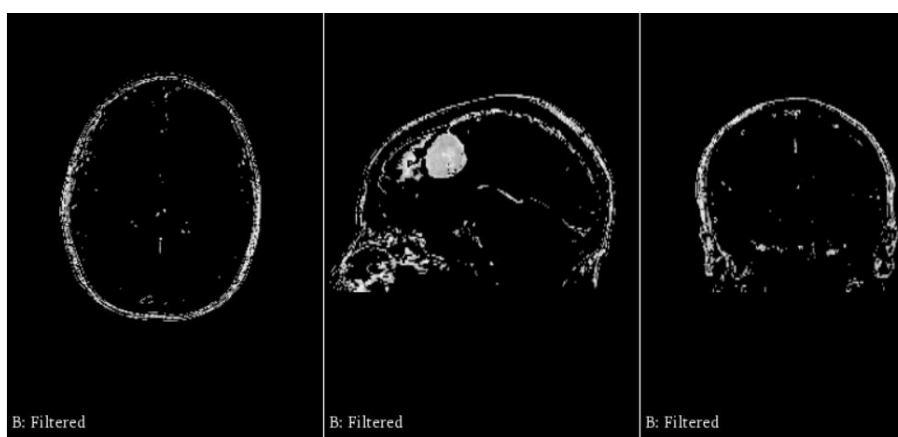


Fig. 2. Color contrast.

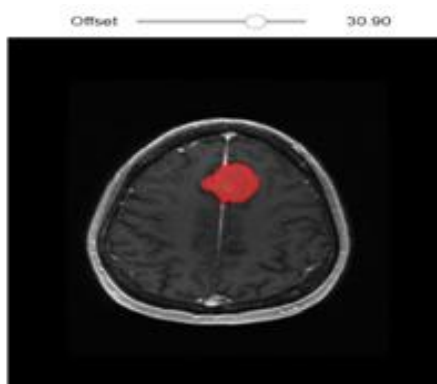


Fig. 3. Slicing

The slicing feature helps to look through the volume of the brain. The offset value guides the user through various slices of brain. By adjusting the offset values, different slices can be visualized. This will give the diagnosing person a clear insight of where the tumor starts and ends. The Fig.3 shows all 3 dimensions of the image, which can be sliced through. For longitudinal view, an offset value of over 5, gives a clear view of the tumor.

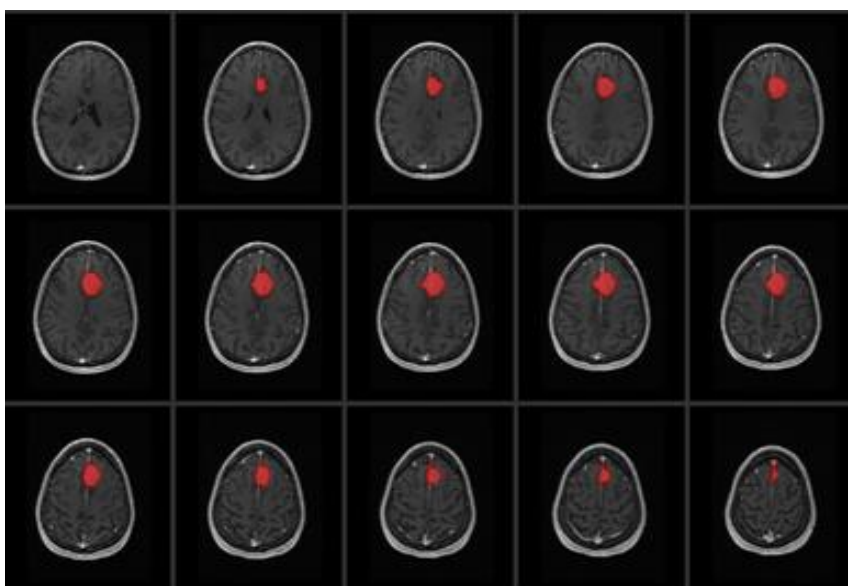


Fig. 4. Segmentation

In order to differentiate abnormal tissue from surrounding areas in PET images, image segmentation methods play a vital role, therefore, accurate image segmentation is often necessary for proper disease detection, diagnosis, treatment planning, and follow-ups[7]. The segmentation process is quite challenging as the low resolution and high smoothing decreases the contrast between objects in the image, and boundaries between nearby objects often become unclear. Several additional factors can be counted under resolution related issues [3].

Figure 4 shows the tumor segmented and highlighted in red color. The sliced image is fed as slices into the segmenter that marks the presence of tumor right from the appearance to disappearance of the tumor.

5. Conclusion

The features extracted in this paper are very valuable for future exploration work. The outcomes may additionally help radiologists to beat issues of manual segmentation. After fruitful segmentation just the information with respect to the Region of Interest will show up as the main passage. The separated highlights may help in the assurance of careful tumor size and area and thusly it will likewise assist with identifying the stage and the development pace of the tumor. Thus, the PET image slicing and segmentation may give significant data in regards to cerebrum tumor regardless of whether there is no earlier information accessible.

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Automatic Saline Level Controller and Indicator

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Abstract. Saline is the most important intravenous fluid which is used to treat the patients to maintain fluid level in the body along with medicines. Monitoring of saline level is important because as the level decreases the pressure under the empty bottle is decreased due to this pressure difference there are maximum chances of backflow of blood from the vein to an empty bottle. To avoid that we have to change the bottle or close the IV knob. Generally, the monitoring of saline is done by hospital nurses or assistants. If the monitoring of the saline level was avoid then it can cause serious conditions for the patients and may cause death. To avoid that we designed a system where the flow sensor can check the saline level and indicates the saline level using some indicators. These indicators are visual as well as audio-based. This paper presents the software implementation of the system for Automatic saline level Indicator and Controller using LabVIEW.

Keywords. BMI, Saline, IV, DAQ, indicator, LED, audio, automation, flow sensor.

1. Introduction

As per the observatory report of Global Health the data shows the ratio of physicians was less than 1 per 1000 persons. To treat the patients in such a huge number we developed a system where the treatment should provide to all patients at a same time with reliability. The most important challenges for the healthcare management was to check the saline level of the patients. As the saline level decreases the pressure under the bottle also decreases, once the bottle was emptied the venous pressure was more which lead to the outward flow of blood from the body to bottle to avoid that we need to check the level in saline bottle, the developed system uses flow sensors which can be triggered when the threshold values reached and indicated by Visual as well as Audio based indicators.

2. Literature review

Existing Approaches – In the healthcare field the growing technology was focused on the automated system where the monitoring can be done as per the user requirements in this case the saline monitoring systems are also developed where it can be observed by detecting the droplets [1] when it was given to patients. The monitoring [2] [3] of empty saline bottle can be observed using IR sensors and further indication can be given to healthcare assistant using Bluetooth module [4], same system can be used for monitoring but to avoid the loss of information the data can be communicated through the internet [5] where the NodeMCU and servo motors [6] are used to stop the saline flow to the patients. Electromechanical systems are also used for monitoring of saline level [7] [8] where the weight of saline bottle is observed based on the load sensors [9]. Another approach to control the saline flow is to synchronize [10] the saline flow rate with the pulse rate using pulse sensors and servo motors.

Proposed System – The proposed prototype is of an automatic saline level controller and indicator which is based on the Body mass index of the patient. The Body mass index is a relation between body fat based on height and weight which varies person to person. Based on the BMI we can estimate the saline flow rate for particular patient to maintain the saline rate we are using flow sensors in controller to avoid the random flow. Further the system is connected to the indicator system which checks the level of saline fluid in the bottle and after reaching threshold level it can gives the indication to nurses or caretakers.

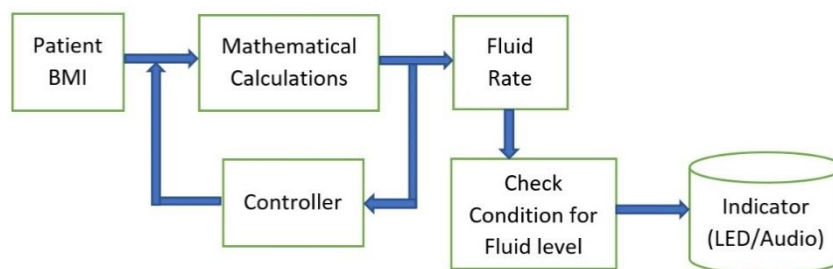


Fig. 1. Flow Diagram

3. Methodology

The whole system we have developed in the LabVIEW software as shown (Fig. 2.).

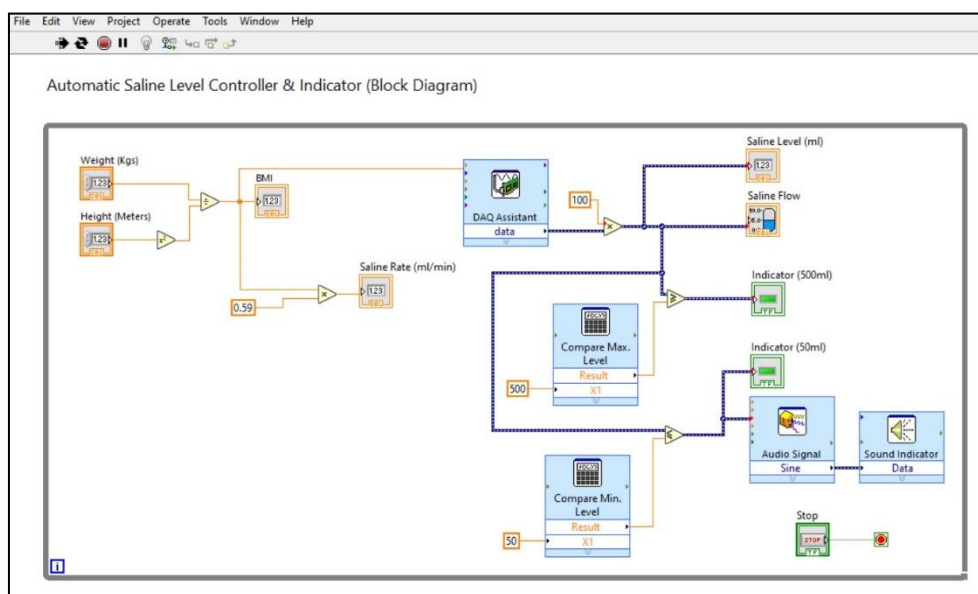


Fig. 2. Block Diagram

A. Calculation of Body Mass Index (BMI)

Body mass index is the relation between the body fat and height and weight which is calculated using Weight in Kgs divided by Height in meters with its square. Same formula we implemented using LabVIEW numerical tool kit and numerical input data block for taking the input of Height and Weight from the user.

B. Calculation of Saline rate from BMI

BMI was the important factor for the analysis of various healthcare conditions, In that we found that the estimation for maximum intravenous fluid flow rate for particular patient can be directly proportional to the BMI which is a calibration constant of 0.59 units which when multiplied with BMI it can gives the saline flow rate (in per minute) for that person. This can be maintained during the system execution to avoid the casualty.

C. Saline Flow simulator using DAQ Assistant

To simulate the saline flow in the bottle we are using classic tank as a bottle for saline and DAQ Assistant as a fluid movement in the bottle. This DAQ is working from 0-10, further we multiplied the system with 100 units for the standard saline bottle volume of 1000ml this DAQ output was given to the tank and parallel channel is used for the numerical value output.

D. Visual and Audio based Indicator system

The indicator system was working as a flow sensor which sense the flow in the form of numerical variations, this numerical variation can be compared to check the saline volume with the help of formula block in LabVIEW system. The greater than mathematical operations are used to check the saline level was greater than the given threshold value in formula block if this condition was true then the connected indicator was triggered. Here we are using 2 indicators one was at 500ml to check the saline level was flowing or not in green colour and second was at 50ml with the audio indicator in Red colour.

4. Result

The Front Panel for the developed system is as shown (Fig. 3.).

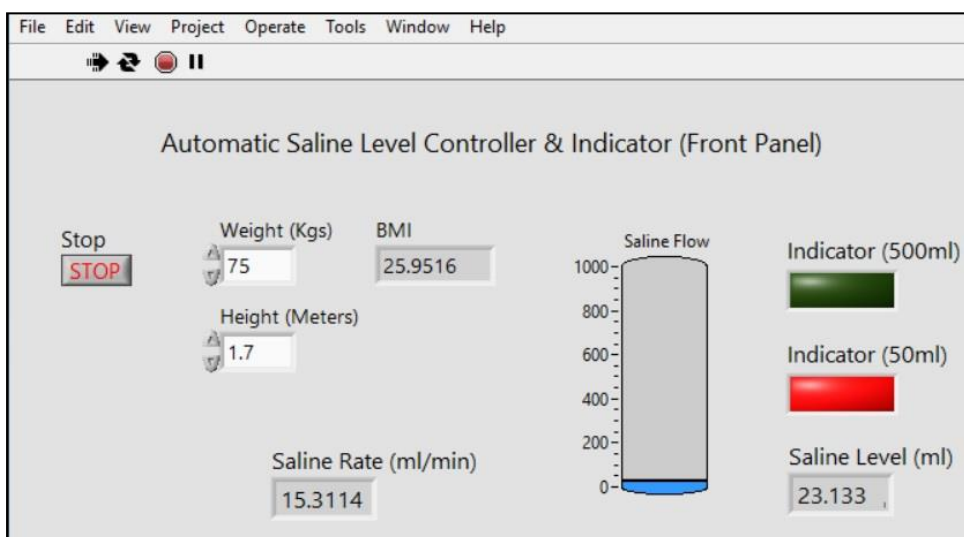


Fig. 3. Simulated System

The system works when we are giving input as a Weight (Kg) and Height (m) based on these parameters the BMI was calculated as per the BMI the rate of the saline will be calculated (ml/min), DAQ Assistant works as a fluid simulator in the saline bottle were the flow sensor output is to be analysed by the indicator system, if the saline level is between 500ml to 1000ml it can be indicated by Green LED to check the saline flow further if the level goes below 50ml the system gives indication in Red LED with audio indicator to intimate the Healthcare assistants for replacing the saline bottle or closing the IV knob.

5. Conclusion

This project is based on the idea of automatic saline level controller and indicator. As we know the negligence in the monitoring of saline can be very serious when it is overdosed or failed to remove the empty saline bottle from the patient. This is the continuous monitoring system where we can decrease the efforts for nurses or caretakers by developing this system. This is a simple and very efficient system for monitoring of saline level based on the body mass index of the patient.

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Bone Fracture Detection Using Image Processing and Neural Networks

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Abstract. As the use of imaging has increased, the demand for higher quality images and detection techniques has also increased. Different applications require solutions that best suit them. The paper explores various methods of fracture detection and reviews potential alternatives. The proposed method attempts to make use of the Speed UP Robust Feature (SURF) algorithm to extract features from computed tomography scans. The extracted features are then fed into a neural network for pattern recognition. This method tests the feasibility of using such an algorithm for fracture detection.

Keywords. Image processing, SURF feature extraction, Bone fracture detection, Medical Imaging

1. Introduction

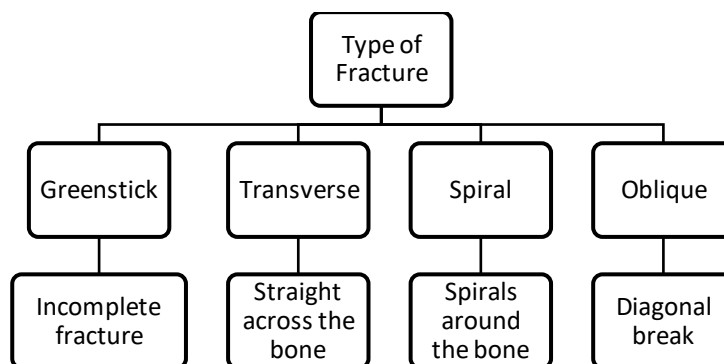
As the use of imaging has increased, the demand for higher quality images and detection techniques has also increased. Different applications require solutions that best suit them. The paper explores various methods of fracture detection and reviews potential alternatives. The proposed method attempts to make use of the Speed UP Robust Feature (SURF) algorithm to extract features from computed tomography scans. The extracted features are then fed into a neural network for pattern recognition. This method tests the feasibility of using such an algorithm for fracture detection.

Medical Imaging techniques have improved drastically over the past half-century. Starting with the invention of X-ray in 1895 by the German professor of physics, Wilhelm Roentgen, the invention of fluroscopy, Magnetic Resonance Imaging, Computer Tomography, etc., has led to a revolution in the medical industry. Diagnostic techniques as well as image aided surgery and procedures have increased the success rate of each procedure by a substantial amount and has also enabled the physicians to diagnose ailments that could be overlooks without proper imaging. But even with the availability of advanced imaging techniques, the task of diagnosing and performing procedures are a human task. One incorrect diagnosis could start an endless chain of reactions which could end in death of the patient. According to Alexis A. Wright [1], up to 85% of stress fractures go undetected on the initial radiographs and up to 50% go undetected on follow-up radiographs, suggesting a high number of false-negative test results. This is a very high number if left unattended. Once a bone fracture is left unattended, it could heal improperly or lead to excess stress and even damage muscles. The pain worsens and can hamper day-to-day activities of the affected patient. This untreated fracture, if healed improperly can lead to visible deformities, misalignment, limited movement and infection.

There are various imaging techniques used to detect bone fracture. These include but are not limited to:

- i. X-Ray
- ii. Computed Tomography (CT or CAT Scan)
- iii. Magnetic Resonance Imaging (MRI)
- iv. Bone Scan

These imaging techniques are used to detect the 4 major types of fractures:



The process of detecting fractures has several steps and takes a substantial amount of time which leaves the patient untreated. The steps involved include imaging, waiting for the result, waiting for an available physician, radiologist or nurse, detecting the break and devising a path of action. To make this process simple, we aim to develop an algorithm which automatically processes the image taken and tells us whether it is a fracture or not. The algorithm will process the image and pass it through a pre-trained network and determine the presence or absence of a fracture. This will enable the physicians to take a course of action without having to spend time on waiting for the results of the scan as well as save time while there might be an emergency patient in the emergency room. The need of one person to complete the entire scan and pass it through the algorithm is an added benefit of reducing manpower required for detection and diagnosis.

2. Literature

Ginneken et al (2010) [3] researched on “Comparing and combining algorithms for computer-aided detection of pulmonary nodules in computed tomography scans: The ANODE09 study”. Results show a substantial performance difference between algorithms, and demonstrate that combining the output of algorithms leads to marked performance improvements. Mixed reference standard, radiation dose, image quality, outdated CTA protocol due to long study period.

Adams et al (2012) [4] conducted a study on the “Fractures of the coronoid: morphology based upon computer tomography scanning”. Anatomic patterns by which coronoid fractures break. Five common patterns were noted: a “tip” type fracture seen in 29% of the cases; a “mid-transverse” type fracture (24%); a “basal” type fracture (23%); and 2 “oblique” type fracture patterns (24%), including an “anteromedial” type fracture (17%) and an

“anterolateral” type (7%). Retrospective nature and its inherent selection and spectrum bias. Fractures included in this series were limited to those in which a CT scan was obtained.

Lee et al (1988) [5] worked on “Occult intraosseous fracture: detection with MR imaging”. Magnetic resonance (MR) images were retrospectively evaluated in eight patients who had recent, symptomatic knee injuries and in whom plain radiographs showed no fractures. T2-weighted images revealed irregular, intraosseous areas of high signal intensity; T1-weighted and proton density images revealed speckled or linear regions of low signal intensity in corresponding areas. In the seven patients abnormalities occurred in subchondral locations. Two patients underwent bone scintigraphy, which showed increased activity in locations corresponding to areas of abnormality noted on MR images. Two patients underwent follow-up MR imaging which showed complete resolution of the abnormalities. The authors speculate that the MR imaging findings represent microscopic compression fracture of trabecular bone and discuss the related entity, stress fracture.

Dimililer et al; (2017), [9] “*IBFDS: Intelligent bone fracture detection system*”. The paper uses a system comprising of image processing for detection of shapes and a backpropagation neural network to detect bone fractures in X-ray images. The proposed method makes use of Rotational Haar Wavelet Transforms (RHWT) and the Scale Invariant Feature Transform (SIFT) algorithm

There are several ways of approaching the problem. After studying literature, we came across several algorithms we could use. The main steps included pre-processing the image and feature extraction. Gaussian and Salt and Pepper Noise is frequently used for pre-processing. After estimating the amount of noise corruption from the noise corrupted image, the center pixel by the mean value of the sum of the surrounding pixels is replaced based on a threshold value. It is handled using an extension of the K-fill algorithm, which depends on computing the ratio of black or white pixels in an $n \times n$ window. Segmentation of the image based on color, intensity etc. is an integral step for processing the image. Feature extraction using Gray-Level Co-occurrence Matrix, Wavelet transform, Scale-Invariant Feature Transform (SIFT) Algorithm, Speed UP Robust Feature (SURF) Algorithm, Edge detection, Corner detection, Contour extraction, Texture detection and Parallel edge detection have commonly been used for problems involving image processing. A commonly used algorithm is the back-propagation algorithm. It uses two conventional 3-layer back propagation neural networks (BPNN) with 1024 input neurons. Output neurons classify the bone using binary coding: [1 0] for the bone with fracture, and [0 1] for the bone without fracture. The sigmoid activation function is used for activating neurons in the hidden and the output layers.

3. Proposed Methodology

This proposed method includes the use of Canny edge detection, SURF features extraction and classification by a neural network. The Canny algorithm is used to detect the edges in the image and thus give an idea of the region of interest in the scan that needs to be focused on. The SURF algorithm finds interest points that are scale and orientation invariant and uses box filters and integral images for faster computation. Select features are extracted and passed to a neural network to train and test to determine if the image contains a fracture or not.

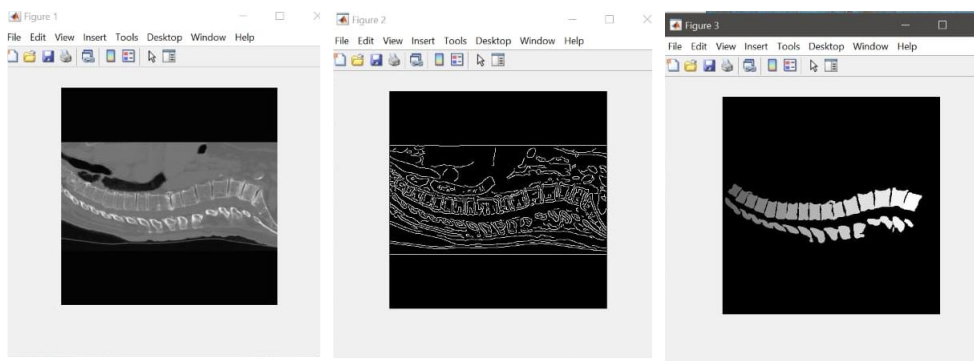
Dataset: CT bone dataset from Verse19 was used. We used 60 scans from the dataset and created a subset for the network.

3.1 Canny

The Canny edge detection algorithm searches through all the pixels and finds those with the maximum gradient intensity. It is implemented using the MATLAB function `edge`.

- The algorithm was used to identify the main portion of the slice to extract features from.
- The distance between extremes was calculated to get an estimate on how much of the image contained useful data. The region was divided into two parts with the most features collected from the center and the least from the extremes.

Figure 1a shows the images before and after Canny edge detection was performed while 1b shows a segmented image provided with the dataset



Before and after Edge Detection

Fig. 1. Canny edge detection

3.2 SURF

The algorithm consists of feature extraction and feature detection by using interest points, matrix approximation and orientation matching. It has a relatively short time complexity compared to other similar algorithms and is hence widely used. The surf algorithm was used as a method to extract features from the CT scan images. After the features were extracted, the strongest features were selected for use. These features were categorized and mapped to the presence of a fracture or not as provided with the dataset. A few other features were also used such as age, bone mineral density etc. which were provided with the dataset.

The MATLAB functions used are

- *detectSURFFeatures*- this is used to detect the feature descriptors and locations of the features
- *selectStrongest*- helps to select the features with the highest metrics or strongest matches
- *extractFeatures*- which is used to extract the feature descriptors

The extracted points obtained by the SURF algorithm from both sides of the centre are displayed in Figure 2.

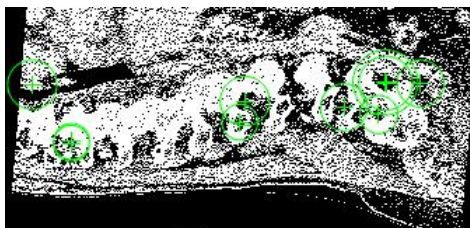
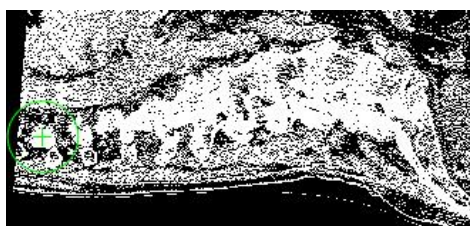


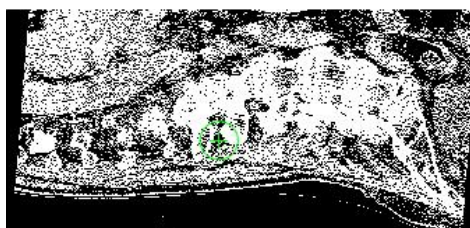
Fig 2: a) Detection of points from side A



b) Detection of points from side B



c) Detection of strongest points



a. Neural network

A neural network is used to recognize relationships between the target and inputs and make conclusions for unknown data based on the relationship identified.

We used the built-in neural network tool in MATLAB to create a network and train it. The inputs and targets were supplied based on the feature extraction previously obtained. The dataset is divided into a training, validation and test set. The tool provides the performance characteristics and error percentage

MATLAB nprtool for neural network training and testing shown in Figure 3.

Results			
	Samples	CE	%E
Training:	45	4.36715e-1	27.7777e-1
Validation:	9	7.56496e-1	16.66666e-1
Testing:	6	7.88550e-1	16.66666e-1

Plot Confusion

Plot ROC

Results			
	Samples	CE	%E
Training:	51	1.95484e-1	1.96078e-1
Validation:	3	1.06391e-0	33.33333e-1
Testing:	6	1.03245e-0	16.66666e-1

Plot Confusion

Plot ROC

Training with different number of neurons

Fig. 3. Training with neurons using inbuilt MATLAB functions

4. Results and Discussions

The aim of the network was to correctly identify the presence of a fracture in the scan. For a dataset of 60 scans, 80% were used for training and 5% for testing. This resulted in a 6.7% error for the overall network. The training resulted in a 4.2% error. This shows that the SURF algorithm has the potential to be used for detection systems such as this but requires more processing and filtering to achieve accuracy required for real life implementation.

Figure 4 (a)-(d) shows the confusion matrix, performance graph, receiver operating characteristics and error histogram obtained.

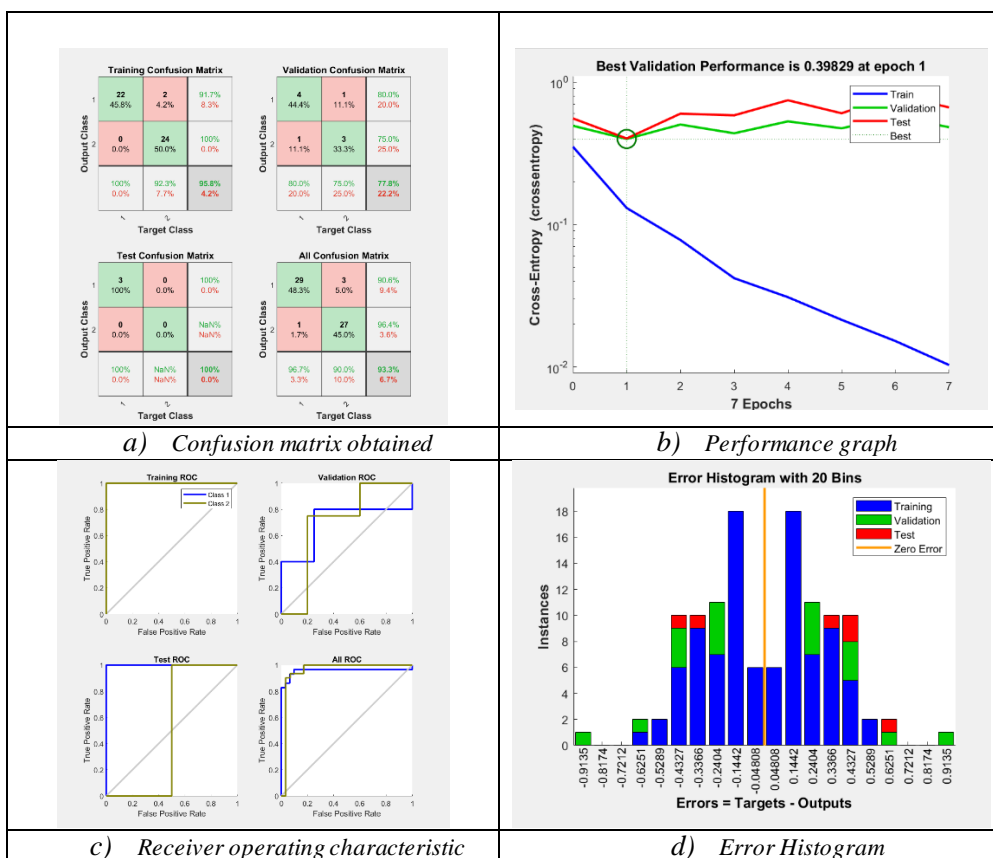


Fig. 4. Results obtained

5. Conclusion

Using 60 CT scans of patients of various ages with spinal fracture we have trained the algorithm to predict whether there is a fracture or not. This algorithm has a minimum efficiency of 73.3%. The achieved efficiency can be improved upon by training the algorithm with more data and changing various parameters so as to ensure higher accuracy and true positives.

6. Further Work to Be Done

This work is not complete and has many features that can be improved on. Filtering the data using wavelet transforms can remove excess noise and give higher accuracy. Instead of SURF, other algorithms like SIFT are also available to extract features, so depending on the data, the algorithm which yields the highest accuracy should be taken into consideration. Future scope of the project includes interfacing with a GUI and image processing to view exactly where the fractures are and to view the extent of damage. The type of fracture can also be detected with further classification and training of the model. Using predictive analysis and available data such as vitamin d levels etc. can be used to identify potentially weak or prone areas in which the probability of a fracture is higher. This helps narrow down the search radius.

7. Declaration of Conflict of Interest

The Authors declare that there is no conflict of interest.

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Cardiac Arrhythmia and Abnormality Indicator

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Abstract. Cardiac arrhythmia is a global health problem and causes 15–20 % of all deaths and Atrial fibrillation (AF) is the most common arrhythmia. Development of arrhythmia indicator in past two decades are advanced mostly around high income countries. But the same has not been implemented in low income countries, especially in low resource clinics in the rural context. The existing ECG system are costly and training is needed to use them. This demands a cost effective yet efficient device for the diagnosis and analysis of heart condition and prediction of arrhythmia. This will allow people to access this test at home and thus reduce number of hospital visits. Since the device gives prediction on heart condition, finding any abnormality user can contact a doctor without much delay. Software implementation is done in LabVIEW software for continuous monitoring and ECG analysis. For this paper, ECG signals are collected from Physionet. This signal has been filtered, analyzed and ECG features are extracted with the help of LabVIEW Biomedical toolkit.

Keywords. LabVIEW Biomedical Toolkit, ECG acquisition, Wavelet denoise, Feature extraction, Arrhythmia detection.

1. Introduction

Worldwide, sudden and unexpected cardiac death is the most common cause of death, accounting for 17 million deaths every year with SCD (sudden cardiac deaths) accounting for 25 % of these. Cardiac diseases including heart failure and cardiac arrhythmias are main factor for non-communicable disease burden mostly in India. For the study of cardiac functioning and interpreting cardiac abnormalities rhythm irregularity, valvular heart disease, cardiomyopathy, pericarditis, and hypertensive disease, ECG is the most important test. ECG signals useful not only in heart illness diagnosis but also in ECG signal processing research. Now a days ECG is used to monitor the drug treatment and to detect electrolyte imbalance. Arrhythmia is abnormal condition of the heart revealing sudden inclined or declined towards efficiency and rhythm of SA node to consistently conduct electrical impulses are needed to pump the heart normally. Cardiac arrhythmia are the lead cause of cardiovascular diseases and its diagnosis and treatment depends on electrocardiogram signals. ECG at rest is different from the ECG tested during or after exercise or if person is in stress then also there is change in ECG readings.

2. Background of the project

ECG estimates the variation in the potential across the electrodes placed on body and they are recorded and transformed into waveforms after filtering and amplification. ECG pattern is a combination of P wave, T wave & QRS complex and their intervals and segments. ECG analysis depends upon P wave, QRS and T wave parameters.

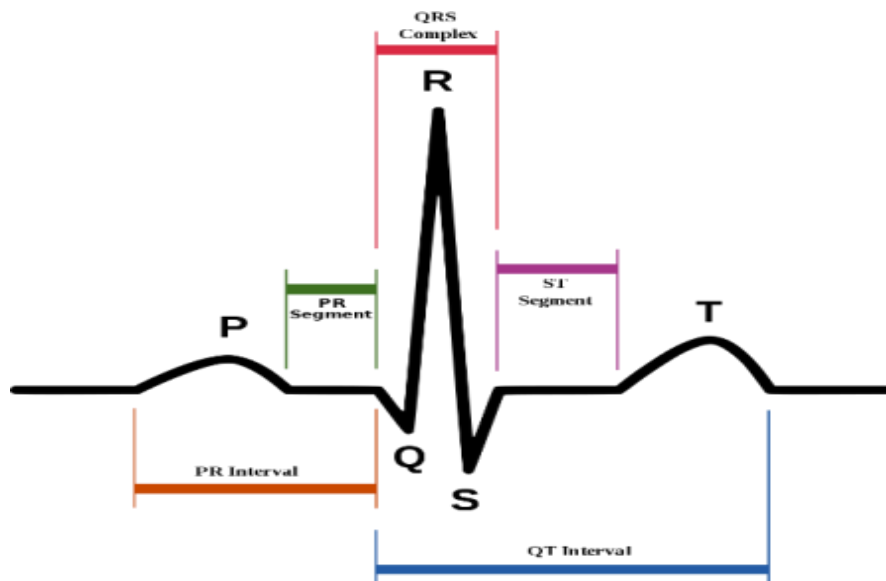


Fig. 1. Normal ECG waveform (source: Wikipedia)

Table 1. Normal ECG Parameters

Waveform and segments	Duration	Amplitude
P wave	0.006-0.12	<0.25
QRS complex	<0.12	0.8-1.2
T wave	0.16	<0.5
ST Segment	0.12	
PR interval	0.12-0.20	
PR Segment	0.08	
QT segment	0.36-0.44	

ECG tracing of the cardiac cycle (heartbeat) consists of a P wave which represents atrial depolarization, a QRS complex for ventricular depolarization, and a T wave indicating ventricular repolarization. An additional wave, the U wave for Purkinje repolarization, not always visible. Proper ECG analysis depends on the accurate detection of these five waves only and by comparing the observed parameters with the normal range we can derive at a decision on the abnormal heart condition. To analyse an ECG signal, proper detection of the QRS complex is very important. The normal heart rate range lies between 60 and 100 beats per minute, it is necessary to find the successive R-R interval for calculating the heart rate, the equation is:

$$\text{Heart rate} = 60 * \text{R-R Interval}$$

Inferences from an ECG signal:

- When all normal waveform of an ECG signal are missing, it represents Ventricular fibrillation
- P wave sudden increase or decrease represents issues related to potassium ion balance in body which in turn alter the nerve activities.
- A missing or irregular P wave represents chance for atrial fibrillation
- The ST complex is usually elevated during a myocardial infarction.
- Heart rate lesser than 60 beats/min represents bradycardia & above 100 beats/ min is a fast heart rate and it is called as tachycardia.
- If the P-R interval is greater than 0.2 seconds, blockage of the AV node.
- In QRS complex duration is more than normal, it is hyperkalemia or bundle branch block.
- The QRS wave amplitude is increased more than normal, then it will be indicating cardiac hypertrophy.

In the proposed system abnormalities analysis is done by developing a real time detection system based on LabVIEW (Laboratory Virtual Instrument Engineering Workbench software approach). A contaminated ECG signal will be giving a false indication. So de-noising and feature extraction is an important requirement. The proposed method enables the display of heart rates and various parameters of ECG signal, i.e, the P wave, PR interval, PR segment, QRS complex, and QT interval. The system code is designed like it will give the notification of any cardiac abnormality, ie, the affected ECG wave, segment, or interval with the help of LED and GUI display in LabVIEW. Through this system, user can do check up by their own and know about the health of one's heart, even before consulting the doctor. This paper do the software implementation where the data is collected from Physionet database and is read in NI LabVIEW. This paper explains how we can use LabVIEW to acquire a recorded ECG signals and then how to extract the important ECG features with the help of Biomedical Toolkit, which allows an efficient ECG feature extraction.

3. Objectives

- Develop code in LabVIEW software for ECG analysis and feature extraction
- To avoid false indication of arrhythmia
- Removal of signal noises from the raw ECG signal
- Feature extraction of ECG
- Detect cardiac abnormalities from extracted features and indication using LEDs

4. Design and Implementation

Initially, a previously recorded ECG signal or data collected from Physionet database is acquired, followed by filtering of theses signal in order to filter out the unwanted noises. The next step is to extract the features from signal inputted and the final phase is analysing the extracted signal for indication if there is a negative health condition noticed.

4.1 Acquiring an ECG Signal in LabVIEW

In the first step, ECG Signals are acquired from database and inputted to LabVIEW by 'Read Biosignal VI' where we need to specify the file path. The acquired raw ECG signals in LabVIEW is displayed in the front panel.

4.2 Filtering and de-noising the acquired ECG signal:

ECG waveform is contaminated with different artefact including powerline interference, baseline wandering, motion artefacts etc. Using this raw signal without filtering will give a false indication about the heart condition. Artefact due to low frequency noise occurred from patient body movement including individual's respiration is called Baseline wander which can cause inaccuracy in detecting the R-peaks. In order to remove these kinds of noise "Wavelet Denoise VI" is used, so that the wideband noise is filtered out and also eliminates the trend of the ECG signal which is necessary for a proper analysis. For removing baseline wander and other noises from the raw ECG signal, 'WA detrend VI' is used, which implements the method of checking a soft thresholding, wavelet selected is db06 which is similar to ECG signal, and transform type used here is Undecimated Wavelet Transform (UWT).

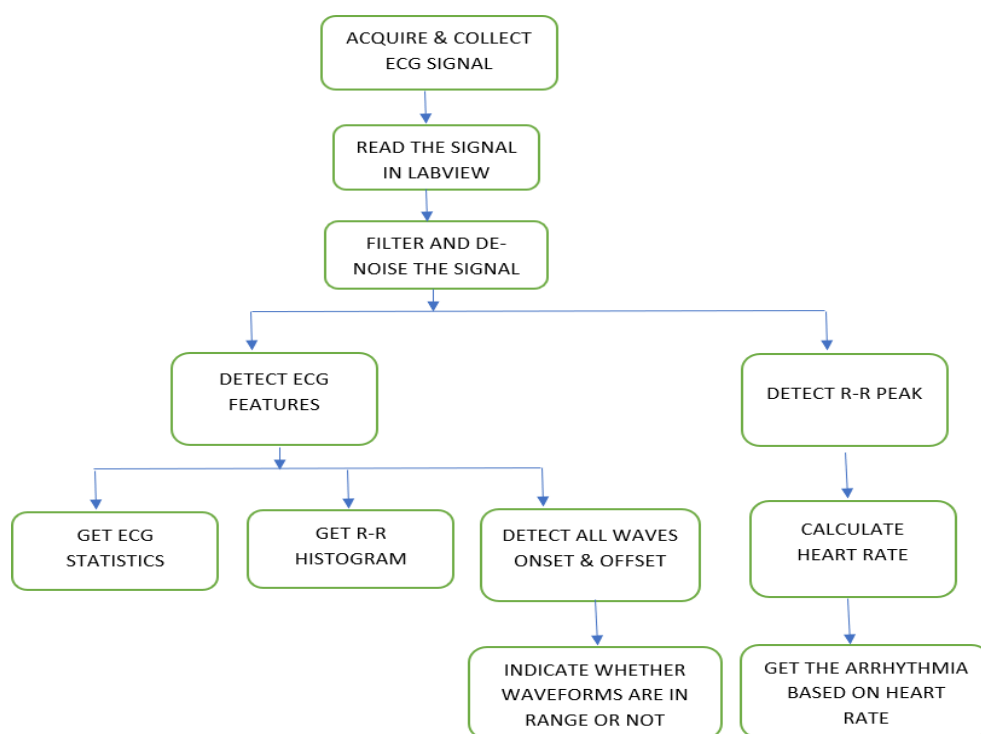


Fig 2. Flow diagram of ECG analysis

4.3 Detecting Peaks and ECG Features

Herein, 'ECG feature extractor VI' from biomedical Toolkit is used to extract ECG feature within the while loop by creating array of features. From the features R-R interval is chosen and mathematical calculation is done to get heart rate and its status whether it is normal or suffering from tachycardia or bradycardia using some more VI's and WA Multi Peak detection.vi is used to detect peak amplitude and display the same in the front panel.

Table 2. Heart conditions based on BPM

Heart condition	Beats per minute (BPM)
Normal	60-100
Bradycardia	0-60
Tachycardia	>100
Supra ventricular tachycardia	140-240
Atrial flutter	160-180
Ventricular tachycardia	120-200
Heart block	20-40

HRV statistics includes finding the Normal sinus at successive interval of 50 ms denoted as NN50. pNN50 measure the HRV score. From this HRV score analysis researchers can analyse the Autonomic nervous system and parasympathetic branch activity. R-R histogram is done for the study of cardiac rhythm which quantitate the response of heart. WA Multiscale Peak Detection.vi is used to detect the R-Peaks, location and amplitude and the detected R- peaks shown in the front panel. From the array to cluster block and unbundle block, each ECG features and their onset and offset values are obtained and using comparisons it is determine whether the waveform, intervals, segment are in range or not accordingly connected to LEDs for displaying the condition in the front panel.

Table 3. prediction based on the ECG analysis

Heart Condition	Prediction?!
QRS Complex duration is more than normal	Hypercalcemia
Prolonged QT Segment	Drug Toxicity
Prolonged PR interval	First degree AV block
R-R <0.12s and prolonged QRS	Wolf-Parkinson's white syndrome

5 . Procedure for developing LabVIEW Code

5.1 Open LABVIEW 2020 and create new VI

5.2 Read ECG signal: Click on Read biosignal express VI and in the Configure Read Biosignal dialog box add the file path that contains ECG signal and click OK. Use while loop to display signal continuously.

5.3 Filtering of ECG signal: Use wavelet denoise and WA Detrend VI from Biomedical Toolkit for filter out wideband noise and baseline wandering

5.4 Use ECG feature extractor VI from biomedical Toolkit and extract ECG feature

5.5 Use array to cluster block and unbundle by name block to get each ECG

features

5.6 Apply condition of normal ECG parameters so as to determine whether the waveform, intervals, segment are in range or not.

5.7 Find heart rate from R-R interval: Determine heart rate per minute by dividing R-R interval by 60 and display heart rate as integer

5.8 Apply condition to determine various heart abnormalities based on heart rate

5.9 Apply conditions for prediction the heart conditions

5.10 Get HRV statistics and R-R Histogram

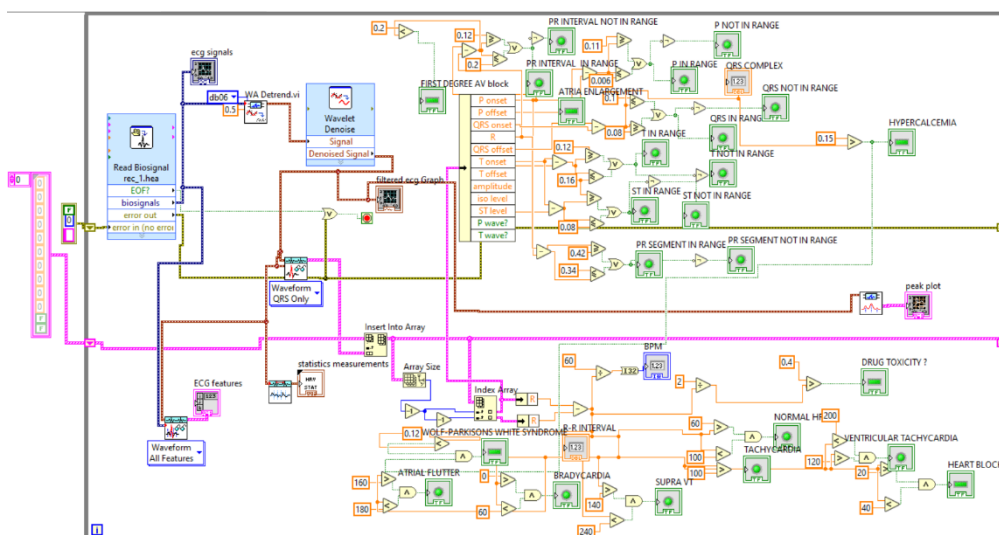


Fig 3. block diagram of the proposed system

6 .Future works

There are several lines of add-ons arising from this work which should be pursued. In the future, we can include more diseases related to the wave structure in the system. We can also use AI algorithms to make this system much better for further processing using LabVIEW along with MATLAB. It is also possible to acquire respiratory rate from ECG signal and find out respiratory abnormalities. Designing this system with data logging functionality could be critical in getting an accurate picture of the physical state of the patient and for further reference for the user and Doctor.

7 . Results and Conclusion

In the scenario where the number of cardiac patients is increasing on a daily basis and heart-related diseases are numerous, proper diagnosis and disease management become crucial. This demands a cost-effective yet efficient device for the diagnosis and analysis of heart condition and prediction of arrhythmia which allow people to access this test for regular check-up at home safely without much training. ECG being the most prominent approach for detecting diseases related to the heart, analysis of ECG signal and maximum possible prediction conducted in this paper. In order to avoid faulty diagnosis of abnormalities, it is important to remove noises and artifacts from ECG signal.

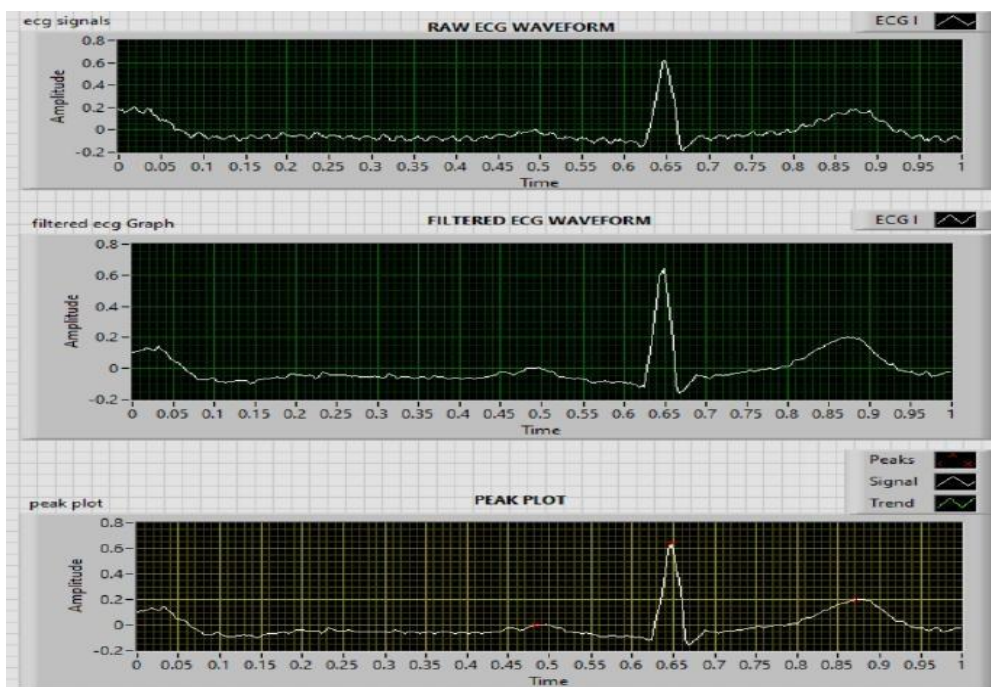


Fig 4. Plot of raw ECG, denoised ECG signal and its peak plot

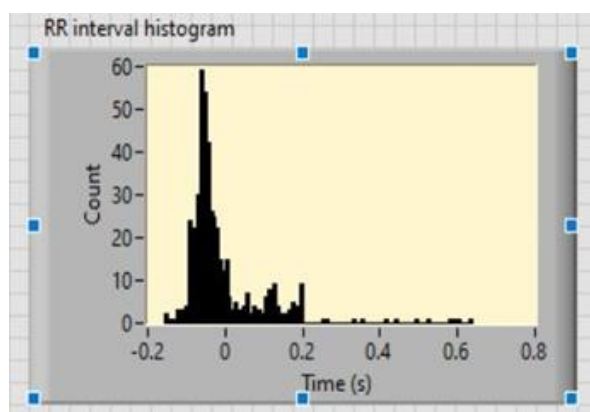


Fig 5. Plot of R-R Histogram

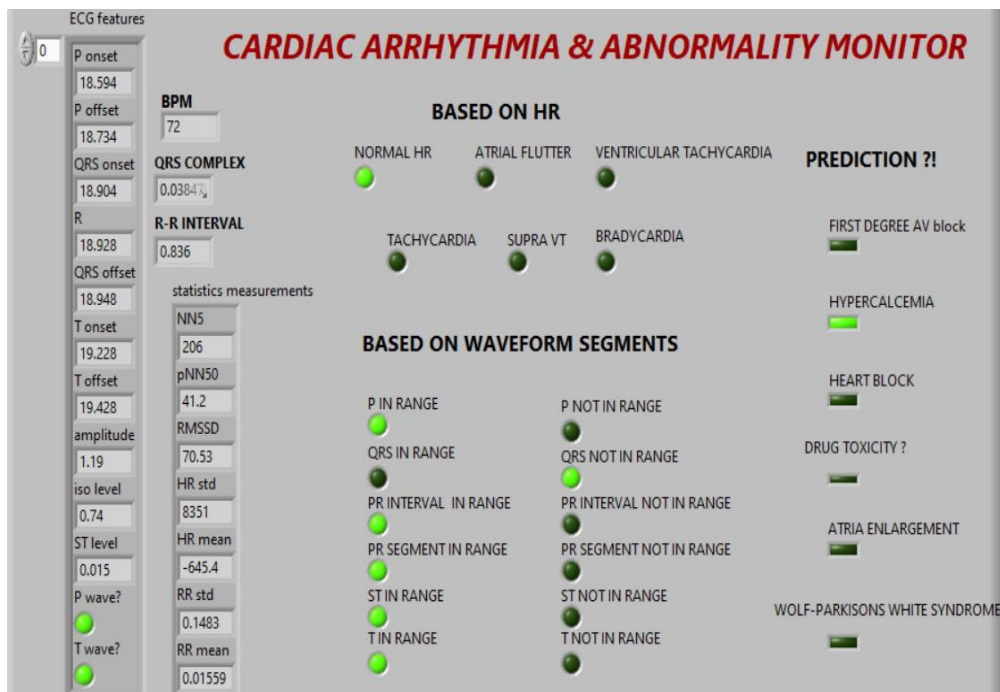


Fig 6. Cardiac arrhythmia and abnormality monitor

This LABVIEW based approach proposes an effective way allowing improved denoising process and to determine abnormalities from ECG signal. After denoising, heart rate along with other features of the ECG signal, such as R-peaks, P onset-offset, PR interval, PR segment, QRS complex, ST segment, QT interval, and T wave. The system will display the HRV statistics of various parameters. Then by applying the conditions and various parameter ranges several conditions are predicted and indication is displayed on the front panel by LEDs. Anyone can use proposed system to evaluate their heart status, even before consulting a doctor.

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Chest and Lung Cancer Detection from PET scan Images Using CNN and Deep Learning

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Abstract. The paper builds a CNN model for detecting the presence of cancer in lungs. Deaths from pulmonary diseases are frequently increasing in this day to day life and one of the main reasons for this is the pulmonary cancer or lung carcinoma. Through PET scans, positron emission tomography, pulmonary cancer can be detected at a very first stage in order to save life of thousands of people since there is a rapid increase of deaths due to pulmonary cancers according to the recent statistics. Again the increased work load for the doctors and other medical stuffs make them suffer from observer fatigue which reduces work efficiency. So to tackle the situation a model can be developed for detecting the early stage cancer from PET scan images. In this paper, we propose a method of detecting lung cancer in a PET scan using deep learning concepts. Finally the result is evaluated using Boolean logic for detecting whether there is any cancerous cell or not through single prediction technique. We reach 97% accuracy after training this model by convolution neural network. The proposed method sums up the concept of deep convolution neural network and statistical analysis for predicting early stage of lung cancer and segregating benign from malignant nodules.

Keywords. Neural network, Deep learning, Pulmonary, carcinoma, PET, convolution, malignant.

1. Introduction

An enormous number of deaths are being reported in favor of lung carcinoma or lung cancer. In fact the highest number of deaths related to pulmonary disease is lung cancer. Lung cancer can be detected using several techniques. One of the early detection methods is PET scan. This PET scan images can be used for further analysis through cancer at an early stage can be detected.

Lung cancer is one of the deadliest diseases found among the pulmonary diseases. Around 125,000 deaths occur annually due to this deadly disease. Over \$12 billion are spent in medical and healthcare in USA for reducing the number of affected people and thereby detecting the people at an early stage [1]. There are several stages of lung cancer. Generally cancer detected at stage 1 and 2 are localized to that specific organ i.e. only to the lung region, but further stages refers that the other organs are also been affected for the cancer. That's why diagnostic procedures like biopsies, PET scan [2]. Early recognition of cancer detection in the lungs (detection during the previous stages) fundamentally improves the odds for endurance; however it is likewise harder to recognize beginning phases of cancer in the lungs as there are fewer side effects. Results show that solitary 68% of the time cancer in the lungs nodules is effectively analyzed when just a single radiologist inspects, and are precisely identified up to 82% of the time with two radiologists. The discovery of harmful lung nodules at a beginning

phase is an exceptionally troublesome, dreary, and tedious errand for radiologists. Screening a ton of outputs with care requires a lot of time by the radiologist, and then it is a lot of blunder inclined in the discovery of tiny nodules [9]. Our main task is the binary classification of the dataset that we have collected from different sources. The deep convolution neural network is being used for classification of the images. [3] Deaths due to lung cancer can be reduced to some extent annually if detected at an early stage through PET scans. The goal is to construct a computer-aided diagnosis (CAD) [5] system that takes as input patient chest PET scans and outputs whether or not the patient has lung cancer. For detecting whether a patient is having lung cancer or not one has to go through the CAD so as to initiate the early stage detection of the cancer and thereby preventing the threats to deaths (< 10 mm in diameter for early stage cancers) [4]. In this generation of statistical and graphical analysis with a vast application of the data science, neural network plays a key role in detecting the early stage of cancer from the PET scan image. Nowadays several powerful models can be made for separation of cancerous cell and normal cell through AI application [8]. Efficient treatment to the cancer patients can be given after early detection of cancerous cell.

In this paper, we propose a method of detecting lung cancer in a PET scan using deep learning concepts. Finally the result is evaluated using Boolean logic for detecting whether there is any cancerous cell or not through single prediction technique. We reach 97% accuracy after training this model by convolution neural network. The proposed method integrates deep convolutional neural networks (DCNN) and other statistical and machine learning techniques to characterize early-stage lung cancer and distinguish benign from malignant nodules. To visualize the behavior of the deep neural network, the attention mechanism [6] was integrated to the DCNN.

2. Dataset Analysis

Our dataset is taken from Kaggle Data Science to classify the cancer and to detect if lung nodules in the PET/CT scans are malignant i.e. cancerous. This dataset has two stages but only first stage is used in this study. This stage 1 data contains almost 465 CT scans images. This dataset contains the labels of benign and malignant forms of tissues. Labels are used to classify the cancer. Further the dataset is collected from different sites for increasing the accuracy of the prediction. The classification of cancerous cell is done in a better way using convolution neural network using the dataset.

3. Deep Learning Architectures

Convolution Neural Network is one of the finest methods for classification of images in a lower level. It is commonly known as CNN and ConvNet. It contains a series of different layers. Here Convolution layer and pooling layer are there for feature extraction and finding the best possible features from a particular image. There are two types of pooling layer, one is the max pooling layer and another is the average pooling layer. Max pooling layer is significantly used for research purpose. For determining the output of neural network, activation function is used. The most common activation function ReLu (Rectified Linear Unit) is used which keeps the positive values and turns the negative values into zero.

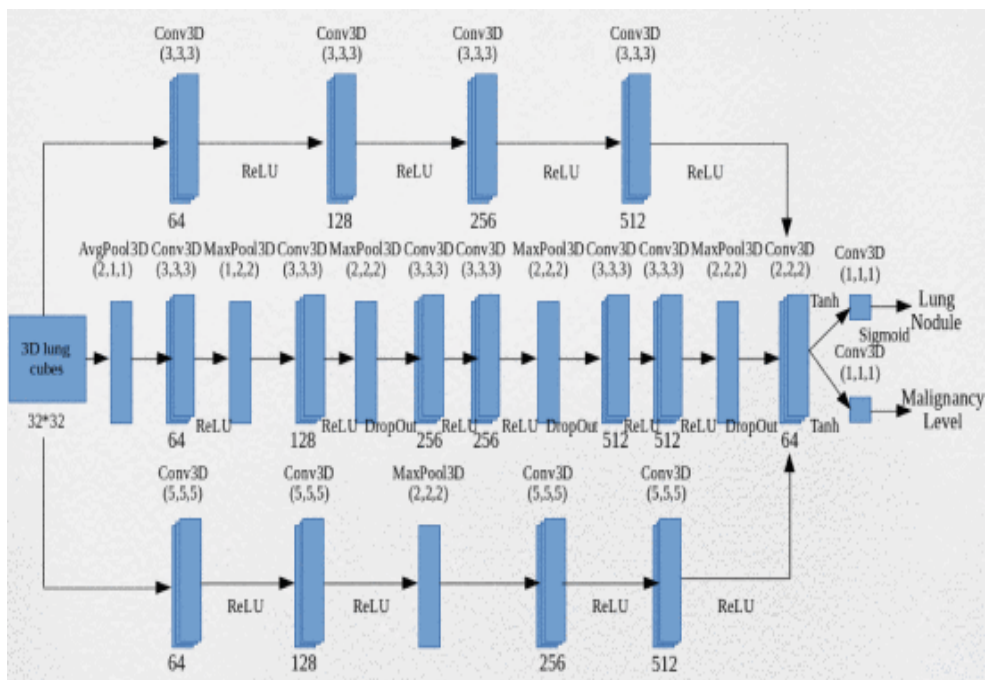


Fig. 1. CNN Model

4. Working Methodology

In the first stage, lung regions are extracted from PET image and in that region each slices are segmented to get tumors. The segmented tumor regions are used to train CNN architecture. Then, CNN is used to test the patient images. The main objective of this study is to detect whether the tumor present in a patient's lung is malignant or benign. The whole code is made in jupyter notebook by using python as a main programming language. Python libraries like tensor flow and keras are being installed for the training the mode in the jupyter notebook. First the literature survey is done of almost 20 current research papers for understanding the logic behind the whole problem. The dataset is collected from the Kaggle official website and also various datasets are referred from MIT database. A series of steps were followed to reach the accuracy of predicting cancer and normal lung conditions.

a. Preprocessing the Dataset

The preprocessing stage involves the median filter to re-construct the dataset image given as input by reducing the impacts of unwanted signals and noises produced during the acquisition. Different preprocessing and segmenting methods of lung nodes are examined in [6]. The median filters essentially replaces every pixels with the middle estimation of its neighbors including its own value. This preprocessing stage of both the training set and the test set is done in the jupyter notebook and determined capacities are utilized for that. Almost 343 images are specifically selected for training set and for the test case set almost 112 images of PET scans are selected.

i. Preprocessing the Training Set

In this step, we rescale the images by plunging the pixel values by 255 to get the scope of the pixels somewhere in the range of 0 and 1. Shear range and zoom range are set to 0.2 to haphazardly shear and zoom a portion of the image. Additionally some of the images are horizontally flipped to get better arrangement results. All the images size are decreased to 64 x 64 to decline the training time and in each cluster 32 images are given as input. The class mode is set to binary as we need to train the images into two sets, one set containing the typical lung condition pictures and the other set containing cancerous lung condition pictures.

```
train_datagen = ImageDataGenerator(rescale = 1./255,  
                                   shear_range = 0.2,  
                                   zoom_range = 0.2,  
                                   horizontal_flip = True)  
training_set = train_datagen.flow_from_directory('dataset/training_set',  
                                                target_size = (64, 64),  
                                                batch_size = 32,  
                                                class_mode = 'binary')
```

Found 343 images belonging to 2 classes.

Fig. 2. Code for preprocessing the training set

Training set sample images:

A. Cancer infected Lungs images



B. Normal Lungs images



ii. Preprocessing the Test Set

Similar to the training set preprocessing step, here also we rescale the images by dividing the pixel values by 255 to get the scope of the pixels somewhere in the range of 0 and 1. Shear range and zoom range are set to 0.2 to haphazardly shear and zoom a portion of the image. Additionally some of the images are horizontally flipped to get better arrangement results. All the images size are decreased to 64 x 64 to decline the model training time and in each cluster 32 images are given as input. The class mode is set to binary as we need to train the images into two sets, one set containing the typical lung condition pictures and the other set containing cancerous lung condition pictures.

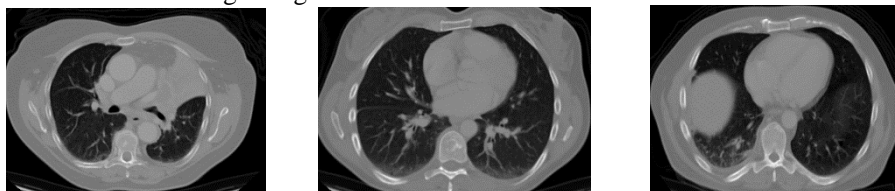
```
test_datagen = ImageDataGenerator(rescale = 1./255)
test_set = test_datagen.flow_from_directory('dataset/test_set',
                                           target_size = (64, 64),
                                           batch_size = 32,
                                           class_mode = 'binary')
```

Found 112 images belonging to 2 classes.

Fig. 3. Code for preprocessing the test set

Test set sample images:

A. Cancer infected Lungs images



B. Normal Lungs images



b. Building the Convolution Neural Networks (CNNs)

A CNN is kind of a deep neural network which comprises of different concealed layers, for example, convolutional layer, RELU layer, pooling layer and fully connected standardized layer. CNN shares loads in the convolutional layer decreasing the memory usage and also increases the network performance. The significant highlights of CNN lie with the 3D volumes of neurons, neighborhood connectivity and shared loads. The convolution and flattening is done alongside a second layer of convolution. The PIL library is then imported for images manipulation and after that the CNN model is compiled. A progression of steps are followed to fabricate a decent CNN model.

i. Performing Convolution of the layers

The feature map is delivered by convolution layer which convolves various sub regions of the dataset images using the kernel. At this point, ReLu layer which is a non-linear activation function is utilized to enhance the combination properties when there is low error. The kernel size is set to 3 to make a 3 x 3 matrix for convolving.

```
cnn.add(tf.keras.layers.Conv2D(filters=32, kernel_size=3, activation='relu', input_shape=[64, 64, 3]))
```

Fig. 4. Convolving the layers using ReLU as activation layer

ii. Pooling the layer

An area of the image/highlight map is picked in the pooling layer and then the greatest valued pixel is chosen from them which is then utilized as the agent pixel so that a 2 x 2 or 3 x 3 matrix can be obtained which will diminish the multi column vector to a single column vector. This causes a huge reduction in the example size.

```
cnn.add(tf.keras.layers.MaxPool2D(pool_size=2, strides=2))
```

Fig. 5. Performing pooling to reduce the size

iii. Adding second convolution and pooling layers

The convolution and the pooling of layers are done again to obtain better accuracy as it will significantly decrease the size of image and more distinguishing features will be taken into account.

```
cnn.add(tf.keras.layers.Conv2D(filters=32, kernel_size=3, activation='relu'))  
cnn.add(tf.keras.layers.MaxPool2D(pool_size=2, strides=2))
```

Fig. 6. Performing convolution and pooling for second time

iv. Flattening, making full connection and output layer

The outcomes of the past layers are taken as input to the fully connected layer which then flattens the images by transforming the matrix into a single scalar vector matrix which can then be obtained as input for further stages. The feature analysis outcome of the images serves as the input to the first fully connected network which then applies loads to foresee the right result. The last stage prediction analysis for each of the layers is given as the output by the fully connected output layer.

```
cnn.add(tf.keras.layers.Flatten())
```

```
cnn.add(tf.keras.layers.Dense(units=128, activation='relu'))
```

```
cnn.add(tf.keras.layers.Dense(units=1, activation='sigmoid'))
```

Fig. 7. Flattening, making full connection and getting output layer

c. Training and compiling the CNN model

The ConvNet model is formed by assembling and utilizing the Convolutional Layer, Pooling Layer, and fully connected Layer. The values of the pixels obtained from fed-in input image is utilized as the information and the yield of neurons that are associated with neighborhood districts in the input is processed by the CONV layer. After this around 30-40 epochs are selected for training the CNN model which will then give the evaluated prediction acquired by feeding in the training and test set images to the model.

```
: cnn.compile(optimizer = 'adam', loss = 'binary_crossentropy', metrics = ['accuracy'])  
  
: cnn.fit(x = training_set, validation_data = test_set, epochs = 30)
```

Fig. 8. Training the CNN model.

After training of the model is finished, the accuracy of prediction obtained by our model was around 97%. The prediction accuracy started from 70% and gradually reached 97% at the end of 30 epochs.

d. Making Single Prediction

A sample image has been fed as an input to our model and at this stage the model can tell the presence of malignant growth in the sample image of a cellular breakdown in the lungs. This process includes taking the input image to the model, which then undergoes preprocessing, feature extraction, recognizing the malignant growth spot and demonstrate the outcomes to the client. If there is any presence of malignant growth, we print cancer and otherwise normal is printed. For checking the accuracy of our model more precisely, a separate dataset is created for predicting a single data whether it is carcinoma or a normal image.

```
import numpy as np  
from keras.preprocessing import image  
test_image = image.load_img('dataset/single_prediction/normal (2).png', target_size = (64, 64))  
test_image = image.img_to_array(test_image)  
test_image = np.expand_dims(test_image, axis = 0)  
result = cnn.predict(test_image)  
training_set.class_indices  
if result[0][0] == 1:  
    prediction = 'normal'  
else:  
    prediction = 'cancer'
```

Fig. 9. Code for making a single prediction.

When a normal lung condition image is given as input to our model, we can see that it correctly identifies it as a normal lung condition image. It was also seen that the model never detects a normal lung image as a cancerous one which is a very good indicative as it won't cause any false implications to the users.



```
print(prediction)
```

normal

Fig. 10. Normal Lung condition image and output given by the model

Next when a cancerous lung condition image is given as input to the model, we can see that the model prints cancer. After feeding in many cancerous image to our model, we came to a conclusion that our model detects 9 images as lung cancer images out of 10 lung cancer images given as input to our model.



```
print(prediction)
```

cancer

Fig. 11. Cancer Lung condition image and output given by the model

5. Conclusion

It has been seen that the lung cancer has been one of the major causes of deaths in recent times which occurs mainly due to lack of early cancer diagnosis. So here in this paper we attempted to develop a model utilizing the ideas of convolutional neural network of deep learning procedures for distinguishing cancerous tissue in lungs of human body from the normal tissues. Lung images with different alignments, shape and size of the cancerous tissues has been taken as input for training the model. The proposed framework can recognize the presence and absence of cancer tissues with precision of about 96%. The deep learning model characterizes neural networks by foreseeing sample image for both carcinomic and non-carcinomic PET scan images. This model is absolutely for self-judgment and expanding the effectiveness in the clinical fields and decreasing the work load for the medical staffs.

6. Future Prospects

1. The study depends on the robustness and accuracy of our binary classifier. For future work we planned to increase the robustness of our model by introducing data augmentation to the pre-processing pipeline. This project was basically built for lower work accounts with high accuracy. So for future perspective, since medical data comprises of thousands of images, we planned to apply data augmentation to make a more powerful model with high accuracy.

2. Further we planned to add drop out layers to increase the work efficiency of our model so as to predict the patient image with maximum accuracy.
3. The hyper parameters of the model can also be optimised to increase the efficiency of our current model.
4. Furthermore we planned to understand the working of our model by using powerful matrix such as f1 score, precession recall, ROC and AUC.

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Contemporary Trends in Diagnosis of Diabetic Foot Ulcers using Thermography

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Abstract. Diabetes Mellitus (DM) has afflicted more than 463 million people by 2019 and by 2030, this number is estimated to spike up to 700 million people. One of the consequences of suffering from DM is that in about 15% of the patients, ulceration occurs on the feet of the patient called Diabetic Foot Ulcer (DFU). If left untreated these ulcers could even require amputation to treat them. Early detection of these ulcers is essential in the diagnosis and treatment of diabetes. To this end a fast, non-invasive, non-irradiant technique would be required. In this paper we analyze the usage of thermography for early diagnosis of diabetic foot ulcers as it matches all the criteria we are looking for in a technique. It is based on detecting the infrared radiation from the feet and producing thermal images of this radiation which can be processed and used to diagnose ulcers in the feet early as ulcerative regions show spikes in temperature even prior to becoming prominent on the outer skin. A suitable methodology for detection is outlined and directions for future research is discussed

Keywords. Diabetic Foot Ulcers, Thermography, Computer Aided Diagnosis, Machine Learning, Image Processing.

1. Introduction

Diabetes mellitus (DM) is one among the major health problems in the world and has increased dramatically over the past 2 decades. The rise in sedentary lifestyles and unhealthy dietary habits are the foremost cause to the growing prevalence of DM worldwide. One of the major consequences of DM is ulceration in the legs (especially in the foot) known as Diabetic Foot Ulcers (DFU). They occur commonly and are a very expensive complication of diabetes. Around 20% of the overall health care expenditure on diabetes can be attributed to DFUs. This is often because, if it is left untreated, these ulcers get severely infected and can lead to needing to amputate the limb and in certain extreme cases, even death. DFUs are preventable through early diagnosis treatment of the signs of DFUs. However, early detection of DFUs would require frequent examination by medical professionals which isn't feasible for the patient or the medical industry because it is usually recommended that patients perform a daily foot examination and check for signs of skin complexion change, swelling, pain, and cuts or bruises. For people with diabetes, temperature changes on the plantar surface of the foot may be an early sign that an ulcer is developing. An increased temperature could also be present up to a week before a foot ulcer occurs. However, diabetes can damage the peripheral nerves with the result that the patient may experience an inability to feel temperature or pain in the foot. Consequently, an individual could also be unaware that their foot has become infected or ulcerated. Treatment of DFUs accounts for about one-third the overall cost of diabetic care. Early detection and treatment are vital for improving the long-term prognosis of those with

diabetes. Early detection of those hotspots will help in treatment and helps to avoid surgeries and amputations. This paper analyzes the current trends that are used in the analysis of thermal images and attempts to propose solutions to monitor temperature changes in thermal images of the patient's feet to detect and diagnose diabetic foot ulcers. The systems are built using MATLAB. Here, one of the proposed systems uses an Artificial Neural Network (ANN) to detect the hotspots, while the other uses a k-means clustering algorithm to do the same. The two techniques are devised, tested and analyzed in this paper. This paper is organized as follows. Section 2 focuses on theory, Section 3 focuses on the current trends used to diagnose Diabetic foot ulcers, Section 4 focuses on our proposed model, Section 5 focuses on the results that were obtained on testing our model and Section 6 focuses on conclusion.

2. Theory

Diabetic Foot Ulcers

Diabetes mellitus, commonly called diabetes, is a group of metabolic disorders characterized by a high glucose level over a chronic period of time. Diabetic foot ulcer is one among the most significant and devastating complications of diabetes, and is defined as a foot stricken by ulceration that's related to neuropathy and/or peripheral arterial disease of the lower limb in a very patient with diabetes and ulceration in diabetic feet is because of lack of protective sensation. They are the most common foot injuries leading to lower extremity amputation. Diabetic foot ulcers usually refer to open sores or wounds that are found in around 15% of all patients diagnosed with diabetes and is generally located on the underside of the foot with inflammation as a major symptom however it is common for patients to have had diabetic foot ulcers for some time before getting it checked because they're frequently painless. Hotspots (areas at least 2.2 °C hotter than the contralateral site) may indicate the areas of inflammation and Thermal imaging is a useful modality for identifying these hotspots in diabetic foot patients.

Thermography

Temperature analysis has been widely considered as a complementary method in medical evaluation and diagnosis. Monitoring temperature changes or variations of the feet of diabetic patients is essential for early detection of diabetic foot ulcers, and also in changing behaviors, which can contribute to reducing its incidence. Thermography is a non invasive test that uses an infrared camera to detect heat patterns and flow of blood in body tissues. Its principle relies on the physical phenomenon that any body of a temperature above absolute zero (-273.15 °C) emits electromagnetic radiation. There is a proven correlation between the surface of our bodies and the intensity and spectral composition of their emitted radiation. By determining its radiation intensity the temperature of an object can thereby be determined as a non-contact procedure. This strategy employs non-invasive testing of inflammation for acute as well as chronic care for the foot, with the intention to prevent ulceration/re-ulceration and subsequent traumatic amputations.

Image Processing

Image processing is a method to perform some operations on an image, so as to urge an enhanced image or to extract some useful information from it. It's a kind of signal processing technique in which input is an image and output may be image or characteristics/features related to that image. Image processing consists of the following three steps: Acquiring or importing images using image acquisition tools, analysing and manipulating the image, generation of output which is mostly an altered image or a report that's based on image analysis. We've performed and analysed digital image processing of thermal images in this paper.

3. Current Trends

In recent times, researchers have proposed various methods to diagnose diabetic foot ulcers. These are still in the research phase and are not commercially used yet. Some of these methods that were used in thermal images for extracting information and for classification are listed here and can be combined to create a novel and highly accurate method which can be commercially used. They can be broadly grouped into the following categories.

Segmentation

Segmentation is the first step in any image processing technique and is sometimes a part of preprocessing. It involves breaking the image into many smaller segments or pixels. It is used to extract the Region of Interest (ROI) from the image and the ROI consists of the desired segments and is further processed upon. Image segmentation typically works by detecting boundaries of objects. Here, segmentation is used to isolate and separate the feet from background noise and other undesirable regions. Various techniques or algorithms can be used for segmentation of thermal images.

Mendes et al. in [1] proposed a genetic algorithm for carotid shaped ROI extraction in breast thermograms. 8-bit equivalents were assigned based on intensities, weights were assigned and the fittest carotid was selected after 50 generations. AB Suma et al. in [2] compared different segmentation techniques such as manual image segmentation which involves selecting thresholds by trial and error method, color image segmentation which involves combining maximum indices and reconstructing the image in red, green and blue channels and k means image segmentation which is a clustering method and is explored in detail in the following sections for ROI extraction from knee thermal images and concluded the k means algorithm to be most accurate. Lanisa et al. in [3] proposed a sobel edge detector-based algorithm to detect edges and segment the image. BG Sudha et al. in [4] and Fraiwan et al. in [5] used the Otsu thresholding technique to segment ROI from thermal images of the foot. R-CNN or Region based Convolutional neural networks can also be used to detect and foot from the thermal images as demonstrated by Quinn et al. in [6]. Neural Networks are further discussed in subsequent sections.

Sikkhandar et al. in [7] segmented images by identifying edges and performing morphological processing. Hence, it is essential to devise a pre-processing algorithm that accurately isolates the left and right feet from the thermal image, minimizing background noise and other undesired information.

Image Processing

Image Processing is primarily used to enhance images. Outputs consist of features from the images or it involves manipulation of the images. It involves the application of various image processing or signal processing algorithms to perform desired functions. Image processing can be used for detection of certain characteristics or is used as an intermediate stage between different techniques. This can be done in different software's while Matlab is most widely used.

Adam et al in [8] decomposed plantar images of foot thermograms using discrete wavelet transform (DWT) and higher order spectra (HOS) techniques. These combined features were ranked using t-values and classified using a support vector machine (SVM) classifier, discussed in subsequent subsections to achieve a maximum accuracy of 89.31%. Susan et al. in [6] used image processing to align segmented feet together, reduce errors and to perform pixel by pixel comparison of temperatures in two different images. Harshavardhan et al. in [9] preprocessed thermograms by transforming the RGB image into YIQ format using a linear transformation or using Histogram Equalization and followed by histogram equalization and noise filtering to compute Grey level co-occurrence matrix (GLCM) which

was applied to a logistic regression model to detect glaucoma. Bennets et al. in [10] used image processing to divide the foot into seven regions and used statistical analysis to extract peak pressures from each region. Fraiwan et al. in [5] used a statistical mean to mean point difference technique to interpret images and identify regions of high temperatures. Sikkandar et al. in [7] performed statistical analysis of the temperature associated with the image to isolate hot and cold regions of the image and detect abnormalities.

Image processing is a broad term that covers many sub-sections, it can be used to perform preprocessing which include segmenting, filtering and resizing the thermal images. It can also be used for processing and identifying regions of high temperatures instead of using machine learning or deep learning algorithms and it can finally be used to perform post processing functions which include noise removal, highlighting specific regions, asymmetry analysis, reconstruction and correction to the processed thermal image

Deep Learning

Deep learning is a subset of Artificial Intelligence (AI) or in other words it is a function of AI. It mostly includes Artificial Neural Networks (ANN) and Convolutional Neural Networks (CNN). It tries to mimic the functions of the human brain and is primarily used in decision making, classification of data, data recognition and translation. Neural networks attempt to mimic the neurons of the human brain, it is organized into many layers and each layer has a specified number of neurons or perceptrons that are interconnected with neurons of the preceding and succeeding layers. Each neuron generates an output by applying a nonlinear function to its inputs. CNN consists of multilayer perceptrons or fully connected networks which is prone to overfitting of data and the images used in this algorithm are subjected to minimal preprocessing. Neural networks consistently learn from the observed data in order to improve the model and minimize errors. CNN and ANN are used for segmentation, processing and classification of thermal images.

Quinn et al. in [6] used an Alexnet trained Region based Convolutional neural network (R-CNN) to detect and segment feet from thermal images. Sikkandar et al. in [7] used a CNN classifier to classify foot as healthy or diseased after image processing and asymmetry analysis. AA Wahab et al. in [11] extracted features such as maximum temperature, mean temperature, standard deviation and breast density types and used an ANN to localize tumors in breast thermal images. Hernandez et al. in [12] used CNN to identify anomalies or malignant nodules in thermal images of the thyroid. The CNN models were tested using GoogleNet and ResNet and the latter exhibited a higher accuracy. Roslidar et al. [13] used a standard CNN for segmentation and image classification of breast thermograms. Moran et al. [14] used 3 different CNN models trained by Alexnet, GoogleNet and VGG CNN to detect nodules in thyroid thermograms and concluded that the Googlenet trained model outperforms the other models by approximately 11%.

CNN models can be used for classification of processed thermal images as diseased and healthy. The algorithm is usually used after feature extraction. ANN models can be employed to convert a RGB image into a grayscale image with pixel values corresponding to its temperature. This is done as the thermal image scale differs from the color scale used by image processing softwares to convert RGB images to their grayscale equivalents

Machine Learning

Machine learning (ML) is often considered as a subset of Artificial Intelligence (AI) and is a method that studies computer algorithms and improves its performance through supervised or unsupervised learning. ML algorithms encompass several algorithms such as K-means clustering, logistic and linear regression models, Decision Trees, Random Forest method and Naïve Bayes. These algorithms are usually applied after feature extraction. Mishra

et al. in [15] performed manual segmentation to obtain ROI, extracted Gray level co-occurrence matrix and Gray level run level matrices features from breast thermograms and classified them using Support Vector Machines, Random Forests, Decision trees, Artificial Neural Networks and Bagging classifiers and concluded the Random forest method to be most accurate. Adam et al. in [8] used Support Vector machines to classify pre-processed thermal images of the foot using 5 parameters obtained using feature extraction algorithms and obtained a specificity of nearly 96.97%.

However, the most common algorithm used for thermal images is K means clustering and is discussed in detail in this subsection. K Means algorithm is widely considered by many as a popular partitioning method for clustering, analysis and classification. It is an iterative algorithm that divides or partitions the dataset into predefined non-overlapping clusters where each data point belongs to just one group. It tries to minimize the variations inside every cluster by minimizing the centroid and tries to maximize the square of the distance between every cluster. It is mainly used for clustering and classification. Quinn et al. used K means algorithm in [6] to remove background noise from the thermal image. Bennets et al. in [10] used K means clustering to classify the peak pressures obtained after image processing and it enabled differentiation of regional peak plantar pressure data and identified several plantar pressure distributions and clustered them into seven categories for better diagnosis of foot. Suma et al. in [2] concluded that the k-means clustering algorithm applied after image processing is the most accurate out of manual segmentation and colour segmentation algorithms.

Similar to CNN's, machine learning algorithms can be used to classify foot thermal images as diseased or healthy after feature extraction. Machine learning algorithms are more accurate than CNN algorithms in some cases whereas CNN outperforms machine learning algorithms in some cases

Asymmetry Analysis

Asymmetry analysis aims at highlighting the differences between two different objects. Asymmetry analysis is a part of image processing and is widely used in computer aided diagnosis to detect abnormalities by comparing a test image with a reference image. Asymmetry analysis is widely used to spot the pre ulcerative hotspots in foot thermograms by comparing the temperatures in corresponding regions of both feet and detecting regions with high temperature differences. High temperature differences between similar regions of the left and right feet correspond to pre-ulcerative diabetic hotspots. It's proven by several researchers as discussed in this subsection using different methodologies for preprocessing, classification and asymmetry analysis that a temperature difference greater than 2.2°C corresponds to pre-ulcerative hotspots.

Frairwan et al. in [5] performed asymmetry analysis by applying a mean to mean point difference algorithm between both feet and some basic image processing algorithms and observed that foot ulcers existed in regions with temperature difference greater than 2.2°C. Quinn et al. in [6] performed asymmetry analysis by subtracting the thermal images of the left and right foot and detected regions of high temperature differences and concluded that temperature differences greater than 2°C correspond to hotspots. Sikkandar et al. in [7] performed morphological and statistical analysis to analyze hot and cold regions and detected abnormalities using asymmetry analysis and proved that all the hotspots were present for a temperature difference greater than 2.2°C. Peregrina et al. in [16] divided the foot into different regions or angiosomes, analyzed the temperature difference between the corresponding angiosome of the left and right feet with respect to the mean temperature difference between the two angiosomes and concluded that a temperature difference greater than 2.2°C is deemed abnormal while temperature variations of around 1°C can be considered as normal.

Hence asymmetry analysis can be applied for detection of pre-ulcerative diabetic hotspots and is found to be the most optimal choice. It can be concluded that a temperature difference between corresponding regions of the feet greater than 2.2°C can be classified a diabetic hotspot

4. Proposed Model

The dataset was obtained from IEEE port. The dataset consists of thermal images of the left foot and right foot for each patient. Image Segmentation was primarily used to separate both feet from the noise in the parent image. The images from the dataset were resized and a pixel detection-based segmentation algorithm was developed. The Red, Green, Blue values of the image were averaged and stored in a variable. The pixels flanked by respective rows and columns are copied to another variable and this step is used to obtain segmented images of both feet. Preprocessing involves resizing the segmented images

An Artificial Neural Network is designed using MATLAB's Deep Learning Toolbox, to predict the value of temperature for each pixel of the image from its RGB values. Dataset to train the ANN was obtained by acquiring various thermal images and the temperature map associated with it. Hence each pixel of the RGB images of both feet is converted to temperature equivalents and the images were normalised.

The K-means algorithm aims at partitioning N observations into k clusters. Each observation is classified into the cluster that achieved the smallest Euclidean distance between its centroid and the observation vector. In this project, after the pre-processing and segmentation of the image, the K-means algorithm uses the particular values of the pixels of red, blue and green in the thermogram as the centroids of the clusters. This is done by converting the pixel values for red, green and blue into matrices. Then each pixel is mapped to each of the clusters formed. The image obtained is then reshaped and levelled. Then this image is compared and subtracted with the image of the other foot to obtain the hotspots.

The grayscale images of the left and right foot obtained by passing the input images into the ANN and the RGB images of the left and right foot obtained after K means clustering are processed to detect hotspots. The images are aligned together and subtracted, the image is thresholded and converted to a black and white image. High differences result in higher pixel values after subtraction and correspond to white regions in the black and white image. After asymmetry analysis, image processing is done to remove noise and false hotspots that occur due to improper alignment of feet and slight variations in the sizes of the feet.

The reconstruction algorithm is used to highlight the hotspots of both feet in the segmented images. The algorithm compares the black and white image with the RGB images of both feet obtained after segmentation and if black pixels are observed in the black and white image, the new image consists of pixel values from the original image and if white pixels are observed, white pixels are assigned to corresponding regions in the new image. Hence hotspots are highlighted.

5. Results

Upon testing the systems with various images, the results are as follows in Fig. 1.

It is observed that the hotspots are detected accurately and precisely showing the viability and sensitivity of the systems. There are slight errors in hotspot detection and false hotspots are also detected in some cases. The algorithm is very sensitive to minute temperature changes, this makes the system very sensitive but also leads to increased number of false positives. These issues need to be focused on in future research.

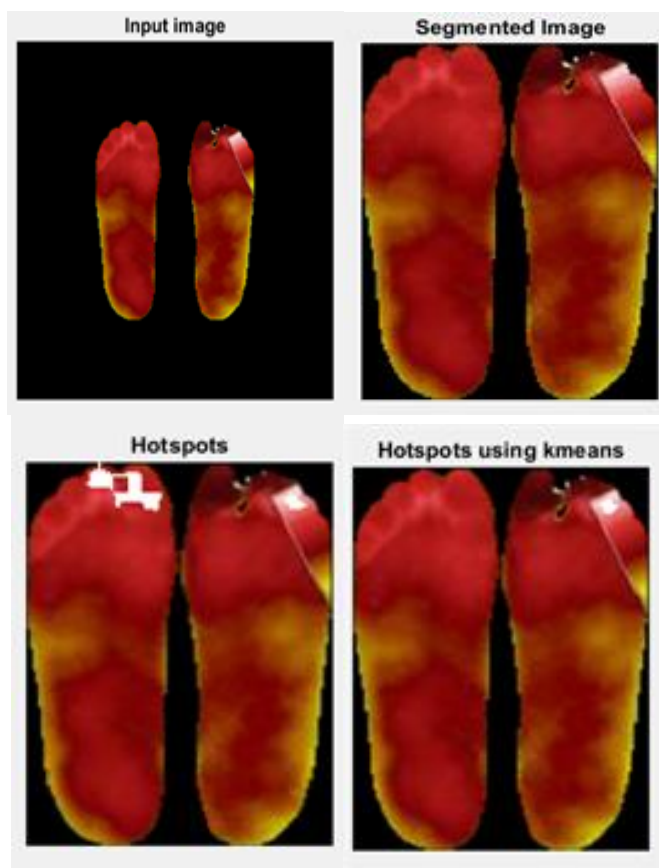


Fig. 1. Results from testing the systems with various images

6. Conclusion

In this paper we have analyzed the trends in detection of the hotspots on the thermograms of the feet obtained from diabetic patients for early treatment of diabetic feet. Upon analysis of these trends we have come up with two novel solutions. The first being an Artificial Neural Network based detection system and the second one being a K-means algorithm-based detection system. Further research can be undertaken on improving the pre-processing techniques employed and improving the accuracy of the techniques. The systems presented must be compared with more systems in place today as well.

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Convolutional Autoencoders for MRI Denoising

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Abstract. Magnetic resonance images are an essential tool in diagnosis of human conditions. These images should be visually elegant so as to infer the right diagnosis. Oftentimes, MR Images are prone to noises that may result in a poor quality of the diagnosis. These noises may arise from the patient, activities of the machine or even flaws in the signal acquisition. The challenge then faced is the retaining of artefacts that contribute to the details of the image while removing all the generic noise. The paper presents a deep learning solution consisting of ConvAutoencoders - a Convolutional Neural Network in the architecture of an Autoencoder, where instead of a single instance of the model, two instances of the same architecture specialized in each of the denoising challenges prove to result in a better denoised image.

Keywords. Magnetic Resonance Imaging, Denoising, Convolutional Neural Networks, Autoencoders, Diagnosis.

1. Introduction

Magnetic resonance imaging (MRI) is an imaging technique used primarily in medical settings to produce high quality images of the inside of the human body. MRI is based on the principles of nuclear magnetic resonance (NMR). Human body mainly consists of water - which has 2 atoms of hydrogen (H) bonded to a single atom of oxygen (O). Under the influence of a magnetic field, the protons in the H atoms in water molecules (H₂O) start to behave as magnets. The magnetic field forces the molecules to align along its magnetic field. Imposing a temporary radiofrequency pulse, disperses the protons from this external magnetic field alignment. After the pulse, the protons try to realign again with the magnetic field. During this realignment process, the energy released from the protons are measured thereby constituting the resonance signal.

These signals measured are then measured by a computer system which carries out the analog-digital conversion - representing the image in temporary image space or K-space. K-space stores digitized image signals during data acquisition. The digital signal in K-space is then sent to an image processor and Inverse discrete fourier transform is applied to receive permanent readable images. Inverse discrete fourier transform converts image space to k-space and vice versa. The constituent of image space is pixel whereas in K-space, it is stripe patterns with phase and magnitude. The phase indicates the width of the strip. The details of the image reside on the edges of the K-space and the contrast, in the centre.

During the signal acquisition phase, there are possibilities to acquire noise along with the desired signal. These noises may contribute from the patient, errors from the signal acquisition, the machine itself, etc. These contribute to the undesirable artefacts that make up the image. MR Images require to be visually noise free so as to provide an accurate diagnostic relevance.

$$\text{Signal} + \text{Noise} = \text{Image}$$

Reduction in noise artefacts while retaining the artefacts that make up the image detail is the primary goal of this project. Hence we look to the similar work done by others.

2. Literature Survey

Prasun et al presented CNN-DMRI with residual learning in MR Images [1]. Danfeng Xei et al used specialised CNN for removing ASL related noise in MR Images [2]. Ronnie Wirestam et al performed rician noise removal using a modified Wiener filter [3]. Ryan Wen Liu et al., proposed to denoise rician noise through a two-step wavelet-domain estimation method to extract the noise map. Following a Bayesian modeling approach, a generalized total variation-based MRI denoising model is proposed based on global hyper-Laplacian prior and Rician noise assumption [4].

3. Methodology

MRI requires visual feedback so as to make it diagnostically relevant. The synthetically added noise in these images when denoised should be as feeble as possible. Whether or not the noise disrupts the image along with retaining the image details even after denoising was to be considered visually. Statistically, the method of testing how accurate the original image and the denoised image in the project, mainly revolves around MSE or Mean Squared Error between the two images. PSNR, Peak Signal to Noise Ratio was also used to measure the noise in the denoised image.

$$MSE = \frac{1}{n} \sum_{i=1}^n (\hat{Y}_i - Y_i)^2$$

$$PSNR = 10 \log_{10} \frac{255^2}{MSE} \text{ dB}$$

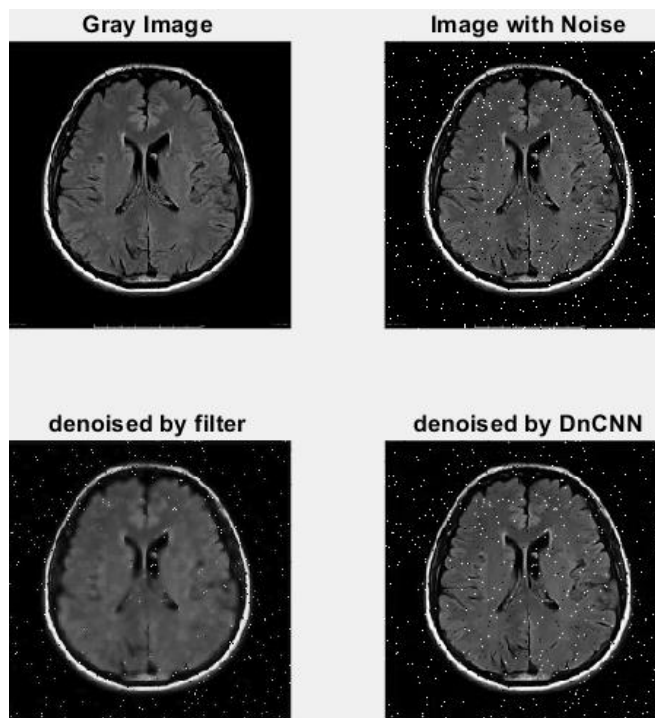
To further strengthen the measures statistically, SSIM or Structural Similarity Index Measure [5] is also calculated between the original image and denoised image.

$$SSIM(x, y) = \frac{(2\mu_x\mu_y + c_1)(2\sigma_{xy} + c_2)}{(\mu_1^2 + \mu_2^2 + c_1)(\sigma_1^2 + \sigma_2^2 + c_2)}$$

The closer to 0 the MSE is, the better. The closer the SSIM is to 1, the better. The higher the PSNR, the better

a. MATLAB and Deep Learning Toolbox™

The initial step was to test out the existing denoising models. dnCNN [6] from the Deep Learning Toolbox™ from MATLAB R2018b [7]. The test image was of an axial brain MRI. A comparative study with a Wiener filter and dnCNN was performed over a noisy MR Image. The wiener filter was of a kernel size of (5,5). The noise added to this sample image was a salt and pepper noise with probability of 2%. This means that 2% of the pixels will get affected.



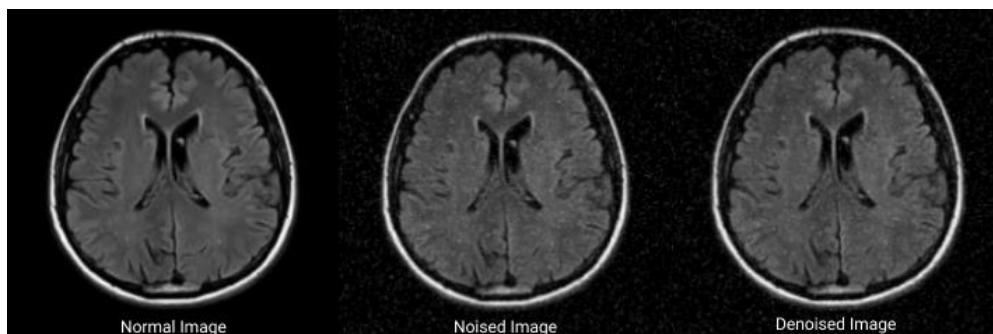
Visually, the denoised Image filter reduces most of the noise but loses out on the details over the edges whereas the dnCNN reduces less noise compared to the filter but holds up the details.

Statiscally,

Method \ Similarity	MSE	PSNR
Wiener Filter	298.2708	23.3847
dnCNN	355.7057	22.6199

b. OpenCV Function

The open source computer vision package[8] for python includes the function for non-local means denoising [9].



The denoiser tries to remove the noise from the image however, most of the artefacts still remain.

Statically,

MSE	SSIM	PSNR
0.0325	0.42	17.877

c. Our proposal

The deep learning model used for this project is a CNN, Convolutional Neural Network [10] with the shape of a denoising autoencoder. The denoising autoencoder has more hidden nodes than input nodes. In the sense the entire architecture portrays a diamond-shape.

i) Architecture

The model takes an input image of 544 x 544 pixels in grayscale. It is passed onto a ConvLayer of 16 filters of shape 3x3 with activation function, Rectified Linear Unit or relu. The image array then is upsampled by a filter of 2x2 producing a shape of 1088 x 1088 pixels. Finally, the array is passed onto a ConvLayer of 1 filter of shape 3x3 of relu activation function which outputs a 544 x 544 image array. The model uses binary cross entropy as the loss function and Adam [11] as the optimiser. The model as a total of 305 trainable parameters.

ii) Dataset

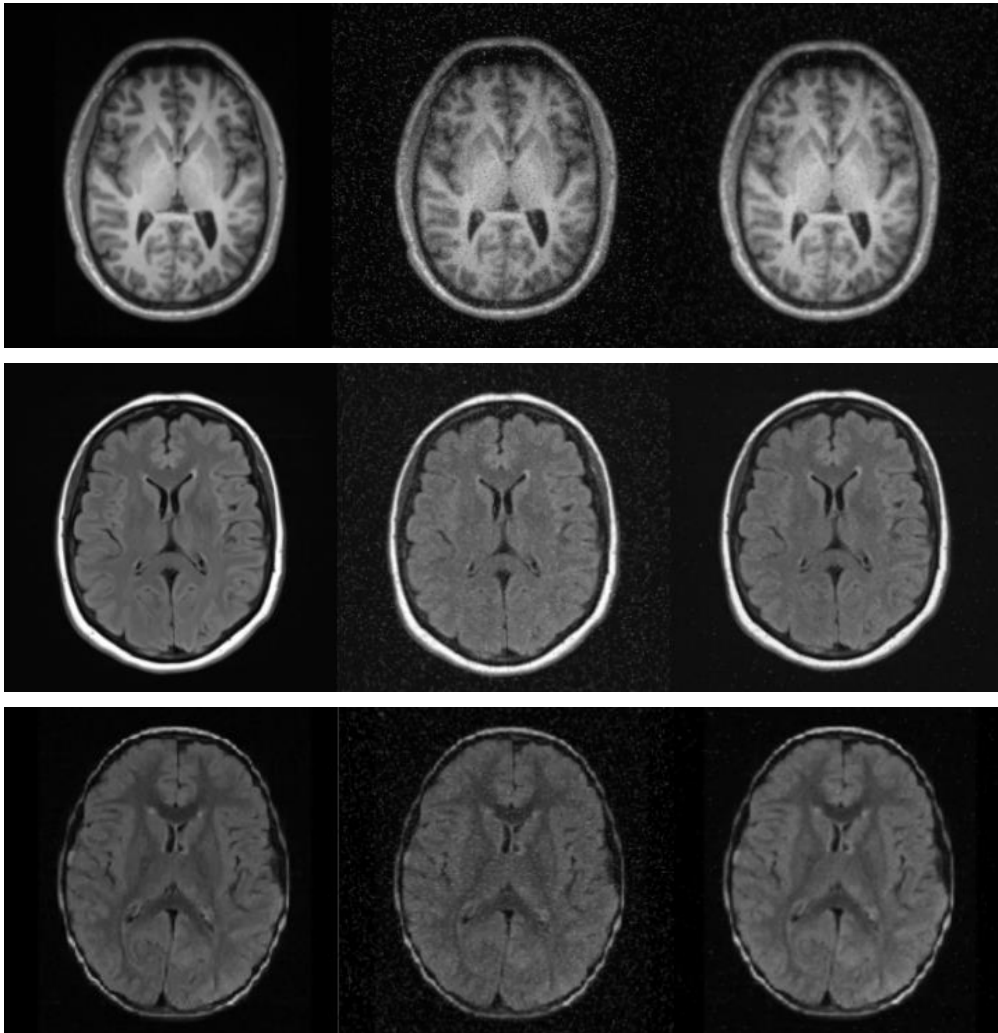
Kaggle Brain MRI Dataset [12] includes 98 images of axial brain MR Images without tumours and 155 images with tumours totalling 253 axial brain images of JPEG, PNG and JPG file formats. These images are made in sets of two - each containing the original image and their noised counterparts. The images were synthetically noised with salt n' pepper noise of probability of 2%. This means that 2% of the pixels will get affected.

iii) Training

The model is built upon Tensorflow [13] in a Google Colaboratory Notebook with hardware acceleration in training with Nvidia Tesla K-80 GPUs. The images infused with the noise, labelled as `x_train_noisy` is the training data and the original images, `x_train`, the result the model should achieve. This is the phase I denoising. The images from the phase I denoised model are collected and trained again with this array of images, labelled as `phase_1_noisy` as the training data and `x_train`, the target. Both the instances were trained for 20 epochs.

vii) Phase I denoising

The loss converged at 39.26% after 20 epochs. It took 1.67 minutes for the complete training.

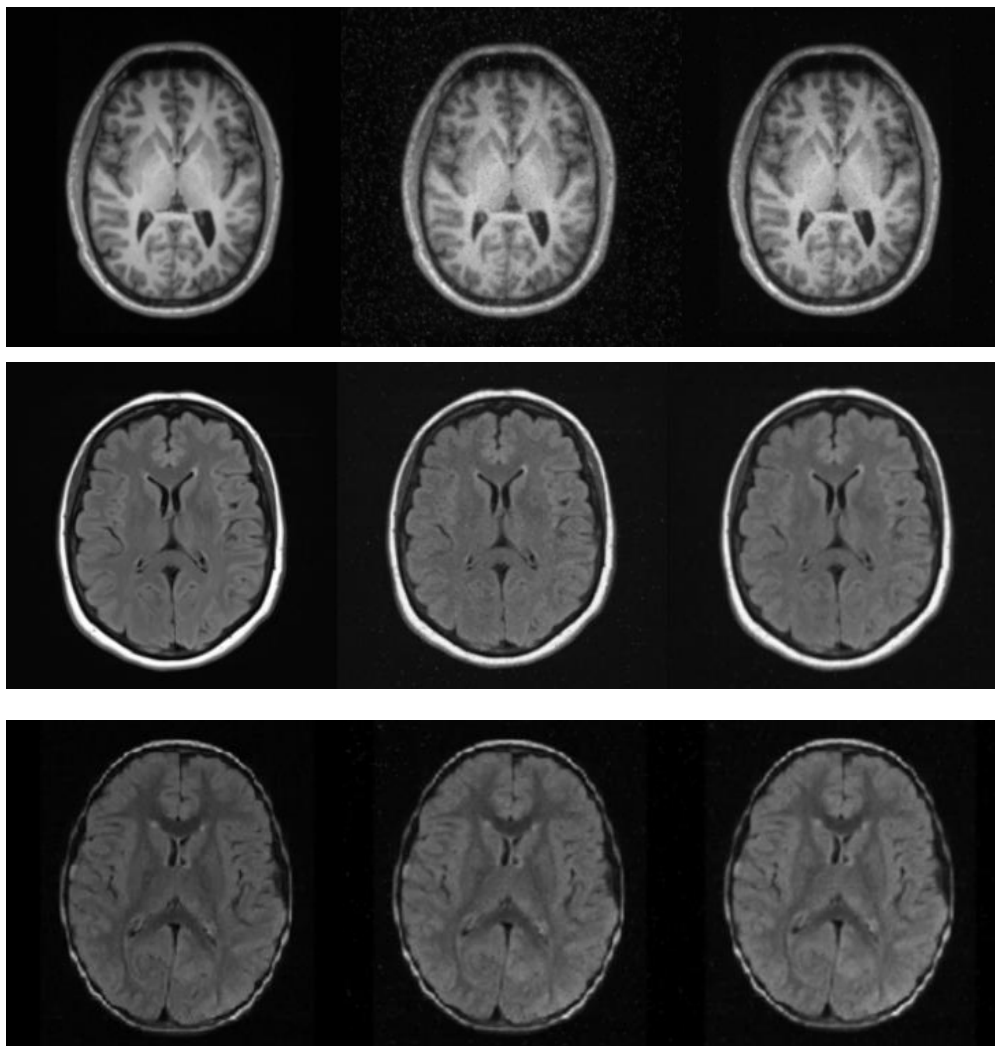


Left - Original image ; Center - Noised image ; Right - Denoised

A significant amount of noise that was in the image has been blurred down but not to an extent that it tampers with the integrity of the image itself. The noise artefacts still remain in the black background of the image.

viii) Phase II denoising

The loss converged at 39.30% after 20 epochs. It took 1.67 minutes for the complete training.



Left - Original image; Centre - Denoised phase I; Right - Denoised phase II

The 2nd instance of the model has successfully denoised the noise artefacts from the black background. The denoised image almost resembles the original image in terms of visual accuracy. A slight increase in brightness is also noticed after the phase II denoising.

5. Results

The following results were the average statistical measure observed from each phase of the denoising.

Statistical Measures	Phase 1 denoising	Phase 2 denoising
MSE	0.0009	0.00063
SSIM	.91	.87
PSNR	79	77

6. Conclusion

The project discusses the effectability of the 2 phase conv autoencoders to denoise axial brain MR Images. The model denoises better than dnCNN found in MATLAB and the non local means denoising function of OpenCV library. The model also manages to retain the image details to an extent that the image itself doesn't have a significant amount of blur. The model has now been trained only upon axial brain MR Images, that too infused with salt n' pepper noise. The future of the project would hold so as to train a robust generalized model that can denoise any MR image. The colab notebook can be found here.

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COVID-19 Infection Management Using Thermographic Image Analysis

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Abstract. The main idea of this paper is to obtain an optimised solution for the current pandemic situation. Body temperature plays a significant role in quick detection of the infection of the Covid-19 and hence being precautionous is the need of the hour as infection sometimes is symptom less, by analysing the thermographic images of individuals from the thermal cameras fixed in an enclosed area will collect the temperature of individuals without actually contacting their body surface. The enclosed area is divided into 6sqmts per person which result in the number of people to be accommodated in that particular area, as we should maintain a strict social distancing of 2meters between each individual. Thermal image analysis was done using MATLAB software.

Keywords. Thermographic images, social distancing, enclosed area, 2meters between each individual, MATLAB.

1 Introduction

Medical diagnostic procedures have developed manifolds for the past two decades and results obtained are accurate and reliable. Many medical complications are resolved with the help of a perfectly designed equipment and medical practises. There has been several researches going on to meet the ever changing human life and environmental situations, a wide concern for better health practices, research in the new equipment designing, proper planning of hospitals has emerged.

The COVID-19 a viral infection which broke out in china early in December 2019. This virus is very similar to the virus that caused the SARS virus, therefore it was named SARS COV-2.

Most people affected with the COVID-19 virus has moderate respiratory disorder and recovered without requiring special treatment. Older individuals, and people with medical issues like diabetes, hypertension, asthma, COPD(Chronic Obstructive Pulmonary Disease), cardiovascular disease and cancer are prone to serious infection. The transmission of disease is via respiratory droplets of spit or discharge from the nose, infected person's coughs or sneezes, virus may travel in the atmosphere and infect a healthy person.

COVID-19 has wide variety of signs and symptoms. Some people might not have any symptoms at all(asymptomatic). It varies from person to person and also depends upon the age group and medical conditions. Scientists are working hard to find a cure for this viral infection. but currently there is no specific treatment for this disease so the medications are given to support body's function until the body's immune system can fight off the infection.

As a responsible citizen, we have to follow the guidelines enforced by the government bodies and help reduce the spread of this infection. This paper elaborates on the temperature measurement using thermal imaging which is a widely practised technique. The temperature

measurement is done to identify the elevated body temperature of a person which is a major symptom of this viral infection. The only way to prevent and slow down the transmission is through human behavioural changes until a vaccine is found. So this paper throws light on correct information gathering and stay informed to prevent from getting infected.

2 System Design

The system primarily consists of a Thermal Imaging Camera coupled with a smart AI algorithm that shows the temperature information of the image captured. The temperature datas are collected and stored in order to find the mean temperature of the people who are about to enter a room or an enclosed area.

According to the WHO (World Health Organisation) social distancing is the best way to prevent infection as there is no vaccine discovered yet for this disease. The WHO prescribed distance to be maintained between individuals is 2 meters (6 feet). Keeping this in mind a room or particular enclosed area can be divided into small human occupancy areas for each person. This way the mean temperature and the exact number of people to be entered are calculated and correlated.

Exceeding the mean temperature or allowing an extra person beyond the individual occupancy can be prevented when this system is implemented as the results are displayed to the managing authorities of the building.

3 Methodologies and Results

3.1. Preprocessing

Binarization: Converts the RGB form of a thermal image into a black and white form in order to get the outline of the object captured in the camera. We mainly implemented this technique to spot humans in that particular area.

Original image



Fig. 3.1.1 Thermal image

Output of im2bw



Fig. 3.1.2 Binarized image

Filtering: We use `imguifilter` to do edge-preserving smoothing to the image and to denoise while still retaining image details. Then we determine threshold values to use in segmentation. The first one differentiates the background from the person and the second threshold differentiates the person from the hot substance.

3.2.Segmentation

Region of interest: Different parts of the body have different heat levels. In order to get the temperature of a particular region, we use the ROI method where we select the shape, size, area and transparency of the selected region manually. This procedure is done to collect accurate temperature data of the person.

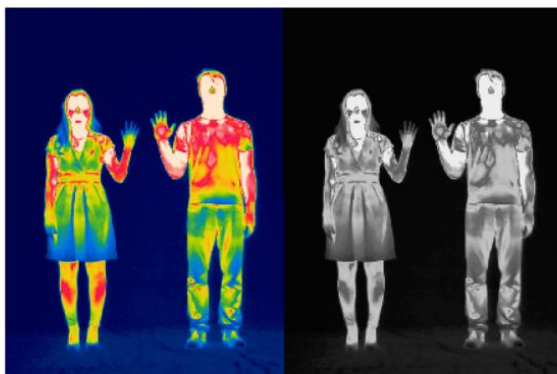


Fig. 3.2.1 Thermal Image

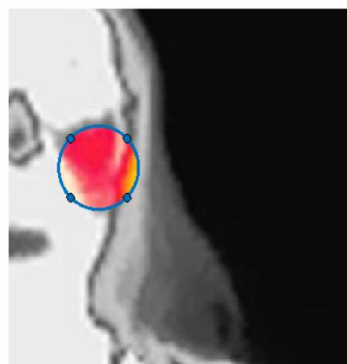


Fig. 3.2.2 Region of interest

Feature Extraction: After selecting the ROI, we apply feature extraction to highlight the different temperature of the person. Then mean temperature is then calculated for all the selected individuals and displayed at the entrance. We have processed the image using MATLAB code but AI thermal cameras are best for this temperature measurement.



Fig. 3.2.1 Thermal Image

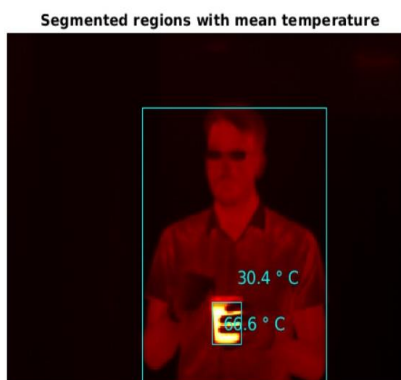


Fig. 3.2.2 Temperature is mapped

3.3 Classification:

Regulation based on social distancing and mean temperature:

We take the room's dimensions, namely, the length and breadth to calculate the area of the room. Then we apply social distancing principles and calculate the number of people allowed inside the room. Further we calculate the average temperature of the crowd with the

data collected from the thermal cameras installed and check for any abnormality. If there is any abnormal temperature reading, then it alerts the incharge of that place.

The social distancing principle stated by WHO says 2 meter social distancing between each person must be followed. So on average, a single person will require a dedicated area of 4 sq units and we have added extra 1 meter for accuracy and defined 6 sq units for each person. The room area is divided by 6 to get the number of people to be accommodated.

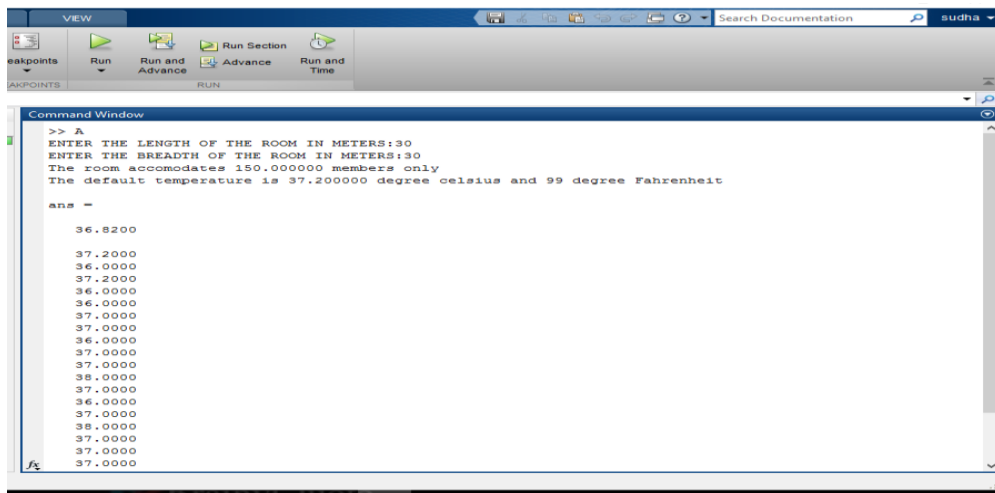


Fig. 3.3.1 The number of people to be accommodated and the temperature details of all persons are displayed and their mean is computed.

4. Advantages

Thermal imaging helps to discover lots of latent issues like heat radiation emitted or reflected by a body regardless of the lighting conditions. The most significant benefit of thermal imaging comes in the domain of security. Security camera surveillance play a crucial role in protection for many across the country.

Early symptoms of the corona-virus include having a fever and dry cough. Timely and accurate monitoring of people with a high temperature in public and shared spaces can play a significant role in containing the epidemic and ensuring effective infection control. They can be deployed and removed quickly based on the entrances in use and in the case of an emergency. They can also be integrated with alarm systems and data can be stored locally on centrally.

Thermal imaging measures the body temperature by using cameras that detect the infrared energy emitted by people.

1. Cost effective: cameras can measure the temperature of multiple people at once, especially beneficial in crowded public areas

2. Contactless measurement: effectively avoids cross-contamination at public spaces

3. Reduced psychological impact: the non-interfering process relieves people from panic and negative emotions

4. Data collection and integration capabilities: centralized data collection enables data collected from thermal imaging technology to be integrated with other solutions, such as facial recognition, alarm systems and more, for effective response and tracking

Body temperature measurements through thermal screening is fundamentally a non-invasive, fast, cost effective and accurate means to identify people potentially infected by corona-virus through temperature extraction. Here the inclusion of social distancing and crowd control based on the area of the room is to provide additional security against the virus. Moreover, deployment can be a fast and hassle free process. For the best results, thermal screening can be integrated with other aspects of your security solution.

5. Conclusion

Thermal image processing is done to extract the temperature of a crowd and the mean temperature of the crowd is calculated. Taking the pandemic situation into consideration an algorithm ensuring social distancing in the room is also implemented. However, unfortunately this solution is not a fool-proof method to identify Covid-19 cases (as people can be infected before they start to develop a fever like symptom) but it can help with early detection of cases and fast action to control the spread of the virus.

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Daily Task Reminder and Alert System for Dementia Patients using LabVIEW

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Abstract. In this generation, the ageing population seems to be on an upsurge which causes many ailments associated with adulthood, primarily Dementia and Alzheimer's disease, other than this, there is generally a prime need for overall elder care also for the elderly who are active and healthy at that moment due to their age factor. Due to this scenario, there is a major requirement for constant monitoring, support and assistance for them, which ultimately causes a substantial burden financially on individuals like their family and their caregivers. LabVIEW is the software used since it is a platform which allows easy GUI interface for monitoring of various physiological parameters which is necessary for the wellness of the patient. The main objective behind this work is to design a continuous real time elderly patient monitoring and alert reminder System using LabVIEW, which allows us to continuous monitor and remind a patient and also help the doctors to arrive at a clearer diagnosis. This paper presents software implementation of system for house automation using LabVIEW.

Keywords. LabVIEW, Alert, Reminder, Dementia, Monitoring, Temperature, DAQ, Gas sensor, Automation, Alarm, Calendar.

1. Introduction

Dementia is not a disease or a disorder but rather it is a variety of conditions all together. It causes a person to lose their memory, causes disorientation, cognitive disability and affects the ability to perform daily activities and tasks. There are about 50 million dementia sufferers worldwide, with 9.9 million cases reported per year [6]. They find it challenging performing basic chores including their day-to-day activities including medication timings and appointments. Memory loss is the primary defect when a person is affected by dementia. It is a serious symptomatic condition where Alzheimer's disease is also said to be a cause of dementia [1]. Early symptoms of Dementia might be mood swings, disorientation, isolation from others and decrease in logical thinking. They always need some kind of assistance or an attender to take care of them. There is no accepted system to provide both reminder and detection system which is user friendly too. There are IoT based automation system and multiple physiological parameter detection and collection [10] but no system to incorporate both

2. Project development

While there are several services available to support these old patients, most of these systems are aimed at tracking patients rather than helping them to live an independent life because of injuries or unexpected changes in their health conditions. The goal of this project is to use LabVIEW to present a Real Time Patient Monitoring and Warning System [5]. A six

parameter warning and reminder framework for easy interface and protection for Dementia patients via LabVIEW software for Dementia patients for easy interface and for their safety even through independence. Since dementia patients tend to forget to do their basic needs and forget reminders, these alarm systems and reminders will be helpful for them to carry on with their life [2]. Older adults who are not technology proficient and who live in care homes will also benefit from communicating with their family via photos on a computer screen [3].

a. Gas sensing and alert

This parameter is to detect the leakage of Liquid Petroleum Gas (LPG) [4] to avoid various fire accidents taking place in industries and factories. It's also used for home safety applications. It works on the principle that when there is an excess of concentration of gas, it is sensed and an alert is given. In this way gas leakage is controlled and fire accidents are avoided. For this purpose, we use a sensor which is the gas sensor here using DAQ assistant and NI LABVIEW software.

2.2 Temperature indicator

The normal body temperature of a person varies depending on gender, recent activity, food and fluid consumption, and time of day [8]. Normal body temperature can range from 97.8 degrees F (or Fahrenheit, equivalent to 36.5 degrees C, or Celsius) to 99 degrees F (37.2 degrees C) for a healthy adult. Body temperature may be abnormal due to fever (high temperature) or hypothermia (low temperature). A fever is indicated when body temperature rises about one degree or more over the normal temperature of 98.6 degrees Fahrenheit. Hypothermia is defined as a drop in body temperature below 95 degrees Fahrenheit.

2.3 Water level indicator

In water level tank system, the overflow and underflow of water level in tank is indicated by LED with ALARM alert. The water control shows normal water level condition of water level in the tank. The two indicators are in OFF position under normal condition. The range in the DAQ assistant is given from 3 to 8 where above 7 is termed as gas leak and below that is normal.

2.4 Alarm reminder

The clock displays the present time and also to set alarm reminder. This a simple alarm clock that lets displays the time and date. It is also designed to set an alarm and lights an LED when it rings. It also has a 5-minute snooze. Time and Date indicator display the current time and date.

2.5 Calendar

A calendar UI in the Timestamp control for selecting Date/Time. Such a calendar UI can be created by leveraging .NET controls. The calendar displays the date and the particular day. It can be used to either create an indicator to visualize the data or unbundle to carry out further manipulations of the data.

2.6 Fall detection

Pyroelectric Infrared Sensor (PIR) are the sensors which are most widely used for fall detection [7,9]. Due to their high ended sensitivity and area of detection PIR sensors are popular. PIR sensor is used to detect the obstacle in front of the person and when in contact,

the alert is a pop up and an LED indicator. The Arduino is interfaced with LabVIEW through Makers hub and Linx toolkit through COM4 port.

3. Methodology

Using two channels in DAQ assistant, the value of gas sensor is taken as output voltage. The range given is 3 to 8 where above 7 is termed as gas leak and below that is normal. It is displayed in the string indicator and also a led indicator. A select switch is used as an if else condition to indicate the difference. The next channel has thermistor values in Fahrenheit units. Two ranges are given, if the person's temperature is below 95 then it displays lower temperature. If the person's temperature is above 100 then it is displayed as high temperature. The temperature is also displayed in a thermometer.

Both these are given to a selector switch and the value is displayed in a string indicator as a message. The next indicator is a water level indicator. The control is a water level which is shown separately. The maximum and minimum level is also given as control beforehand. When the water level goes above the given range then the led indicator blinks for maximum level. When the level is below the given level then it is also indicated using a led indicator. The water level in the tank is also indicated using a water tank level indicator. Using a .net container, the calendar is created to remind. An alarm clock to display time using time stamp is also created. The Arduino is interfaced with LabVIEW through Makers hub and Linx toolkit through COM4 port for fall detection.

4. Results and Discussions

For dementia patients and older adults, this Memory-Aid and Reminder Device helps and assists them carry on with an independent lifestyle while providing their patients with a strong tracking system for health care staff. It is a notification generation setup that can be used as a reminder for appointments, time to take medication, etc. This is demonstrated by the buzzer and warning device used in the event of an emergency to transmit an alert signal. It can also be used for domestic security reasons.

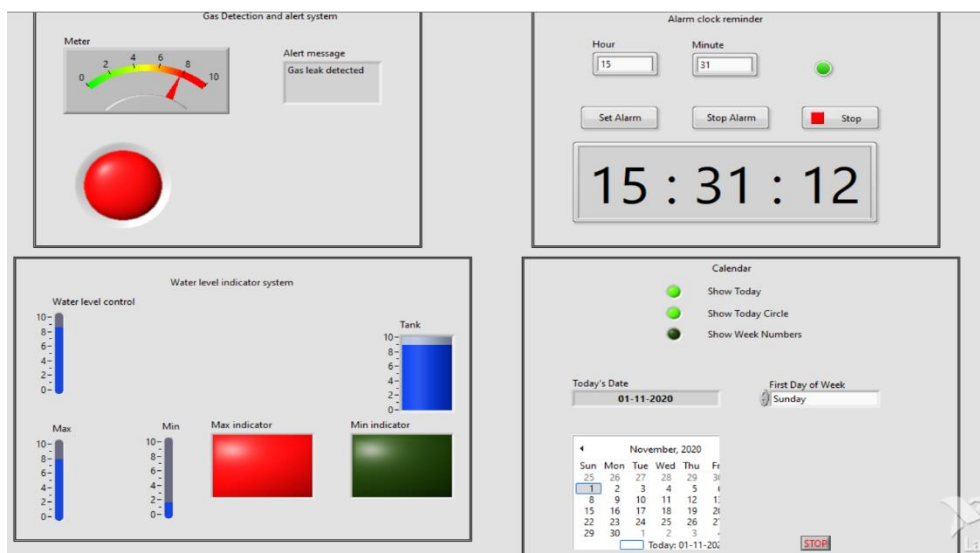


Fig. 1. Front panel first set of parameters

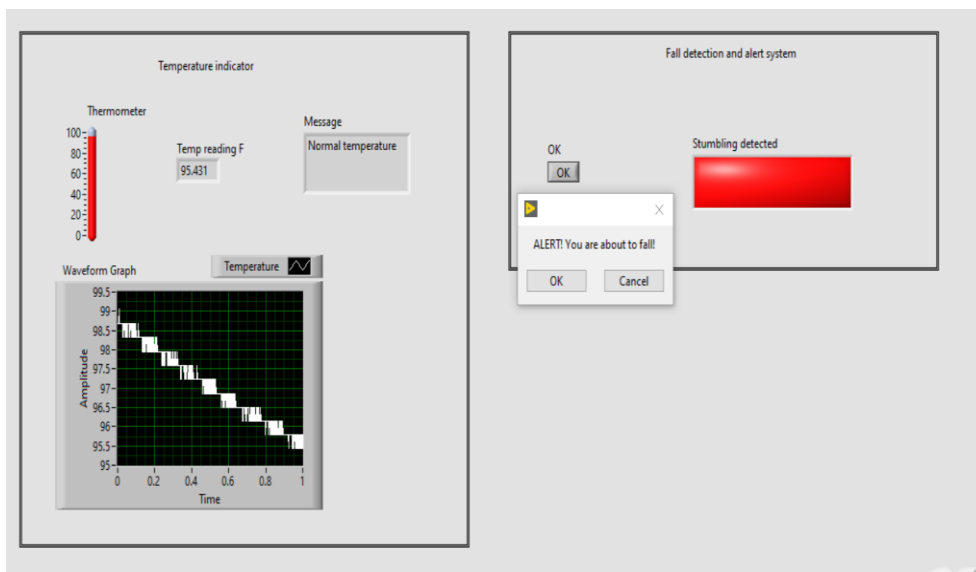


Fig 2: Front panel other parameters

5. Conclusion

In order to support them in their everyday lives, elderly adults and dementia patients are usually admitted to rest homes or private homes with personal caregivers present. However, with the aid of our proposed scheme, these elderly adults and dementia patients who want freedom in their daily lives will achieve this goal. The proposed system supports people, including loved ones and appointments, with job reminders and medicine reminders. These six parameters are the most important for a dementia patient who want to live alone without the help of their family members or attenders. These assistive technologies will reduce the burden and cost for governments of healthcare systems and also give patients their right to stay away from the hospital [8]. This is a simulation of all the required parameters but it is not the ultimate solution for them.

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Design of Vital Parameter Monitor and to Store Data in Excel Sheet Using LabVIEW

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Abstract. Now a day's there is a need to monitor the vital parameters of one on a regular basis. And hence real-time monitoring or easy monitoring of physiological parameters is important. Today in this paper, we introduce to you a LabVIEW based approach for monitoring the vital parameters of an individual. The vital parameters measured in this work are Electrocardiogram (ECG), Heart rate, Temperature, Respiration rate and Oxygen saturation (SpO₂). The parameters are obtained and displayed in the graphical user interface using LabVIEW. The measured values are then stored in an excel sheet to create a patient management database. The main feature of this monitoring software is that, its user friendly and has the feature to record your data. Using this recorded data, doctors can take major clinical decisions about the patient's health and condition.

Keywords- ECG, Monitoring, LabVIEW, Temperature, Heart rate, Oxygen concentration, Respiration rate, Simulation.

1. Introduction

This paper aims at designing software based patient monitoring system for the continuous monitoring of patients condition. In medical terms, monitoring is nothing but observing the physiological signs displayed by the patient monitor and detect any abnormal condition in the patients health. The monitoring is easier if more than one physiological parameter is being displayed on the patient monitor. And because of which in my current work, I have considered four important physiological parameters. They are, Electrocardiogram (ECG), Heart rate, Temperature and Oxygen saturation (SpO₂). This way of monitoring the patient is better than repeatedly performing medical tests. Patient monitors also save time and quickly doctors can reach to a conclusion in choosing the treatment. And to make this happen virtual instrumentation plays an important role by allowing engineers to simulate and create software's for this purpose.

LabVIEW is a graphical programming language that uses icons instead of lines of text to create applications. In contrast to text-based programming languages, where instructions determine program execution, LabVIEW uses data flow programming, where the flow of data determines execution order. LabVIEW programs are called Virtual Instruments, or VIs, because their appearance and operation imitate physical instruments, such as oscilloscopes and multimeters. LabVIEW contains a comprehensive set of tools for acquiring analyzing, displaying, and storing data, as well as tools to help you troubleshoot our code.

2. Acquisition and processing of physiological parameters

In this paper, we are going to acquire the signals by using Data Acquisition unit (DAQ) from LabVIEW for the measurement of temperature, and from temperature respiration rate is

formulated. For the measurement of ECG and further computation of heart rate from ECG and calculation of SpO₂ is done using Simulate ECG VI.

2.1 ECG Measurement

ECG measurement gives us the electrical activity of our heart and in turn can tell us different heart condition. The measurement of ECG is done by placing electrodes on the chest region of a patient. The ECG mainly consists of P wave, QRS complex and T wave. These waves tell a lot about the functioning of our heart.

For this project we will be making use of Simulate ECG VI to generate the ECG signal. The ECG signal is then filtered with a low pass filter using a Kaiser window. The wavelet denoise VI of advanced signal processing tool kit is used to remove the baseline wandering and wideband noise in the acquired ECG signal. Once the ECG signal is filtered the features like P interval, QRS interval, and T interval are extracted using the ECG feature extractor VI. Also the filtered ECG is displayed in the graphical user interface.

2.2 Heart rate and SpO₂ Measurement

By studying the rhythm of heart via ECG measurement, the heart rate can be easily calculated. The normal heart rate for healthy adults ranges from 60 to 100 beats per minute. The pulse rate may fluctuate and increase with exercise, illness, injury, and emotions. By using this knowledge we can calculate the heart rate from ECG signal. The block diagram is shown in the later section. The high and low heart rate are also monitored.

Next is the calculation of Oxygen concentration (SpO₂) in blood using heart rate of the patient. There is a study involved for calculating SpO₂ from the heart rate of the patient. Using this knowledge the SpO₂ calculation is formulated in LabVIEW. The high and low range of SpO₂ is also taken care of. The block diagram is shown in the later section.

2.3 Temperature and Respiration rate Measurement

Usually the body temperature is calculated using a thermometer by place it in mouth, ear, armpit or even rectum. The normal body temperature of a person varies depending on the gender, recent activity, food consumption and etc. The normal body temperature ranges from 97.8 degrees F to 99 degrees F for a healthy adult. Using this information, DAQ can be configured accordingly. We have configured Thermistor channel in this case and the values are set from 31 degree C to 39 degree C. This outputs the temperature signal.

Using body temperature the respiration of an individual can be calculated. The measurement steps are carried out in LabVIEW and the respiration rate is displayed. The normal respiration rate of a person lies from 12-16 breaths per minute. If the rate is too low i.e. below 12, it is called bradypnea. And if it is above 16, it is called tachypnea. This measurement is also done and proper indications are given.

3. Database Management

The computed values are stored in excel file for record purpose. For this, LabVIEW has many tools which carry out this function. We have used write demilitated spreadsheet VI here. The input to this VI is a strings of data. As soon as we run the code, the program ask for file name for data to be stored in and when the program is stopped all the calculated values over the time is stored. The VI looks as shown in the figure below.

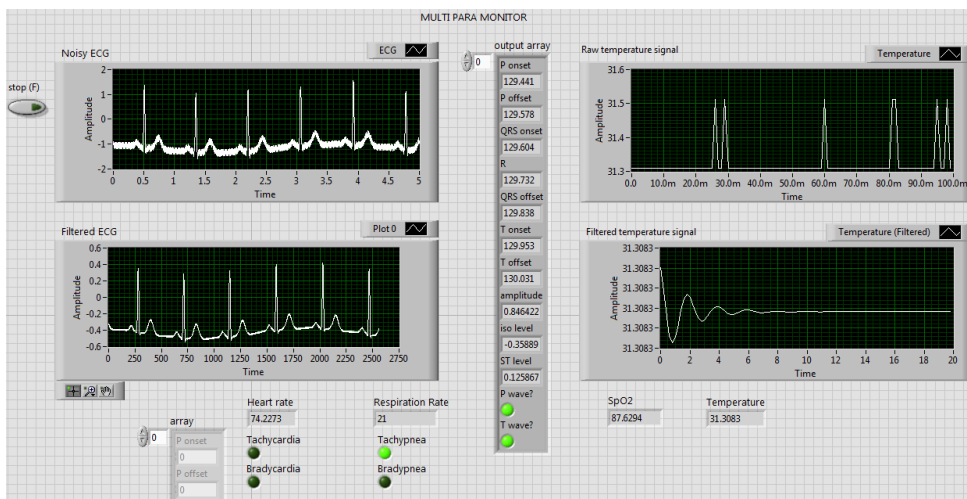


Fig2. Front panel of multi-para monitor in LabVIEW

4. Result and conclusion

The program is successfully implemented in LabVIEW and all the vital signs were measured. The stored data provides an ease of understanding of the patients health and any abnormal condition and hence can help physicians in better decision making and providing high-quality care.

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Galvanic Skin Response for Detecting Emotional Arousal and Stress

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Abstract. Human emotions are very difficult to decode and study as there are several factors leading to their intensification. Due to the daily stresses we all face in our day-to-day life we tend to ignore a lot of serious details about our emotional state and mental health. Galvanic skin response (GSR) is one of the very effective mediums to get a deep insight in the person's emotional state. GSR is also called electrodermal skin activity. It refers to the changes in sweat gland activity due to the intensity of emotions that is also known as emotional arousal. This project mainly focuses on the simulation and monitoring of GSR of a person. LabVIEW was used as virtual instrumentation software to simulate the signal, add other signals which belong to the sympathetic nervous system and study the change in skin conductance which is indicative of the nature of a person's emotional state. This can be very useful in today's time and age as everyone is leading a very stressful life and in times like these, if one could monitor their stress levels it would give them an insight and they could change their lifestyle and behavior accordingly.

Keywords. Emotional arousal, Stress, Skin conductance, Galvanic Skin Response, LabVIEW.

1. Introduction

Just going to the gym, having big muscles and a lean body does not make a person healthy. Not only physical but also mental health is important for a healthy body and healthy life. Being stress free is as important as having a good diet and regular exercise is. Mental health is often neglected when it comes to taking care of ourselves. Moreover it is considered to be a taboo. People are afraid of discussing their stress with someone just because they think people will make fun of them or they'll think that the person having some mental health issues is mad. Humans are social animals so living with harmony and understanding each other in good and bad times is the least that is expected of us.

Humans are often prone to errors and this also implies while recognizing the emotions of other people. There are a lot of people who hide their feelings and are stressed from inside but don't tell anyone. This could harm them in many ways in the long run. Every year there are a lot of cases of suicide or people leaving their jobs and other such situations happening to people and the main reason is stress. We tend to get easily overwhelmed by some situations which affect our emotional state. It affects both personal as well as professional life of a person. Considering how busy and hectic our lives are Human emotions are very difficult to analyze as there are a number of factors that are responsible for how we react to certain situations and this response changes the intensity of our emotions. Emotional intensity can indicate how the person is feeling at a moment and even the amount of stress a person has. Emotional intensity can be different for different people in response to the same situation. This makes the study an even harder nut to crack. If we could know that we or someone we know is going through stress there is a chance that we could help them in some way or even help ourselves to better our lives and lifestyles.

There are a number of ways in which we can peep into one's emotional and mental state. Of course the primary and age-old method is just observing the behavioral pattern of the person how they behave or react to a certain situation. But some people especially introverts are used to keeping their troubles to themselves and don't share much with others. In this case it becomes very difficult to understand a person. There is a need for a technological help that could help us know more about people and also about our health also. Galvanic skin response is one such not every much explored signal by our body which is indicative of our emotional changes. Galvanic skin response is the electro-dermal activity of our skin which is controlled by the autonomic nervous system. Autonomic nervous system regulates the involuntary processes of our body like body temperature, heart rate, blood pressure, digestion, galvanic skin response etc. It is broadly divided into two categories-Parasympathetic and sympathetic. Sweat gland secretion falls under the sympathetic nervous system. Sympathetic nervous system regulates the involuntary response in stressful or dangerous situations. Whenever sweat glands are triggered, they become more active leading to a change in ionic balance in the secreted fluid due to which the electrical current flows more readily, resulting in measurable changes in skin conductance. This change in skin conductance is termed Galvanic Skin Response (GSR).

While sweat secretion plays a major role in thermoregulation, the changes in skin conductance are also triggered immensely by emotional stimulation. The higher the emotional arousal, higher is the skin conductance. The level of our emotional arousal is majorly dependent on our surroundings – whether something is scary, threatening, joyful, or emotionally relevant in any way, and then the corresponding change in emotional response that we experience also increases sweat gland activity. Research has shown how the sweat gland activity is linked to emotional arousal. Both positive and negative stimuli whether it is happy, joyful, threatening or saddening can result in an increase in emotional arousal and therefore an increase in the skin conductance. The Galvanic Skin Response signal is therefore not representative of the type of emotion, but the intensity of it. By the increased intensity of the GSR signal, the intensity of one's emotional arousal can be predicted. It is also used during interrogation process for criminals.

Even though this method is very famously used for lie detection, its application is not only restricted to this alone. In lie detection test which is also called the polygraph test, the subject most commonly a criminal is made to go through a test in which he's asked some questions and based on the GSR signals received while he gives the answers are acquired which helps in finding out whether the person is saying the truth or not. The application of GSR goes far beyond lie detection- in assessing several mental disorders, stress and many other health issues. It is a subject which interests a lot of scientists who work in the field of psychological issues.

GSR SENSOR

Using GSR sensors is very easy. Just use two electrodes, in this case very tiny electrodes can also be used made up of silver/silver chloride. Then apply a very small but constant voltage to them, now measure the voltage difference between them and then find the corresponding skin conductance. GSR signals are measured by detecting the electrical activity changes resulting from the sweat gland activity changes. So the electrodes used must be sensitive to these changes, and should be able to transmit the collected information to a recording device. Most of the GSR electrodes nowadays are made using Ag/AgCl (silver-chloride) as the contact point with the skin. Ag/AgCl electrodes are the best choice for this as they are cheap, robust and safe for human contact; it can also accurately transmit the signal from the electro-dermal activity of the skin. Some electrodes available in the market also come

pre-packaged with ionic gel that can increase the signal fidelity, or otherwise the ionic gel can be applied to achieve the same effect. After acquiring the signal the data is either stored within the device to be later uploaded or is transmitted wirelessly to a computer system, or the signal is sent through a further wired connection to a computer. Different types of GSR sensors allow different means of transmission depending on the kind of research is to be carried out. The skin conductance data is acquired and is measured in units of micro-Siemens (μS). This data can later be used for a number of purposes.

LabVIEW

Laboratory Virtual Instrument Engineering Workbench (LabVIEW) was developed by National Instruments. It is an engineering software and a visual programming language that can be used to design, measure, test and analyse either simulated or real data. It is a development software and not a coding language. Here, in this paper it is the main tool used as the entire project was done using LabVIEW. It is very easy to use software and can give us the possible results a long before implementing the device in hardware. So, it can be made sure before putting the device in hardware that there are no errors. It saves a lot of effort, time and money that otherwise is wasted if we directly implement our ideas into hardware. Also direct implementation takes time as we don't know if a particular idea would work or not or if it is practically possible. This leads to a lot of wastage which can easily be avoided by using a virtual instrumentation software like labVIEW.

2. Literature Review

GSR is a very old concept but combining it with technology is the main aspect on which researchers are working on.

Ming Zher Phoet.al built a novel wrist worn device for unobtrusive continuous measurement of GSR. This is one of the first attempts which successfully built a daily wear device to monitor GSR. The author validates the fact that the region to tap GSR signals need not be restricted to the palms or feet alone, the distal forearm region shows strong correlation with signals from the palm or feet. Further, the authors validate that the signal varies for various activities performed by the human and also investigate the use of these signals in assessing the onset of epileptic seizures.

A.M Amiri et al., investigate the relation between external stimulus and physiological response data. Along with GSR, ECG and respiration rate are also monitored to find the best emotional reactivity feature that can be considered best to consider as suicide factor. Data is acquired using Biopac MP150 interfaced to a computer. Participants undergo 15 minutes of baseline resting before administration of the stimulus. The authors prove that physiological data can be very useful in assessing suicidal tendencies. A few researchers have estimated sleeps period time using GSR. GSR signal acquisition is done using BIOPAC systems with the sensors attached to the middle joint of the middle and ring finger of the dominant hand and sleep wake transitions were monitored to detect sleep disorders like sleep apnea. The authors have accurate the detection of sleep onset and offset times.

Greco. et.al have considered investigating how changes in autonomic nervous system activity can be correlated with clinical mood swings to detect bipolar disorder in humans. The authors conclude that variations in GSR components maybe a suitable indicator for discriminating mood states for bipolar disorder.

In [1], the authors performed experiments under stress and no stress conditions on 14 subjects, both male and female from 18 to 28 years old. Their observations demonstrate a strong relationship between measured GSR signals and the corresponding human

physiological states. They used LabVIEW for making the virtual device and MATLAB software for calculation of features. In [2] the authors evaluated the physiological response of students towards e-learning materials. The experiments were conducted by introducing two separate e-learning materials, one was interactive material and the other was non-interactive. They used different feature extraction methods to know which one of them gives accurate results. In [3], the authors built sensor for detecting stress based on Galvanic Skin Response (GSR) controlled by ZigBee. In order to check the device's performance, they used 16 adults who were given tests requiring an effort, such as mathematical operations or breathing deeply. On completion, they concluded that GSR is able to detect different emotional states of each person with an accuracy of 76.56%. In [5], the authors have studied the relationship between skin resistance changes and pain resistance. In [6], the authors have tried to bridge the gaps in detecting both types of driver distraction are that the interactions of visual and cognitive distractions and also they have developed an algorithm to detect the different types of distractions.

In [7], the authors have discussed various methods of emotional state detection and they also have developed practical applications using Internet of things (IoT) and computing systems. In [8], the authors have used electrodermal activity to decide whether the person is drowsy or not. They developed a device to detect and alert a driver when detected drowsy using sweat as the parameter. [9] is a website of a manufacturer of various sensors one of which is the GSR sensor. It explains in detail the working and need for a GSR sensor. They also have explained about the GSR signals, how they are acquired, how they can be processed and used for our purpose. In [10], the authors have focussed on the effect of physical activity on galvanic skin response. In [11], the authors have developed a stress detection device using low cost heart rate sensors. On the basis of the change in heart rate of the subject stress was detected. In [12], the authors have used heart rate and galvanic skin response to get information about the state of mind of a person. Their system is based on fuzzy logic.

There are a lot of such examples where GSR signals have been used to detect mood swings, sleepapnea, psychological disorders and stress in general. So, monitoring GSR signals can be very beneficial for psychologists and also for personal use of people. This field of research has yet many more miles to go. Researchers are trying to bring such a device into reality that can accurately detect the stress levels of people.

3. Methods and Methodology

In this paper, a LabVIEW based model of GSR sensor was made and then other signals responsible for the emotional sweating were collectively analysed. Through this it would be possible to know the emotional arousal and stress levels of a person. First of all, the signal for GSR was simulated using a DAQ Assistant. DAQ Assistant comes very handy when we have to simulate any signal in LabVIEW. It is a very simple procedure; we just have to choose the channels we want, set the minimum and maximum values, the scale, units, acquisition time, number of samples and the sampling rate. All this can be done by just using one block i.e. DAQ Assistant. It helps simulating a signal with the range of values provided by us.

ALGORITHM

- Open a blank LabVIEW VI (Virtual Instrumentation).
- Go to the block diagram window and bring a DAQ assistant. Double click on it to make the channels and necessary settings.

- In this case, two channels were taken in the DAQ Assistant, one for current and the other for voltage. Put the DAQ Assistant in a while loop as we want the signals to be acquired continuously.
- As shown in Figure 1, the signal coming out of the DAQ is connected to a filter. A low pass filter with cut off frequency = 35 Hz was taken as bio signals are very weak signals and we want to detect even the slightest amount of signal produced.
- After filtering, the signal was split into two signals so that signals from both the channels can be segregated. The first one corresponds to the first channel and the second corresponds to the second channel.
- Then a formula block is used to apply a very simple formula to the signals from the two channels to get skin conductance by using the formula

$$\text{Conductance} = \text{Current}/\text{Voltage}$$

- Two separate signals were simulated, one for ECG and the other for BP using simulate biosignals block from the biomedical toolkit. Required settings were done for simulating the ECG to get the required heart rate and BP.
- The three newly formed signals namely, Conductance, ECG and BP are merged with each other using append signals block. The final signal obtained is tested for the number of peaks using the peak detector. Divide the number of peaks obtained by 60 in order to change to peaks per minute.
- Add a slider to mimic real-time changes in the signal and display the number of peaks per minute.
- Set values for the device to show relaxed, activated and aroused Boolean LEDs.
- Make sure all the connections are correct.
- Check for errors and broken wires. Rectify if any.
- Go to the front panel and adjust the blocks to get their better presentation.
- Run the VI.

Figure 1 is the block diagram of the VI. It shows how all the blocks are connected as discussed in the algorithm discussed above.

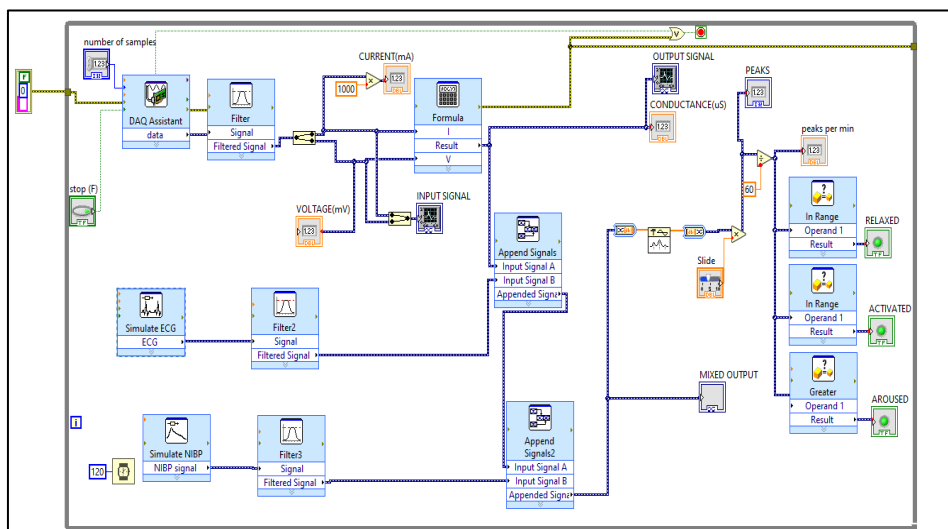


Fig. 1 Block diagram

4. Results

This VI can tell about the emotional state of the person by detecting the change in the number of peaks of the obtained signal. The number of peaks or rather the increase in number of peaks is indicative of whether the person is emotionally relaxed, activated or aroused. A horizontal slide has also been added in order to mimic a real time change in the combined GSR signal. All these categories can be easily mapped; if the number of peaks is normal i.e. when the slider is at its starting point (0), the person is at relaxed state. If the slider is moved, which is similar to a situation in which a person's GSR, heart rate or BP increases then we can see an increase in the number of peaks. If the increase is very little than the normal then the person can be considered to be in activated state. But if there is a drastic increase in the number of peaks then the person is considered to be in aroused state.

Now aroused state can be anyone of the extreme emotions, the person might be extremely happy, extremely sad, extremely angry, etc. this is a very simple and clear method to get an indication of the emotional state of a person (as shown in figure 2). This device in combination with physically examining the person can give a better insight into the person's emotional state.

Figure 2 is the front panel of the VI which is the representation of the device. It is the user interface which helps the user to understand and analyse the results of the VI. On the front panel one can easily visualise the results and interpret the consequences. It is just like a physical device would be. The difference is that it is a virtual device i.e. a device made in a computer using some software to function like a real device.

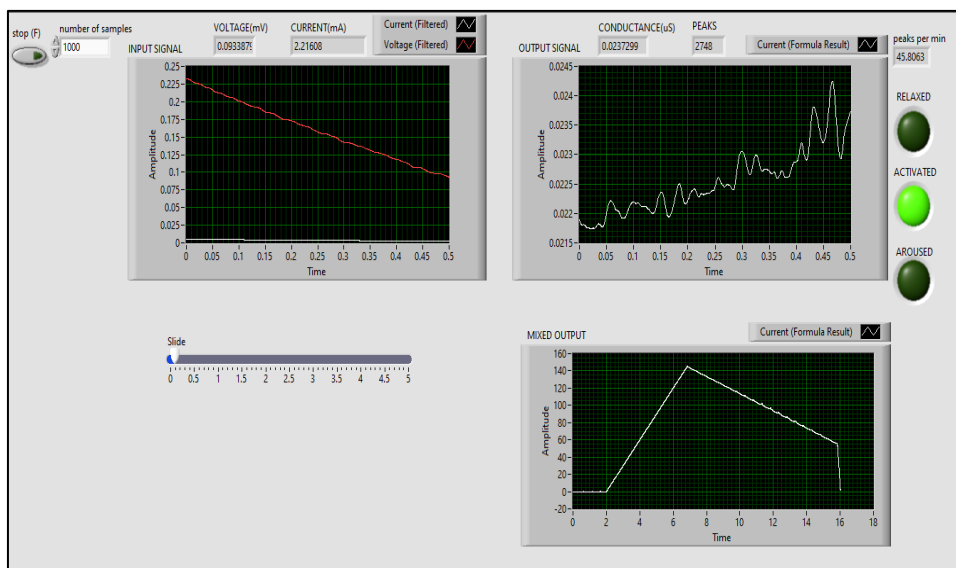


Fig. 2. Front panel

5. Discussion and Conclusion

The crux of this project was to simulate a real time monitoring system of emotional state and stress of a person. Through this study, the emotional state in terms of the increase in the number of peaks can be known very easily. This device can also be implemented into an

actual device and not just a simulation. For that we have to connect DAQ hardware and the GSR sensor to our computer and then we can analyse it in LabVIEW using our VI.

Every person reacts differently in a given situation so “One size fits all” is not the case here. So, the method of analysing the pattern of increase in the number of peaks gives us a clear indication of how the person/patient is feeling. By subjecting people to different situations like photos, videos or verbal cue which reminds them of a childhood memory or a memory that traumatises them. Hence, we can notice how differently they behave in different situations. This can be particularly useful for psychologists and counsellors during their therapy sessions. It can help them better understand their patient’s situation.

GSR monitoring can also be beneficial to the common people. If GSR is included in a wearable device people can monitor their stress at home and if there’s any alarming situation or even the indication of stress they can try to change their lifestyle and try to indulge in therapeutic activities like exercise, yoga, dancing or anything that calms them down and elevates their mood.

The main motivation for this study was bringing the importance of mental health to the attention of people and also knowing that along with keeping our bodies healthy physically healthy we also have to be mentally healthy. So for that such a device that can measure our stress levels can be of great help. In a world full of wearable devices which can be used to count our number of steps, heart rate, and what not this device which is capable of measuring stress using galvanic skin response needs to be introduced to people.

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Knee Braces for Prevention of Unilateral Knee Osteoarthritis-KOA

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Abstract. Unilateral knee osteoarthritis is a long-lasting joint condition caused by wearing down of knee cartilage which is leading factor of pain and disability occurring in 10% of men and 13% women aged above 55 years. This can't be cured completely, but the technologies can delay the progression of condition. Studies shows that knee orthoses have a direct biomechanical control over the knee. Earlier metal type knee orthoses will be uncomfortable due to its weight and side effects. The newly designed doesn't have gait monitoring ability, causing delay in rehabilitation. This demands re-design of knee orthoses for improving its functionality. The proposed design will be a single-unloading wearable orthosis with a flexible frame extended to foot and thigh for support, opening around the kneecap and a ligament protection pad. The material used is carbon fiber. Along with improving biomechanics, it can be designed with provision for transcutaneous electrical stimulation (TENS) for treatment. During the gait training, brace may be coordinated with walking aids to give feedback to user in cases of excessive loading which in turn aid in diagnosing the progression of the condition. Thus, the brace can be for gait monitoring and with stimulator it will be providing therapeutic effect.

Keywords. Knee Osteoarthritis, Braces, Gait rehabilitation, TENS, Force sensitive resistor

1. Introduction

Osteoarthritis is a long-lasting joint condition which is not reversible due to wearing down of cartilage of hip, knee or other joints. Studies conducted in United Nations says that by 2050, worldwide 130 million people will suffer from OA, out of these 40 million will be severely disabled by this. Knee osteoarthritis (KOA) is the most prevalent and is a leading cause of pain and disability which occurs in 10% men and 13% in women aged 55 years or older. Some people get OA in just one knee, known as unilateral KOA. It can't be cured completely, but can delay the progression of condition. OA can cause softening of affected knee cartilage, cushioning buffer that it provides disappears causing bones within joint rubs together and loss protection. This damage can accumulate over time and cause wear and tear, increase chances of fracture as well.

Stages of Knee OA:

- First stage: healthy cartilage and joint is movable
- Second stage: cartilage begin to wear, thinner cracks on surface
- Third stage: this gap expands and reach bone
- Fourth stage: complete loss of cartilage and bone-bone contact, leads to cyst and bone spur.

OA has an impact on the individual patient, resulting in pain and disability due to which patients are no longer able to do daily tasks or work and its economic burden on patients and society is considerable.



Fig 1. Comparison of healthy knee joint and osteoarthritis knee joint
(Source: coreconcepts.com)

2. Prevention of Knee Osteoarthritis

Prevention strategies are intended to prevent the onset of KOA by risk reduction, altering exposures that can lead to this. Prevention of knee injury is the first and foremost way of prevention of KOA. Secondary prevention includes diet control and exercise in individuals who have impaired muscle function or prior joint injury. Tertiary prevention involves early treatment of OA to prevent progression of the disease using assistive devices.

Physical therapy and Occupational therapy has an important role in KOA management. Exercises are to strengthen the muscles around knee joint, increase flexibility and reduce pain. Occupational therapy is done to improve motor skills without putting extra stress on already painful joint.

3. Current technologies in OA management and their limitations:

- **Technology in exercise therapy:** A short message service intervention to support adherence to self-directed home-based strengthening exercise for people with KOA, designed with the behavior change wheel framework is recently developed. This provides a clear framework to develop a targeted intervention to exercise adherence in people with knee osteoarthritis [3]. This has got several limitations including, the SMS delivery mode requires users to have adequate vision, user should know English language, access to a mobile phone, and ability to use the SMS function on their phone.
- **Electrical stimulation:** Transcutaneous electrical nerve stimulation (TENS) uses a low-voltage electrical current to providing a short-term relief for people having osteoarthritis in knee and hip area. An electro-therapy with stimulator using low-intensity pulsed ultrasound (LIPUS) combined with TENS in patients with painful knee osteoarthritis (OA) is designed currently. It provides 50% of the stimulation by LIPUS, and remaining by TENS where the current intensity was set to produce a strong tingling

sensation, for effective cartilage regeneration and pain relief, physical functional improvement.[2] But the result of study is that effects of a stimulator using LIPUS with TENS on pain relief and functional improvement were not superior to the only TENS therapy.

- **Neuromuscular and proprioceptive training programs:** Primary prevention of knee OA is possible for regaining impaired muscle associated with KOA for 50% of major knee injuries during sport. The targets for improvement are postural control, proprioception, muscle activation, muscle strength and coordination [5].
- **Electroacupuncture:** Electroacupuncture is commonly used to improve the symptoms in patients with KOA for regaining balance and reduce the risk of fall. In the recent assessment, results giving an indication that EA as not a conservative treatment to improve the dynamic balance.[12]
- **Nanotechnology and nanomedicine:** Currently, nanoparticles are used for diagnosis and management of KOA. Magnetic NPs, photoacoustic imaging, Quantum dots aids in OA diagnosis and nanomaterial biosensors or biomarkers to early diagnosis. NPs containing anti-inflammatory drugs and proteins are able to release some therapeutics in a prolonged fashion, ensuring sustained release and delivery for pain relief. [4] These nanocomposites are currently under scrutiny and also costly procedure. While using for pain relief, higher doses drugs may increase the side effects.
- **Assistive devices:** Assistive devices can help relieve stress on knee joints.

Braces, Shoe inserts and orthoses: Braces are mainly of 2 types- unloader braces, takes the weight away from the side of the affected knee and support braces which can provide support for the entire knee.

A novel smart assistive knee brace mechanism is developed with wire actuators made of shape memory alloys to address issues associated with weight and flexibility of existing brace designs. The proposed orthosis includes pressure sensor, shape memory actuator, and smart linkage to overcome the weight of the lower limb during swing phase. But the braces design will be complex structure with the electromagnetic relay and wires [11]. Shoe inserts or other devices might help reduce pain when standing or walk. OA inspired specialized footwear are designed to reduce the load placed on the knee joint during ambulatory activities by changing joint alignment and redistributing loading location within the joint. Lateral wedge insole foot ware is designed for this purpose [6]. Knee malalignment and associated pain may be reduced by the use of foot orthoses which alter knee alignment by changing the position of the tibia. Knee orthoses increase the distance a client can walk and may delay the need for surgical intervention [7]. Recently prototype for a new pneumatic knee orthosis (PKO) is developed to support the knee by increasing the pneumatic pressure in the stance phase of walking. Force-sensing resistor sensors and air cuff are used to detect foot pressures and retains pressure to support the knee in real time [8]. Valgus braces (for medial knee loading) and lateral-wedge orthotics (force to foot towards pronated position) have been tested in patients who had medial knee OA. This combination, or the brace alone, decreases pain and somewhat shifts the load in the knee from the medial to the lateral side of the knee which might delay or prevent the onset of OA [5].

Crutches and canes: A cane/crutches can take weight off knee when standing or walking providing a support to the user. Patient can hold the cane in the hand opposite the leg that hurts due to their injury. of cane may reduce risk of KOA progression. Recent days instrumented crutches and canes are designed which is able to measure gait parameters and provides self-monitoring facilities. The smart crutches/cane be adjusted for each user by taking

user's health details like BMI, knee pain etc., while the normal cane is non-adjustable. In such a design of cane which have real time monitoring feature, load exerted on the joint is measured and instruct user about the maximum number of steps the user should walk.[10]

Non-operative treatment can prevent KOA progression to a greater extend. Physiotherapy, acupuncture, TENs, magnetotherapy are procedures with minimal effect or may provide moderate benefit for KOA patients for pain relief. These strategies could be used to prevent future OA, but poor compliance is currently a problem and further development of devices and clinical studies are needed.

4. Design consideration

The use of assistive devices, especially during exercise can relieve pain and thus improve functionality and increase patient motivation. But there is a chance that long-term use of assistive devices may cause discomfort or even side effects. Among the biomechanical interventions, knee braces/orthoses are found to be a better choice in altering contact stress, suggesting way to prevent or delay KOA. Modification in the design of braces can further improve KOA management.

In designing such a device focus should be on:

1. A wearable device which will that reduces knee loading and remind users to maintain unloading gait pattern giving a feedback.
2. Design to relieve knee pain by KOA with dynamic mechanisms for protection of joints.
3. Design that doesn't cause muscle movement restrictions
4. Design with light and soft materials to increase comfort and aesthetics

5. Proposed design and implementation

The design will be a single upright unloading wearable orthoses with a flexible frame around knee which is extended to foot via elastic band and extended across the thigh for support. There will be two pairs of straps: 2 straps for thigh and 2 for knee region. Elastic band can form assistive abduction moment. Design is in such a way that, there will be opening around the kneecap and a ligament protection pad that can press on the tibia helps in minimising the rotation of knee. The material used may be carbon fibre so as to be light weight, breathable and stretchable. Carbon fibre also adds strength and abrasion resistance.

a. TENS circuit and Timer

Along with improving biomechanics, it can be designed with an add on like a space for placing the electrodes pad inside the brace at right position so as to provide transcutaneous electrical stimulation for treatment from an external pocket-sized electrical signal generating module. A battery operated; single-channel stimulator can be designed.

It is recommended to keep the pads attached to the painful knee region and activating the TENS unit on and off as necessary or as advised by the physiotherapist. Research has shown that both high-frequency (50–100 Hz) and low-frequency (2–10 Hz) TENS are helpful in decreasing the pain due to osteoarthritis by causing the muscle to contract, thereby allowing muscles to maintain strength and muscle tone that may atrophy from disuse and it can help increase a user range of motion.

The circuit consists of CMOS 555 timer to produce a pulse which is then fed to a transformer, with a capacitor it will make a parallel resonant circuit and the pulse width can

be adjusted using a potentiometer which is connected to the on-off switch. Wider pulses produce higher output voltages and the peak voltage obtained from this circuit is up to 200 V. For knee being a less sensitive part, it needs a higher voltage and hence a correspondingly higher potentiometer setting can be done.

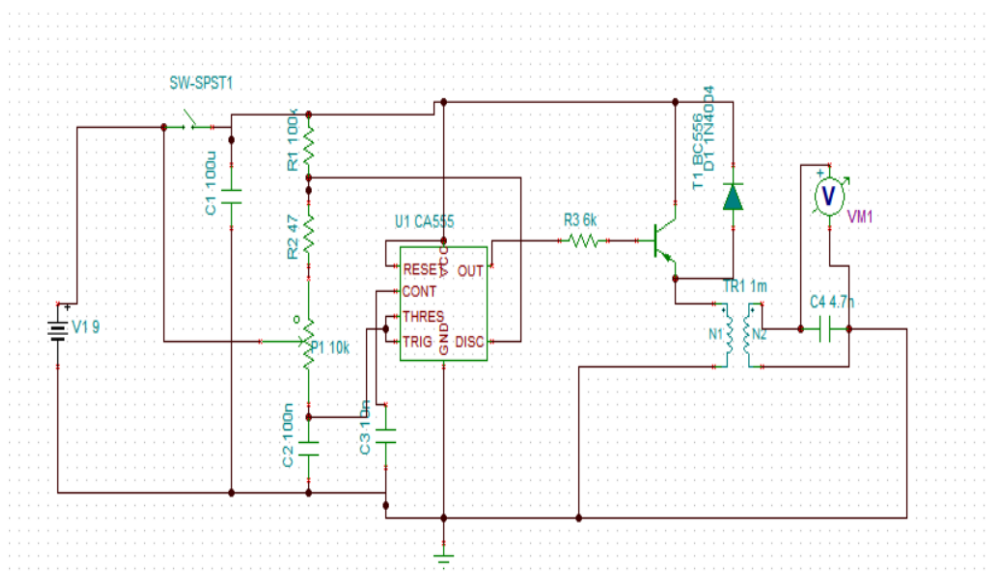


Fig 2. Simulation of TENS done in TINA software

A timer with a separate switch and a 9V DC battery may be included in same cabinet as the stimulator, using NE555 wired in monostable mode. Initially, when switch is on, the monostable triggers and its output goes high for 10 minutes. Thereafter, its output goes low to light up the red LED indicating that muscle stimulation time is over.

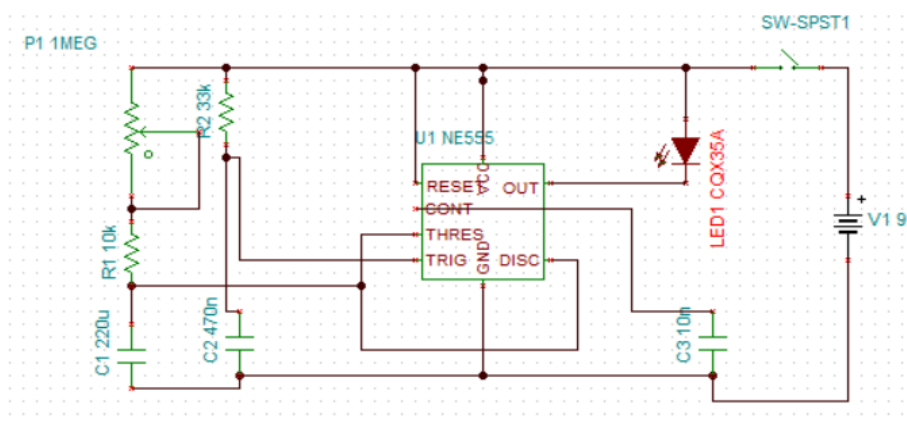


Fig 3. Simulation of timer done in TINA software

b. Diagnosing excessive loading on Knee

During gait training, use of this brace may be coordinated with walking aids which can give feedback to user in cases of excessive loading on knee using a force sensitive resistors which can be arranged in the foot portion and to study the gait pattern from the foot pressure, which will aid in diagnosing the progression of the condition.

Patients with KOA have pain when the load is on the medial side of their knee resulting in narrowing of the joint gap. For mitigating this, an abnormal gait is observed in those individual. Such posture can be a reason for increasing lateral foot pressure and increasing the knee compressive force. The knee adduction moment (KAM) is commonly measured from the ground reaction force (GRF). For this an Arduino control system can be developed for determining the gait phase in real time by analysing the foot pressure distribution.

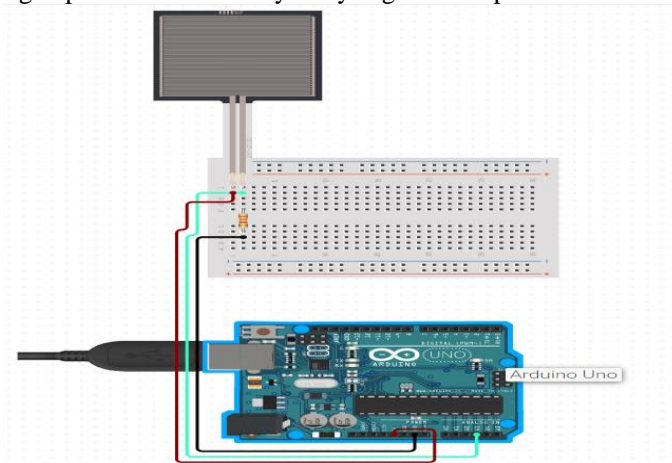


Fig 4. FSR interface with an arduino board

6. Result and Conclusion

From the literature review, it is observed that knee orthoses provide direct biomechanical control over the knee. So a design modification of wearable knee orthoses for KOA is proposed which can help in unloading and having usage monitoring and therapeutic effect. This brace with joint stimulator design is supposed to have positive outcomes when compared to existing assistive devices. The purpose of this project is to develop an assistive device which relieves painful symptoms of unilateral knee osteoarthritis by reducing knee loading along with providing comfort and providing feedback for gait assessment.

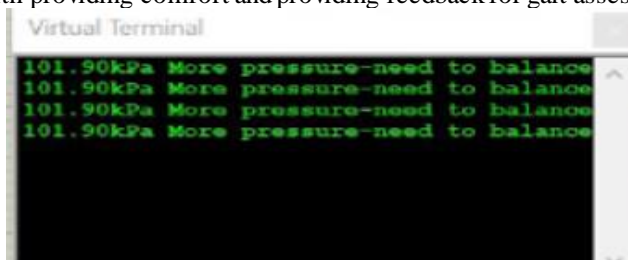


Fig 5. Output of the force measuring unit suggesting the user to balance his weight by transferring force to the other leg.

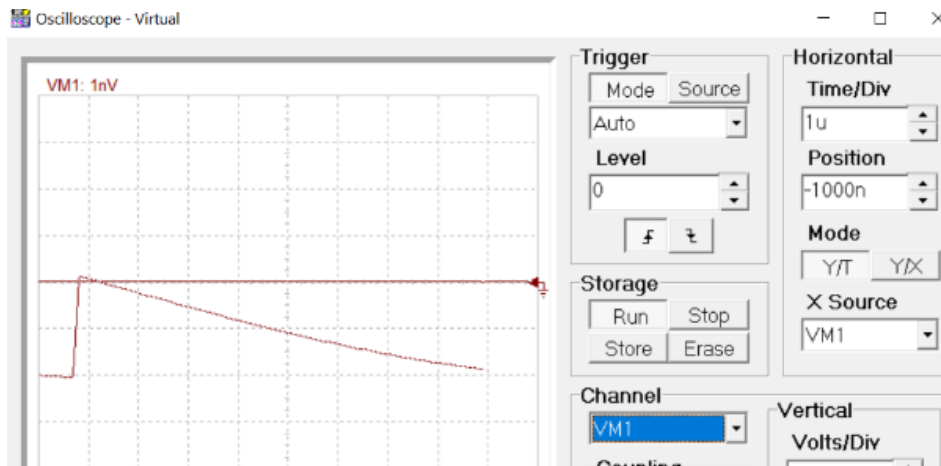


Fig 6. A damping kind of waveform obtained in the Oscilloscope for the TENS circuit

This design is intended to:

- Reduce the contact loads and friction
- Reduce pain, swelling and delay progression of KOA
- Improve comfort since material is soft and breathable
- Brace with stimulator for providing therapeutic effect
- It can be used alongside a rehabilitation exercise for gait monitoring

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Nerve Stimulator to Prevent Deep Vein Thrombosis in Bed-ridden Patients

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Abstract. Deep Vein Thrombosis is the most common condition among bedridden patients generally occurs in the legs. This happens when you are not able to move your leg for a longer period due to some reasons like serious operations or after an accident or complete bed rest conditions. DVT can cause blood clots in veins which can break into small pieces and travel into the entire circulatory system and wedged into the lungs which may cause a pulmonary embolism. To avoid that we designed a system where the electrical stimulation is given to the nerve which is associated with the calf muscle of the legs, due to this activity muscle contracts and relaxes which can create pressure on veins this continues the blood flow and results in the prevention of DVT.

Keywords. DVT, blood clot, nerve, calf muscle, electrical stimulation.

1. Introduction

Deep Vein Thrombosis (DVT) is a formation of blood clots in the veins. This type of disease generally occurs in patient legs or in pelvic veins. Deep Vein Thrombosis can be caused due to several reasons like major surgery, old age, obesity or if the person is on complete bed rest. Symptoms of DVT are cramping pain in leg, swelling, warm skin around affected area and colour change of skin. Traditionally DVT can be treated by blood thinners, clot busters, filters and compression stockings but all these treatments are time consuming and need to check from doctors as per the appointments. To avoid and prevent this type of condition we need to develop a system which can prevent the formation of DVT in the legs. We developed a system which gives the electrical stimulation to calf muscle associated nerve due to this compression and relaxation of muscles takes place which creates the pressure around veins. This activity continues the blood flow in legs and DVT can be prevented.

2. Literature review

Existing Approaches – Several systems are developed to treat and prevent the DVT [1] [2] in patients. These systems work on the pneumatic compression techniques [3] [4] along with the mechanical systems the electrical systems are also used during the surgeries [5], after critical surgeries [6] the patients are confined to bed for longer period which stops the movement of legs due to restrictions to prevent DVT in such case the external mechanisms [7] are used by merging 2 or more entities to make wearable one like socks [8] [9]. These mechanical systems are used for the movements of leg joints like a robotic system due to this the blood flows [10] continuously in the legs which automatically prevents the DVT.

Proposed System – A Wearable device was developed which can be connected to the body through the electrodes, the position of electrodes varies based on the patient which was

connected to the back side of legs on the calf muscles were the associated nerve stimulate for the movement of leg muscles. This activity creates the compression and relaxation on the veins which leads the movement of blood in the veins. The main function of this device is to prevent formation of blood clot in the veins. The device consists of Power supply, IC555, Transistor and Transformer for the step-up function to give sharp stimulation.

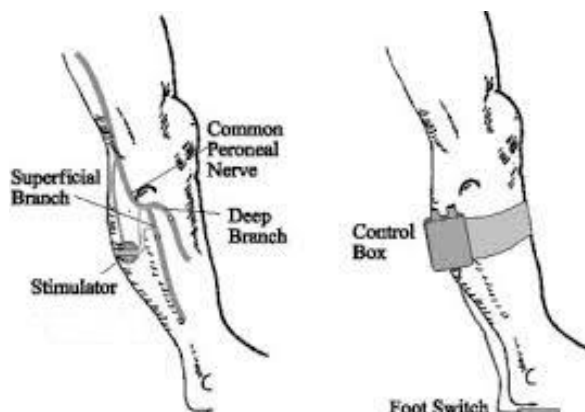


Fig. 1. Two Channel Nerve Stimulator

The figure represented here is an actual arrangement of device where the stimulator device is connected to the leg with holding band, the switch was operated and controlled by patient or the caretakers.

3. Methodology

The whole system we have developed in the MULTISIM software as shown:

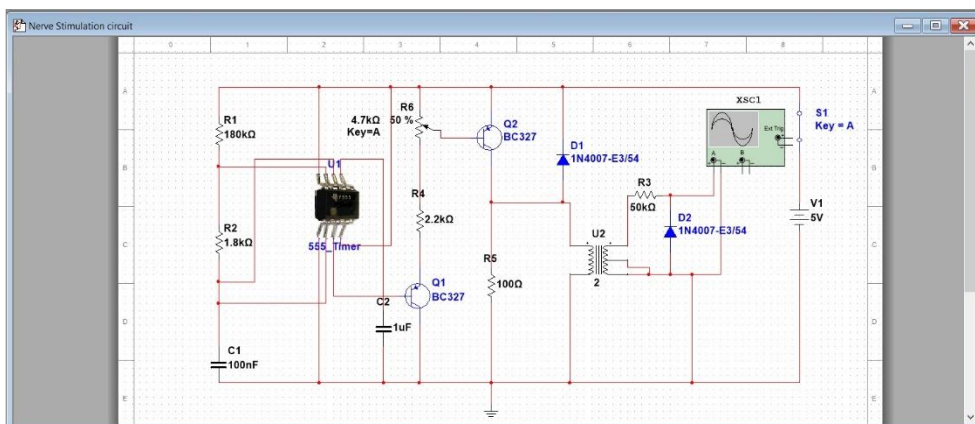


Fig. 2. Circuit Diagram

A. Use of timer IC555 circuit

It is an integrated circuit which is used to vary the timer, delay and pulse generation based on our requirements. Commercially it is used as SR flip flops and latched switches. It is a 8-pin IC which works as Astable, Monostable, Bistable and schmitt trigger, the design can be made with the combination of resistors and capacitors. Here capacitor is connected between ground and trigger with the combination of resistors in between threshold and discharge to generate the pulse with particular threshold and discharging time.

B. Function of transistor circuit

It is a semiconductor device generally used for the amplification in circuits or act as a switch for electronics signals and electrical power. BC327 was a PNP general purpose transistor with the feature of 800mA collector current. The output of timer IC555 was given to the base of transistor where the Emitter connected to the variable resistor and collector connected in between the ground and control pin of the IC555. And further the variable resistor connected to the base of the second transistor. The function of this whole assembly is to amplify the generated signal.

C. Transformer (Step-up)

Step-up transformer is used for the amplification of voltage from primary to secondary coil windings, this was connected in the circuit between collector and ground terminal of the circuit with the combination of diode to avoid the back flow of electric current from the transformer. The transformer is used to amplify the voltage from 220V to 250V by step-up principle.

D. Clipper circuit

Clipper is a standard circuit used to resist the signal from exceeding the predefined reference voltage level. This can be designed with the help of resistor-diode configuration. This is a wave shaping circuit with the help of this arrangement we can design the clipper as per our requirement by adjusting the resistor value of the clipper circuit. The end terminals of this arrangement can act as a nerve stimulator electrodes which can be connected to the patient near the calf muscle.

4. Result

The Output of the developed system is as shown in Fig. 3.

The pattern generated from the developed electrical system is shown above, this can be operated when the patients are not able to move their legs for a long time. The generated signal in red colour was actually the electrical impulses which are given to the patients around calf muscle for the movement of leg using associated nerve. The electrical impulses are timed impulses operated within period of time as shown after one another, this can be operated for a particular duration of time.

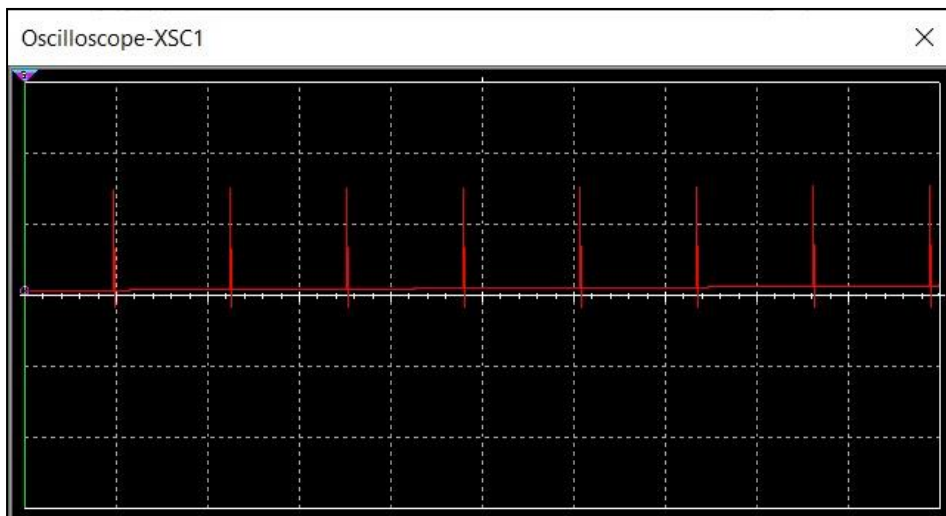


Fig. 3. Electrical stimulation

5. Conclusion

The project is based on the idea of electrical nerve stimulator to prevent deep vein thrombosis in bed ridden patients. As we know DVT can be very serious which leads the patient to serious casualty if not treated or prevented properly, hence to avoid that we designed a system where the whole system was connected to the patient through holding band with connecting electrodes. The automatic electrical stimulus was given to the affected areas by operating the system. This can be controlled by the patient or caretakers based on the condition of patient. The developed system is a simple and very efficient to prevent and treat the condition of DVT in Bed-ridden patients.

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Patient Monitoring System Using LabVIEW

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Abstract. A patient requires a health monitoring system in various situations to determine his/her health conditions. Rural areas where there is lack of medical professionals, they are tend to travel long distances to get proper treatment, hence by the use of IOT devices the patients Vitals can be transmitted through the Internet and the medical professions can view it from different places. This can also minimize the visit of elderly patients to hospitals. The paper reviews on the current trends in research on IOT based patient monitoring system. It describes the need and development of the concept. The concept used here is of simulation of patient vitals and measuring it using LabVIEW software. The use of LabVIEW is done to measure patient vitals such as Blood pressure, ECG, Temperature, BMI. This helps in identification and study of various diseases. This paper presents a LabVIEW based patient monitoring system.

Keywords. Biosensors, LabVIEW, Patient monitoring system, DAQ, Sensors, BMI, Temperature, Blood pressure, ECG.

1. Introduction

The purpose of this project is to make a Patient Monitoring system using LabVIEW. The LabVIEW is a software developed by National Instruments. It helps in monitoring continuously the vitals of the patients and provide the Information to the doctors to provide diagnosis to the patients. In this LabVIEW based Patient Monitoring system, the system first acquires the data, then analyze it, then process the analyzed data such as Blood pressure, Body Temperature, ECG(Electrocardiogram), BMI of the patient. In this the ECG is simulated using the Simulated ECG block, the Temperature is acquired from the simulated- DAQ (Data Acquisition Techniques) which consists a Thermistor to measure the body temperature. The Blood pressure and BMI is provided using the controls to provide our own data. The output from the data given is shown in the means of graph and Indicators. The Indicators indicate the warnings in case of any abnormality and also indicate the Normal values. This is used to analyze physiological parameters which is Important to determine a patients Wellness.

2. Literature survey

There are several reviews on patient Monitoring system, some of them have an Importance of Tele medicine. Such as Vandana Milind Rohokale et al[1] provided an IOT approach of Health observation and Management system which consists of detecting physiological parameters such as Blood pressure, Hemoglobin, Blood sugar, abnormal cellular growth in any part of the body. The major part of the paper is it is based on the RFID system. The IOT based RFID system is used to determine and management the objects via the WEB.

This paper amplifies the forward technique in how it saves energy which is achieved at low threshold. The disadvantage in this paper is the requirement of authentication and authorization which is required for IOT systems.

Thirumalasetty Sivakanth el al[2] provided a reconfigurable device network for the observation of structural health. This paper is based on the monitoring of the patient's vitals using NFC technology. The NFC technology fetches the patient's data and provide the information using the web top the doctors. This is a low cost and much effective health sensing device. The disadvantages of this paper are the NFC technology which is not secure and the use of web which provides information lately due to the web-based monitoring.

3. Propose system

In this paper we can understand that it is used to determine the physiological parameters of the body such as Blood pressure, Body Temperature, BMI (BODY MASS INDEX), ECG (ELECTROCARDIOGRAM). This project is fully based on a simulated patient monitoring system. The simulation of the patient monitoring system is fully done using the software LabVIEW, which is developed by National Instruments. LabVIEW is a user-friendly software. The LabVIEW is used to provide an GUI based environment which is simpler and cheaper by all means. The simulated - DAQ (DATA ACQUISITION TECHNIQUES) is used to measure the body temperature, for the measurement of the ECG the simulated ECG block is used and it is measured and shown in a graph. The measurement of the Body Mass Index (BMI) and Blood pressure is done using controls to change the values of the input and the output is shown by indicators. The Implementation of hardware can be done in the future with this method by means of IOT devices.

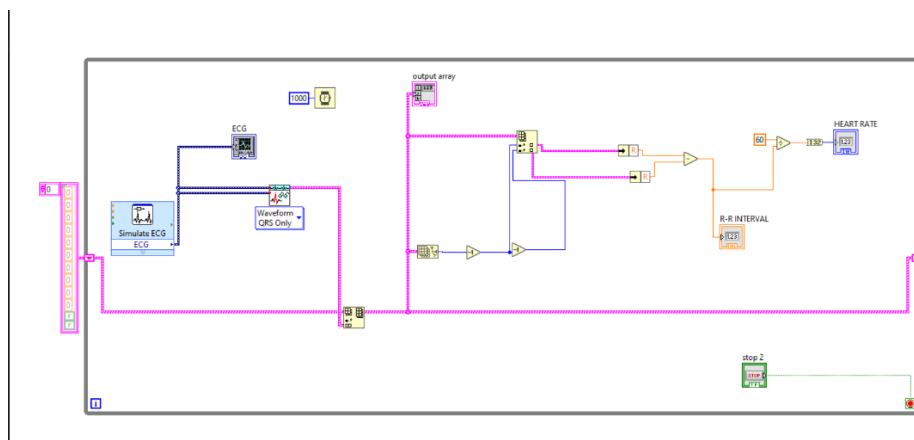
4. Methodology

Patient Monitoring system is a system that is used to measure the Patient's vitals and provide the available information. The methodology used here is patient monitoring system using LabVIEW software. In this patient monitoring system, the, measurement of Electrocardiogram (ECG), Blood pressure (BP), Body temperature, Body Mass Index (BMI) is done. The Measurement of these are explained below.

1) Measurement of Electrocardiogram (ECG):

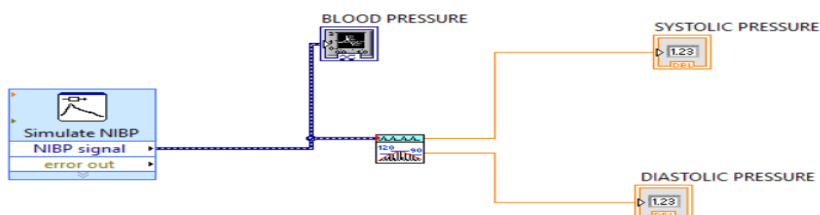
ELECTROCARDIOGRAM (ECG) is one of the most important in the patient monitoring system. In ECG there are different segments and intervals. Here the bio signal DAQ & Simulation express Vis is used form the Biomedical toolkit it contains simulate electrocardiogram (ECG) signals in LabVIEW. ECG settings contains certain specific basic settings for simulating ECG signals. Output options for the simulate ECG signal is specifies as upper and lower limit in millivolts. And it has power noise that specifies the amplitude and the frequency of the noise that this Express VI adds into the simulated ECG signal. The express VI ranges from 50 Hz or 60 Hz noise. The sampling rate of the simulate ECG signal ranges from 10 to 1000 Hz. Block size shows the length of the simulated ECG signal. Simulated ECG signal contains the option like simulate acquisition timing or Run as fast as possible for the timing mode. The basic setting like heart rate, respiratory rate and standard deviation. The standard deviation specifies the deviation in heart rate. Waveform morphology contains the following option like signal type that represents the ECG signal shows the normal, Tachycardia and Bradycardia. There are user defined options for the manual selection purpose like wave selection, position, amplitude and width of the simulated ECG signal. To show the heart rate

form the simulated ECG signal feature extraction is used. The output simulated ECG signal is connected to the feature extraction as input by using wire. The heart rate is calculated form using RR intervals. To extract the RR interval, form the simulated ECG signal the feature extraction is used by selecting the option QRS waveform. The extracted signal is passes through the two arrays into the element and it subtracted to get the RR interval and its divided by 60 to get the heart rate.



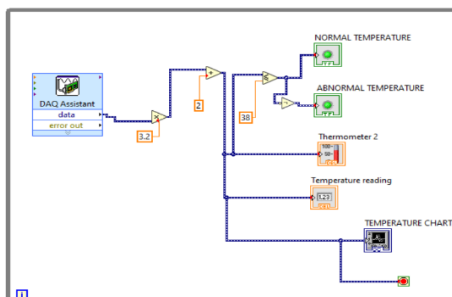
2) Measurement of Blood pressure (BP):

Blood pressure is another essential part in the patient monitoring system. Blood pressure is the force that push the blood against the wall of the arteries. Whenever the heart beats, it pumps blood into the arteries. Blood pressure is high the heart beat pump more blood it is called systolic pressure. When the heart is at rest, between beats, the blood pressure falls. This is called diastolic pressure. Here the bio signal DAQ & Simulation express Vis is used form the Biomedical toolkit it contains simulates noninvasive blood pressure signals in LabVIEW. This setting can be access through the block diagram panel. The specific parameter is output option it consists of white noise amplitude, power noise and sampling rate. White noise amplitude specifies the amplitude of the white noise to add to the simulated noninvasive blood pressure signal, in millimeter of mercury. Power noise specifies the amplitude and the frequency of the simulated non-invasive blood pressure. Sampling rate specifies the sampling rate of the simulated noninvasive blood pressure signal and its ranges between 10 and 1000 Hz. Blood pressure setting specifies the simulated noninvasive blood pressure signal. Blood pressure setting consists of systolic and diastolic pressure settings. The systolic blood pressure of the simulated noninvasive blood pressure signal, in millimeter of mercury. Systolic must be greater than Diastolic and less than 200. The diastolic blood pressure of the simulated noninvasive blood pressure signal, in millimeter of mercury. Diastolic must be greater than 50 and less than Systolic. Waveform chart palette is used to show the waveform of the blood pressure. To show the systolic and diastolic pressure from the simulated signal the NIBP feature extraction palette is used. The output simulated noninvasive blood pressure signal is connected to the feature extraction as input by using wire. NIBP feature extraction is used to extract the portion of the simulated blood pressure.



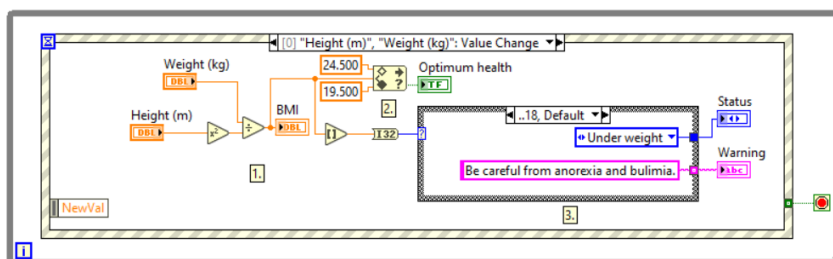
3) Measurement of Body temperature:

Body temperature varies by person, age, activity, and time of day. The average normal body temperature is generally accepted as 98.6°F (37°C). The "normal" body temperature can have a wide range, from 97°F (36.1°C) to 99°F (37.2°C). Here NI DAQ assistant is used as a temperature sensor. The LabVIEW interfacing with NI myDAQ in software basis. For accessing the DAQ assistant on block diagram panel, right click on the block diagram → Express → Input → DAQ Assist. Double click on the DAQ Assistant. The Create New Express Task window will be opened. Select Acquire Signals → Analog Input → Temperature → Thermocouple. Select the Thermocouple. In this select the ai0, the important of this channel is to read the data from. After the DAQ assistant is managed to show the accurate temperature. The output signal forms the DAQ is carried out by some arithmetic operation to show the body temperature. The indicator is used to indicate the temperature of the body is normal or abnormal by using lesser than equal to palette. The normal body temperature is set to 38 degree Celsius, if the body temperature goes beyond the normal body it shows the indicator as abnormal temperature. The numeric indicator, chart and the thermometer slide are connected to the output of the DAQ to show the temperature reading and waveform of the temperature.



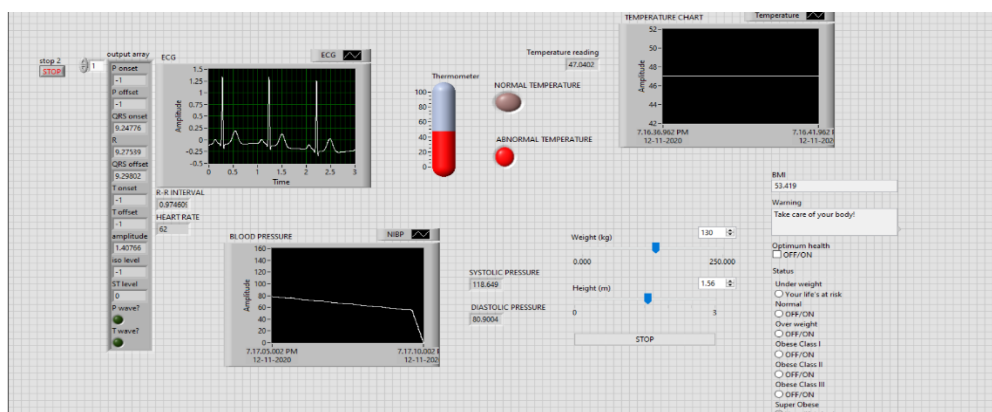
4) Measurement of Body Mass Index (BMI):

The BMI is used to determine the correct body ratio with respect to height and weight. The BMI is used to see the ranges of Body ratio and the type of body it is. In here, with the use of LabVIEW software the BMI is calculated. The input of height and weight can be given then it shows the output with the warning signs and also the range of BMI ratio which helps to decide the Body fit ratio. The BMI is calculated by the formula of Body weight divided by the square of the body height.



5. Result

When we run the LabVIEW code, we get the required results. The ECG waveform is acquired by the simulation of the ECG and it is viewed in the form of a graph with the required parameters. The Body temperature is measured using the Simulated – DAQ in which a thermocouple is used to measure the body temperature and the output is shown in the form of graphs and Indicators. The Blood pressure (BP) is measured by means of simulated blood pressure which helps in simulating the required parameters and the output is shown. The Body Mass Index (BMI) is used to determine the body ration and the output is shown in terms of Indicators.



6. Conclusion

In this, the implementation of a Patient Monitoring system is down successfully using LabVIEW software. The use of Biomedical Toolkit, Simulated – DAQ, and advanced signal processing Toolkit is done here, with this the calculation and the output of the required results is derived. LabVIEW is a user – friendly software which helps in the ease of measurement and calculation of result. In case of any variation in normal range values there are warning signs, which helps in understanding that there is an abnormality in the Patient's vitals. In the future with the help of hardware we could implement this with IOT devices to provide an efficient and user – friendly Patient Monitoring software.

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Real-Time Monitoring of Complex Impedance and Finding the Stability of a Fuel Cell Using LabVIEW

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Abstract. To analyze the performance and to get an insight into the behavior of the fuel-cells, it is necessary to monitor the impedance in real-time. Under varying time intervals and different frequencies, fuel cells are prone to performance degradation and membrane exhaustion due to which they produce a complex impedance that is a function of applied phase shift and varying frequencies. By studying the impedance over a wide range of frequencies and a particular transfer function, we can non-invasively detect the stability of the fuel cell. To calculate the impedance and other related parameters, LabVIEW, a virtual graphical programming interface is used. In this context, I have developed a sensor for measuring, and also to monitor the impedance in real-time through NI-DAQ software. I analyzed the Nyquist plots obtained from the transfer function provided and a conclusion was made on the stability of the fuel cell. This sensor can also be used for applications like On-Road Monitoring, analyzing Biological tissues, water detection, disease diagnosis, etc.

Keywords. Complex impedance, Fuel-cell, Impedance Spectroscopy, LabVIEW-Based Electrical Bioimpedance Spectroscopy, Nyquist Plots,

1. Introduction

The challengers in energy and climatic conditions are currently very entrenched. The utilization of hydrogen in power device is a basic vector, and has been the focal point of escalated concentrate lately as promising elective fuel sources. In this manner, different examinations have been done in the electronic-physic area of these sorts of generator [1] [2]. The improvement of the adequacy and the existence season of power modules requires the streamlining of parts, for example, layers and cathodes and upgrade the progression of gases. To this end, the impedance estimation is basic. Impedance estimation is a ground-breaking strategy, which can give helpful data on the electro-substance frameworks in a genuine and extremely brief timeframe [3]. This strategy can be considered as a decent device to decide the condition of charge of batteries or energy units. The greater part of impedance estimations on energy components are made without load. Impedance estimation on a battery or energy unit with load is significant to look at the impact of this last mentioned, on its exhibition. Consequently, we are keen on the turn of events and the acknowledgment of a framework to accomplish impedance estimation of a battery or power device on burden, in our lab. This framework depends on the electrochemical impedance spectroscopy (EIS) strategy for estimating and plotting the outline Nyquist of battery or power module impedance. The examination and the state of the outline can give data about the condition of charge of the gadget under test.

A gadget fit for producing power via a compound response is an energy unit. They present as another wellspring of electrical energy, and furthermore as one of the choices for

the future since they can't produce toxins. Despite the fact that the guideline of the power module is moderately old, the improvement for energy units has dramatically expanded as of late be it from mechanical advancement to natural mindfulness. The presentation of an energy component is influenced during the existence pattern of a power device as it corrupts continuously because of irreversible and reversible changes. The thermodynamic requirements in a power device quicken layer depletion.[3]

One method of recognizing the condition of the films of a power device is to screen the impedance of the cells. In this work, I have proposed a technique to gauge the impedance of a Fuel cell through the electrochemical impedance spectroscopy strategy.

Utilizing this technique, making estimations progressively are achievable as well; checking the security of the cell by monitoring film debasement after some time. Specifically, Nyquist plots are acquired utilizing the genuine and fanciful pieces of bioimpedance and serve to show the steadiness, Impedance analyzers are utilized either to gauge the unpredictable impedance of materials at a solitary recurrence or to consider its variety over a wide scope of frequencies. Because of the humidification condition of the film, a power device can have a variety of the interior impedance, and at last, this variety influences the usefulness.

The exhibition of energy units and impact of various parts on it are generally surveyed by polarization bends which are helpful to know the pattern of cell potential and of the yield power thickness as a component of the current thickness. Accordingly, such bends are identified with the naturally visible conduct of the entire gadget and give no exact data about the impact of internal segments.

To beat this issue, electrochemical impedance spectroscopy (EIS) must be done along with polarization bend estimations. EIS is a settled method for a total investigation of electrochemical gadget conduct, yet it has additionally been utilized in different fields of applied sciences to assess, for example, the consumption conduct of tempered steel and distinctive metallic combinations at different working conditions and in various media and in any event, for biomedical applications

Therefore, it is important to make estimations progressively. The contrast between the sizes of the stage move between the information and the yield signal causes us to identify the estimations of the impedance at different frequencies.

The plot of this impedance is typically done in the Nyquist plot speaking to a fluctuating exchange work, the fanciful part as an element of the genuine part.

2. Electrochemical impedance Spectroscopy (EIS)

EIS is an exploratory method that can be utilized to portray energy units. The method is to impart an air conditioner sign over a scope of frequencies inside the power module; the proportion between the yield signal and the info is its exchange work, including the energy stockpiling and scattering properties, which can demonstrate as an organization of impedances thus spoke to and considered. Truth be told a latent complex electrical framework involves both energy dissipater (resistor) and energy stockpiling (capacitor) components. This model can well legitimize the three wellsprings of voltage low normal of power modules: the dynamic misfortunes comparing to charge move initiation, ohmic misfortunes comparing to particle and electron transport and fixation or then again "mass exchange" misfortunes. Bode and Nyquist diagram are frequently used to plot information acquired by EIS.

The proposed study [4] depicts the significance of EIS. The air conditioner the improvement is given by a recurrence reaction analyzer (FRA) what's more, is shipped off the gadget under test (DUT) through a particular load. The air conditioner voltage and current reaction is then dissected by the FRA which decides the impedance - resistive, capacitive and inductive - the conduct of the cell at that specific recurrence. All the physicochemical cycles

happening inside the cell [5](electron and particle transport, gas and strong stage reactant transport, heterogeneous responses, and so on) have distinctive time-constants trademark and in this way show up at various frequencies.

3. Related Literature

Utilizing a wide scope of frequencies, impedance spectroscopy assists with recognizing and measure the impedance related with these various cycles. In this work, the experimental setup description and the results obtained for different operating conditions are displayed “Relevant Characteristics” definition is presented in and also, a procedure for obtaining these relevant characteristics when the operating pressure varies., a simple equivalent circuit is presented and the procedure for the parameters determination from relevant characteristics is detailed. Also, a complete equivalent circuit is proposed and the evolution of its parameters is studied.

The Electrochemical Impedance Spectroscopy (EIS) has the favorable position, contrasted with different strategies, to affect battery or power module during the working of these last mentioned. It can give more data on the condition of the heap. Estimations are commonly done without load [5]. It is helpful to cover an enormous recurrence range to get more data from the impedance range created. For a PEM power device, the impedance range was produced in a recurrence going from 1Hz to 10kHz [6]. The quantity of focuses gathered by decade differs somewhere in the range of 8 and 10 focuses. The standard of estimation is to add a sign, at consistent recurrence, to the yield of the voltage of the battery when this last is delivering the ideal current. The superimposed sign can be acquired by three strategies: potentiostatic, galvanostatic or load adjustment techniques. Among of these three last techniques, we have chosen the heap regulation strategy. It comprises in differing the obstruction of the heap as per the sign that we might want to superimpose.

Impedance analyzers are used either to measure the electrical impedance of materials at a single frequency or to study impedance variation over a wide range of frequencies. Impedance analyzers are typically developed with selected current frequency limits and other fixed specifications. Occasionally, changes to measurement parameters are required for a specific application, making the individual development of impedance measurement systems [7-15] advantageous and essential. Impedance analyzers or the impedance measurement hardware developed as low-cost [7, 12] and application-specific instrumentation measure the impedance data, but it requires some complementary dedicated software to process and analyze the impedance response of materials. More specifically, this software is required to calculate impedance parameters and extract tissue information by identifying the equivalent electrical circuit of the material being tested. Modern electronics technology offers a number of fast, portable, robust, user-friendly platforms for analog or digital data acquisition and signal processing that can be suitably utilized for developing a standalone impedance measurement workbench. When a standalone impedance measurement workbench is developed to collect the impedance data, it is found essentially required to be complemented by any software program or virtual instrumentation such as [16] for impedance data analyzing. Here, they developed a LabVIEW-based electrical bioimpedance spectroscopic data interpreter (LEBISDI) for tissue impedance analysis in medical, biomedical and biological applications by extracting the equivalent circuit parameters of biological tissues using their Nyquist plots. They tested and calibrated the LEBISDI software with both the computer-simulated impedance data and experimental impedance data collected from a number of electronic circuit combinations developed by high-precision resistors, capacitors and inductors using a standard impedance analyzer using low amplitude, sinusoidal current signal. They then used LEBISDI to interpret impedance data collected from fruits and vegetables under different physiological

conditions. We conducted EIS studies on these tissues using a standard impedance analyzer. They used LEBISDI to analyze their Nyquist plots to calculate and correlate the electrical impedance parameters of the compositions, structures and conditions of the tissues

Another decision was the utilization of the heap adjustment strategy; this technique is to fluctuate the opposition of the heap contingent upon the sign that we need to superimpose. For sure, the surprising impedance of the energy component can be estimated by separating the Fourier changed of the voltage by the current from the stack to the recurrence of estimation [17, 18, 19]. The decision of this strategy was spurred by the resignation of this procedure that doesn't infuse electrical energy to the power module. The other two methods are more dynamic, which could harm or opposite the synthetic responses at the power device. All together for this technique to give a right outcome it is vital that the current reaction is direct. The energy component is in from the earlier a nonlinear and non-fixed framework. Hence it can be concluded that decide the intricate impedance by infusing little plentifulness irritations around a working point spoke to by a fixed current which is accepted fixed [20, 21]

4. Materials and Methods

1. To measure the complex impedance of a Fuel-cell- For the measurement of complex impedance, LabVIEW, a strong, robust graphical based programming tool is used which helps in designing and testing of the sensor. It is a compact and highly compatible software for any measurement or control systems.

It includes tools that engineers or researchers use to build a vast variety of applications. In this case, I used LabVIEW to measure, display the complex impedance with the method of impedance spectroscopy and plot the different voltage signals obtained from a data acquisition card from National Instruments. DAQ samples the current and voltage given by a fuel cell and sends the information of these variables to the software in order to perform the further data processing required.

Different DAQ devices have different channels, for instance, The DAQ card NI-9205 from National Instruments NI-is made out of 32 channels of information type simple contribution with an information voltage sign of $\pm 10V$ territory. This card must be embedded into a casing of National Instrument NI USB-6008 which is associated with the PC through a USB link to handle the information on LabVIEW. The decision of working with this card is because of the explanation that it concedes a high examining rate to restore the correct state of the sign voltage and current at the terminals of the stack, other than to its little estimate and effortlessness association with the PC.

In this work I have created three applications with LabVIEW, right off the bat to quantify and show the intricate impedance and the furthermore to screen the impedances progressively and thirdly to discover the steadiness of the framework. cell. A. The LabVIEW application for the estimation and show of the perplexing impedance LabVIEW application for instrumentation depends on a realistic programming language.

A LabVIEW program is made out of a front board which is the UI to show the qualities estimated and a square graph which is the essence of the program.

This application that I have shown here consists of multiple stages. We find the block "DAQ- mx Assistant" that integrates hardware driver of the data acquisition card from National Instruments NI-USB-6008.

It provides signal voltage and current taken at the terminals of the fuel cell. Each signal is then fed to a digital low pass filter to form a good return signals picked. "Level Measurements" LabVIEW block is the one that calculates the parameters for the different measurement such as the frequency, amplitude and phase. For measurement the complex impedance we need two essential parameters which are the amplitude and phase of the two

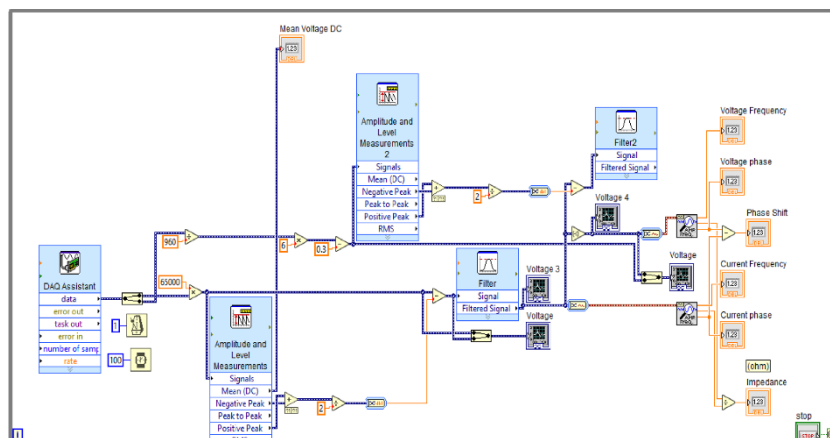


Fig. 1. Block Diagram showing Measurement of Complex Impedance

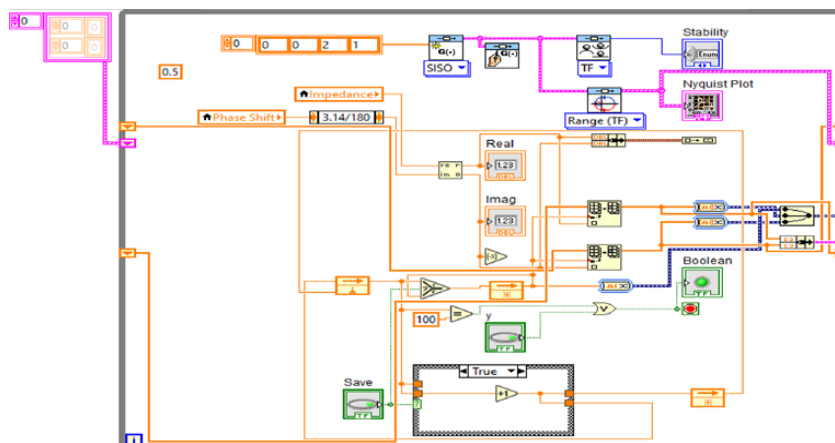


Fig. 2. Block Diagram showing Monitoring of complex Impedance in Real-Time.

- i. The desired signal from DAQ is used to generate the voltage and current values.
- ii. In the system itself, a local variable is created with phase shift and impedance for the real-time meeting/
- iii. A measurement of resulting voltage is passed to the system analyzer from the electronic load.
- iv. The values are shown and a transfer function is created.

- v. The plots are obtained with the help of Nyquist plot and the stability is measured

In this work, graphical interface is shown developed by LabVIEW to make the estimation of the unpredictable impedance, the interface is made out of a Nyquist diagram to show each purpose of the impedance estimated progressively. Three computerized pointers are given to show the various boundaries of the voltage and current at the hour of estimation (Voltage and normal current, recurrence of the signs, stage move between the signs). An expansion can be made in this interface as we have a coordinated catch to spare the deliberate focuses to a document that you can utilize it to show information from other programming, for example, Microsoft Excel or MATLAB, the STOP, to stop the application toward the finish of the complete estimating purposes of the unpredictable impedance. For the execution of this sensor, we have built up the square chart of the LabVIEW application; it is the basic piece of the application since it incorporates the vast majority of the squares needed for the information handling to play out the impedance estimation

5. Results and Discussion

The above work shows the usage of a DAQ assistant to display the complex impedance of a fuel cell. Figure 3 shows the different Voltage waveform graphs at different point intervals of varying amplitude followed by the values of Impedance, Current frequency, voltage frequency, current frequency, Phase shift in real time. Figure 3. shows the various parameters calculated in real time.

The impedance of the following sensor using the DAQ was found out to be 1ohm followed by mean voltage DC as 73.0337V, Voltage Frequency as 12.9158Hz, phase shift as 180degrees, current phase as -129.938degrees, Voltage phase as 50.0616V, current frequencies as 12.9158Hz. The real and imaginary values calculated were 1.00015 and 0.01744 followed by the estimation of the stability of the system.

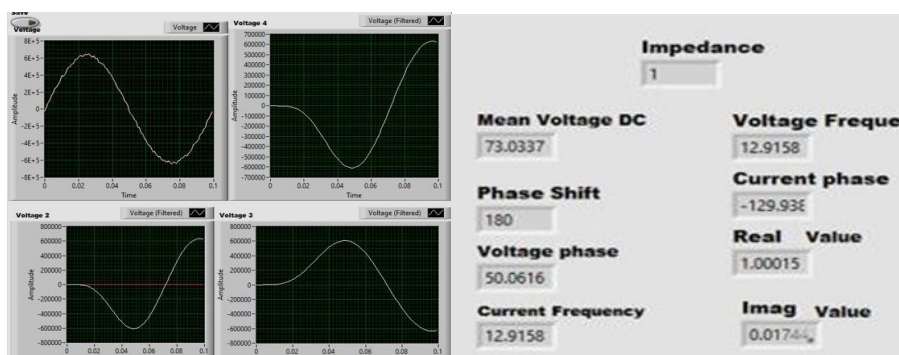


Fig. 3. Front panel showing the voltage graph and other related parameters.

LabVIEW programming can be reasonably utilized for breaking down the perplexing impedance information for non-invasive energy unit portrayal. The proposed study is principally connected with the electrochemical power devices however the investigation of complex impedance information can be effectively led with the proposed programming. As a future bearing, the proposed sensor can likewise be applied for human tissue portrayal for wellbeing examination and infection determination. LEBISDI can likewise be applied for multifrequency bioelectrical impedance examination (BIA) based tissue creation evaluation, electrical impedance-based tissue portrayal, and additionally infection finding and EIS based tissue wellbeing portrayal in natural, biomedical, and clinical applications.

6. Conclusions

In the proposed work, I have developed a LabVIEW based complex bioimpedance spectroscopic data interpreter for fuel cell analysis in biomedical and biological applications by studying the equivalent circuit parameters of fuel cells from their Nyquist plots. Under varying different frequencies, fuel cells produce a complex bioelectrical impedance that varies at different time intervals. By identifying the frequency response of a cell's complex impedance, it is possible to identify the equivalent sensor, which depicts the stable properties of the fuel cell that can be used later for research or experimental purpose. The performance of fuel cell can be predicted, tested, and evaluated with simulated impedance data as well as with the impedance data collected from several high-precision resistors, capacitor, and inductor circuit combinations using a standard impedance analyzer with a low amplitude sinusoidal current signal.

To study the practical applicability, I tested Fuel cells with an impedance analyzer and the impedance data were interpreted by the sensor; their equivalent circuit parameters were also evaluated. Calibration studies show that the spectroscopic data accurately interpreted the simulated and practical electronic circuit combination data. Furthermore, results show that the sensor successfully interpreted the impedance data and estimated the parameters of the fuel cell. It was also observed that LEBISDI efficiently calculated and estimated variation in the impedance parameters and that the simulated data and various studies demonstrate that the sensor can be used to reveal the equivalent sensor parameters from the impedance data obtained from EIS studies. Impedance-based studies with an impedance element could be conducted and reported in future communications.

As a future study, the proposed work can also be used for complex impedance-based biological tissue characterization, cell- composition analysis, tissue anatomy, water detection, health studies, and disease diagnosis

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Preventing Deep Vein Thrombosis in Bedridden Patients

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Abstract. Deep Vein Thrombosis or DVT is a critical condition that happens when a blood clot is formed deep inside the vein in body. The average number of cases of DVT increases exponentially each year. Some of the symptoms of DVT are swelling in leg, cramping, pale or redness of skin, skin warmer than surrounding. This work proposes for an intelligent biofeedback system for intermittent pneumatic compression therapy device. IPC devices can be used to prevent formation of blood clot inside the vein of the legs. The IPC devices which are currently present in the market only involves a control or an analog input system, which are incapable to time timely monitor and obtain real time feedback of pressure dosage delivered to the biological human body and is also unable to visualize pressure variations with inflation time. The IPC is to be equipped with force sensor resistor (FSR) which can be used to measure the exerted pressure on the skin. Air mass flow sensor is to be used to measure the air volume in the bladder quantitatively. These sensors will help in giving biofeedback to the user to use the intermittent pneumatic compression device with proper pressure and air flow.

Keywords. Deep Vein Thrombosis, Intermittent Pneumatic Compression Device, Feedback, Force Sensor Resistor, Air Mass Flow Sensor.

1. Introduction

It is necessary for the body to clot the blood or else there are chances of high loss of blood in small injury also but when the blood starts clotting unnecessarily inside the body that causes several medical problems.

Deep Vein Thrombosis refers to a condition where blood clot is formed in a vein which is present deep inside the body. Deep Vein Thrombosis usually occurs in thigh and lower leg region. Some of the common symptoms of DVT as per the Centers for Disease Control and Prevention (CDC) Trusted Source are as follows: swelling in one side of the foot, leg or ankle, cramping in leg starting from calf region, severe pain in foot, feeling warm at a region of skin than the surrounding and paleness of that region of the skin[1].

Deep Vein Thrombosis can lead to pulmonary embolism. Pulmonary embolism is a state where the blood clot travels to the lungs through the artery and creates blockage. Deep vein thrombosis and pulmonary embolism are highly correlated. Even if pulmonary embolism does not occur to the patient, there are several causes for morbidity like post thrombotic syndrome[8]. As most of the patients remain undetected for the deep vein thrombosis the exact number of patients affected per year is undetermined. Approximation can be done that 60000-1,00,000 Americans die of deep vein thrombosis or PE per year. One third of the affected people will have complication for lifetime. The average number of cases of DVT is increasing exponentially each year. The average number of DVT cases is 1 in 100 above 80 years. After the age of 45 years the chance of developing permanent symptoms of DVT is 8%. The chance

of DVT in black people is greater than the white people in comparison and is lower in Asian people.

There are some factors leading to deep vein thrombosis.

1. *Venous stasis*

The smooth wall of the vein helps in free flowing of the blood. While flowing the blood gets merged with the anticoagulants which are naturally present in the body. When the free flowing of the blood is hampered in the vein and it cannot merge with the anticoagulants, it can lead to clot formation of blood. This is one of the main reasons of deep vein thrombosis in bedridden patients.

2. *Hypercoagulability*

The tendency of blood to coagulate faster is one of the reasons for deep vein thrombosis. Sometimes during surgery fat and collagen tissues are released in the blood flow and the blood tends to thicken around those materials causing formation of clots.

3. *Vein wall damage*

Sometimes the vein walls get damaged during any accident or bone fracture. This leads to narrowing or blockage of the vein. This narrowing or blockage is one of the reasons for deep vein thrombosis

4. *Other factors*

Other factors like the age of the patient, previous history of deep vein thrombosis vein disease or any blood disease can lead to DVT.

Risk factors:

1. *Pulmonary embolism*

When the blood clot that is formed inside the deep vein travels to the lungs that can lead to pulmonary embolism. In majority cases deep vein thrombosis is not cured until it goes to the stage of pulmonary embolism. Due to pulmonary embolism the oxygen rich blood flow goes down to the entire body leading to heart failure. To prevent this emergency case deep vein thrombosis needs to be treated as early as possible. It is seen that among hundred DVT patients at least one person dies of pulmonary embolism.

2. *Post-thrombotic syndromes*

Post thrombotic syndromes can be seen when there is damage in the deep vein of the leg. This happens usually whenever blood thinners are used as a treatment of deep vein thrombosis. The blood thinners do their name suggest but they cannot thin the blood. They can only prevent new blood clots to form. When the previous blood clots tries to breakdown this causes damage to the vein. This thing causes a huge pressure on the leg that can lead to ulcer on the leg[4].

2. Current conventional treatments of deep vein thrombosis

There are some conventional treatments for curing DVT. The first and the most common treatment is using of blood thinners. They are also known as anticoagulants[6]. They are non invasive, less complex. Using anticoagulants can decrease the chance of DVT to 4% and chance of PE to 2%. They can prevent a clot from growing larger and prevent new clots from forming. Some of the blood thinners are heparin, rivaroxaban, warfarin, apixaban, betrixaban etc. Though they are named as blood thinners but they cannot really dissolve the clots which are previously formed. The main disadvantage of these anticoagulants is they have

increased risk of bleeding if the dosage is higher and if the dose is low the anticoagulants will not work properly.

Another type of drugs which are used is TPA or Tissue Plasminogen Activator[5]. Tissue plasminogen activators are important and powerful clot busting drug. Initially this drug was thought to be a solution for deep vein thrombosis. These drugs help in curing swelling in the limb, chronic pain for people who has difficulty in walking. They are given directly via an intravenous line in order to break down the blood clots. But using this type of drugs has a high risk of excessive bleeding. These are even dangerous than the anticoagulants or blood thinners. So these tissue plasminogen activators are only used in life-threatening conditions where the use is mandatory.

Vena cava filters are also used to treat pulmonary embolism. This Vena cava filter is suggested for people those who have deep vein thrombosis and has a tendency to grow pulmonary embolism. Results from studies show that using Vena cava filter decreases the rate of pulmonary embolism but it does not have any result on deep vein thrombosis. Even it increases the rate of DVT. The Vena cava filter is surgically inserted into the vena cava that is the large vein in the abdomen going to the lungs . These filters can filter the blood clots in the vein and prevent them from travelling to the lungs. There is always some risk factor because as the filter is inserted by surgery and it needs to be removed also by surgery after the treatment.

A compression stocking can also be used to prevent deep vein thrombosis. It is a device that uses pressure to help prevent and symptoms of DVT. Gradient compression stockings provide tightness at the ankle and the pressure decreases gradually as it moves up. They are snug fitting and stretchy socks . They help to promote circulation energise tired aching legs and helps to prevent and reduce swelling . They also offer wearer support. The pressure put by the stockings to the leg helps in the blood circulation. The arteries get more oxygen rich blood and the muscles get relaxed. The gradient compression helps in moving blood through vein towards the heart but these kinds of stockings are not very useful in case of bedridden patients[9].

3. Pneumatic compression devices

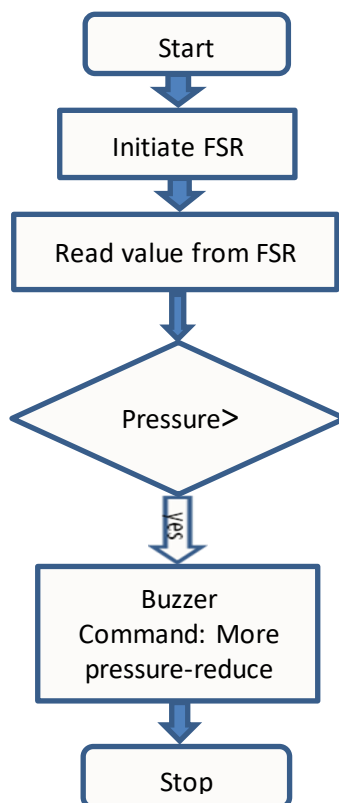
Intermittent pneumatic compression device is an important technique for the prevention of deep vein thrombosis in bedridden patients. Blood circulation disorders can be cured by using this proactive compression technique. This device includes an air pump. There are cuffs present around the whole leg or the lower leg those fill with air and squeeze. This helps in increasing the blood flow through the veins and increases oxygen-rich blood to the muscles. The proposed intermittent pneumatic compression device aims at developing equipment to help the long term bedridden patients. They fail to give appropriate pressure to the affected leg. This hampers the blood flow of the region and the patient tends to grow deep vein thrombosis. So pneumatic compression devices can be used externally for around 6 to 7 hours to treat deep vein thrombosis in bedridden patients. The cuffs fill with air and squeeze the leg and then relax. This process is repeated again and again. This promotes blood flow to the heart through the vein. This IPC can be used for bedridden patients who are bedridden for a very long time. There are a variety of IPC devices which are currently present in the market. They differ in the number of air bladder present, time duration of squeezing and relaxing, single chambered or multi chambered and constant pressure and sequential pressure devices[7]. They can also be divided on the basis of portability and design parameters. Most intermittent pneumatic compression devices which are currently present in the market are analogue type and can be controlled from outside. They are not able to monitor how much pressure is given to the leg. More pressure than the required can be harmful from the patient. This demands a smart feedback system for the pneumatic compression devices. The pneumatic compression

device needs to give feedback whenever there is more pressure than the required and needs to stop the pressure. This will also help in monitoring the amount of pressure given to the skin[2]. A flexible force sensing resistor can be attached to the pneumatic compression device to give timely feedback to the user. Air mass flow sensor is required to measure the quantity of air in the bladder. This air mass flow sensor will also indicate whenever there is more air in the bladder than the required.

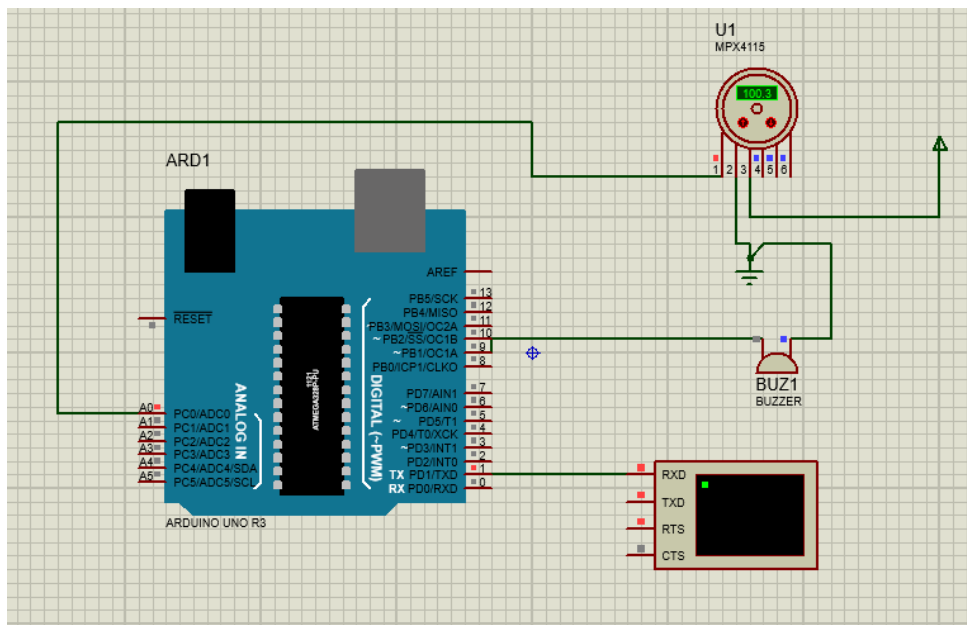
4. Methodology and circuit

The IPC devices mimic the muscular function. This squeezing and the relaxing of the bladder can be controlled by using pneumatic pressure and timing settings. The pressure dosage is dependent on the physiotherapist as per the body weight of the patient, age, gender and the seriousness of the disease. A flexible force sensing resistor can be used to measure the pressure created on the skin by the IPC device. The resistance of the sensor changes as the force increases in the sensor. Using this principle the arduino board can be programmed in such a way that it will monitor the amount of pressure given to the skin. A preset pressure value is set to the arduino board and while squeezing whenever the pressure is greater than the pre set value it will give a buzzer indication. When the present value is less than the prior value it will give indication as medium pressure. But whenever the present value exceeds the prior value set it will give a buzzer indication and give command to reduce the pressure. The buzzer will continue buzzing until the present value is less than the preset value.

The workflow of the force sensing resistor is as follows:

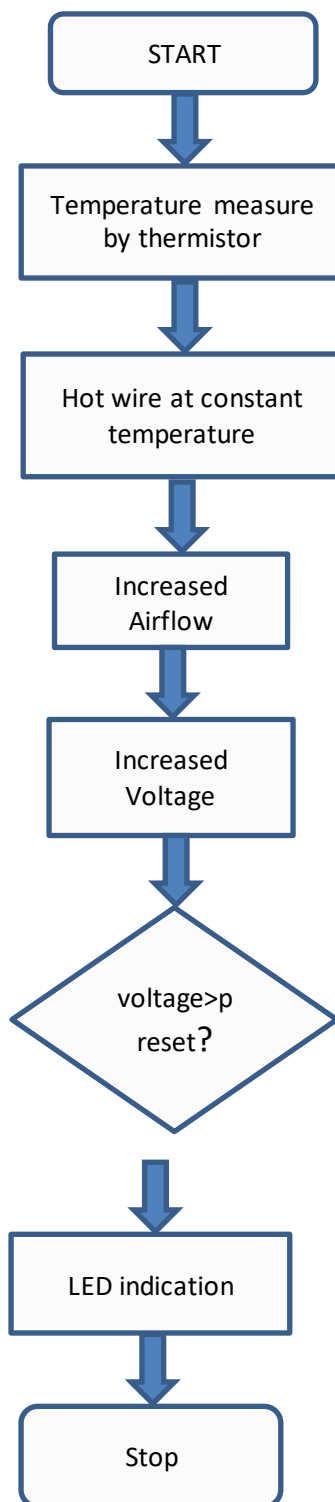


The circuit is constructed on Proteus software.



The circuit shows the simulation for force sensing unit. MPX 4115 pressure sensor is used here to simulate the unit. The input pin of the force sensing resistor is connected to the analogue pin A0 of the arduino UNO R3. The virtual terminal is connected to the digital pin 1 and the buzzer is connected to the digital output pin 9. the arduino board is programmed in such a way that whenever the pressure is more than 100 kilo Pascal the buzzer will buzz and the comment written 'more pressure-reduce pressure' will be displayed on the virtual terminal. As the pressure goes below 100 kilopascals it will show medium pressure. This way the force sensing unit can be used to control the given pressure and give feedback to the user and the physiotherapist.

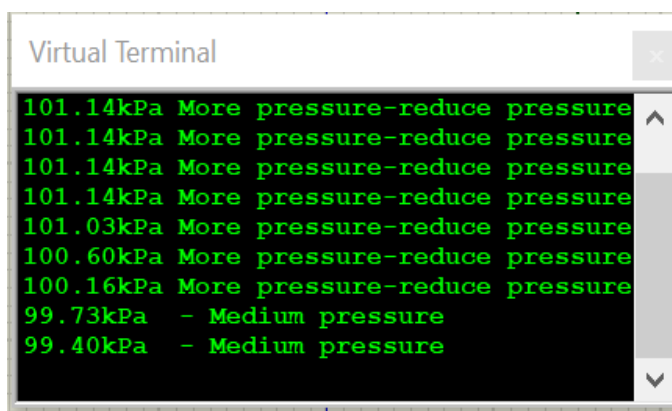
Another sensor that is used in this pneumatic compression device is the air mass flow sensor. This sensor is used to measure the volume of the air inside the bladder of the device. The working principle of air mass flow sensor is, there is a thermistor present in the sensor to measure the temperature of the air flow. a hot Platinum wire is already present in the sensor with a constant temperature. The temperature is controlled using an electric board unit. Whenever air flows through the sensor the temperature of the hot wire gets reduced and it releases heat. The electric board tries to compensate the temperature and the current flow through the hot wire is increased to maintain the temperature as the current is increased the voltage of the sensor also increases.



The arduino board can be programmed in such a way that whenever the voltage of the sensor goes higher than the pre set value it will give LED indication indicating that there is more air flow in the bladder. It will indicate that there is more air in the bladder than the required. The LED will keep on glowing until the voltage goes down than the prior set voltage. The analogue input of voltage is given to the analogue input pin of arduino. The LED can be connected to any of the digital output pins and a virtual Terminal can also be connected to display the command like there is more air in the bladder.

5. Result

The virtual terminal of the force sensing resistor is displayed here. It is shown that whenever the pressure exerted to the skin is more than 100 kpa, it will indicate, 'more pressure-reduce pressure'. When the pressure is less than 100 kpa, it will indicate medium pressure.



This kind of pressure indication will help the user to identify appropriate pressure that needs to be given to the patient to prevent deep vein thrombosis in bedridden patients.

6. Conclusion

This work shows how an analogue pneumatic device can be made smart to give feedback to the user. This work uses two simple sensors that can be used in the pneumatic compression device. In future the circuit for the air mass flow sensor s to be prepared and both the sensors needs to be assembled and validated manually. A software platform can be prepared to continuously monitor the pressure graph and the physiotherapist needs to be consulted as per the improvement seen in the patient. This type of smart intermittent pneumatic compression devices help in preventing major medical problems like pulmonary embolism.

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Ultrasound Image Denoising

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Abstract. The paper reviews about the ultrasound imaging technique. Ultrasound image is in the form of 2D structures. They contain information regarding particular organs in our body. It diagnosis the internal organs such as tendons, blood vessels or blood flow. It will be very useful to find any abnormalities in the human body. So basically these ultrasound images contains several intrinsic noises and therefore these noises can cause in the degradation in the clarity of the image. To enhance the clarity of the image by denoising them we have came up with this idea. Our project technique is Ultrasound Image Denoising, which basically denoise the ultrasound image using these three different filters, 'butterworth', 'ideal', 'median' using MAT LAB.

Keywords. Noisy image, Filters, Denoising, Cut-off frequency, NSR

1. Introduction

Ultra sound image denoising is one of the technique used to reduce the intrinsic noises of the 2D ultra sound. These intrinsic noises present in the image reduce the clarity of the ultra sound abruptly. Therefore the examination of the image by the doctor will be difficult. So the information gain through the image will not be accurately correct. To avoid this we have used mainly three different types of filters. Our project is to enhance the clarity of the image by denoising them using these filters. The noises in the image gets denoised, and the clarity of the image gets enhanced. So the examination of the image can be done easily by the doctor. So basically the filter types are 'Butterworth', 'Median', 'Ideal'. What the filter does is they performs the filtration process.

2. Butterworth Filter

This type of filter has the frequency very flat. So this type of filter is also called flat magnitude filters.

3. Median Filter

This filter is a non linear filter which removes noises from the image or signal.

4. Ideal Filter

This type of filter allows only specific range of frequencies by removing unnecessary noises. It classified into two different types, 'Low Pass Filter' and 'High Pass Filter'.

5. Methodology

A MATLAB code is created, first we are setting save location of the filter image. Then we are assigning the different types of filter such as 'Butterworth', 'Median', 'Ideal'. We use input function to assign the corresponding filter choice. Then we are including the cut off frequency. The cut off frequency work is to reduce the energy of frequency response. By changing the NSR(Noise to Signal Ratio) using the filters. The filtered denoised image is obtained.





6. Conclusion

The four different cut-off frequency shows drastic difference has compared to one another. So the aim of the project was to denoise the ultrasound image and enhances the resolution and it came out success. The result obtained has a much more clear image with high resolution so the diagnosis of the patient can be easily done by the doctors.

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The Scope and Application of Nanorobots in Biomedicine

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Abstract. This Review paper aims to break down and analyze the application of nanorobots in the field of biomedicine and elucidate on their possible future developments. Wide research on ‘Smart nanorobots’ has helped in making significant breakthroughs in fields such as cancer treatment, disease diagnosis, high-precision medical procedures, directed drug delivery, detoxification and gene therapy. The minimum requirements of nanorobots in the field of biomedicines in factors such as safety, accuracy and cost have been highlighted. The gamut of nano cameras and application of robot-aided Minimal Invasive Surgery (MIS) and the promising field of robotics in treatment of cardiovascular fields is also vividly considered in the scope of this paper. The use and development of famous nanorobots such as the Endoscopy bot, antibacterial nanorobots and the da Vinci system is also explored and deliberated upon.

Keywords. Nanorobots, Biomedical Systems, Minimal Invasive Surgery, Autonomous Systems, High-precision medical procedures.

1. Introduction

The range of applications of nanotechnology in multiple fields is more prevalent than ever before in the modern world. More than sixty years since the ground breaking lecture by acclaimed theoretical physicist Richard Feynman, at the meeting of the American Physical Society at Caltech titled “There’s plenty of room at the bottom”, the field of nanotechnology has grown by leaps and bounds. [1] The world of physics has seen a gradual but unmissable switch of interest in studying from the macro world to the micro world in the last four centuries and this lecture proved to be a pathway to dive into the possibilities provided by the nano world. Feynman believed that the nano-world provided an opportunity wherein the atoms could be arranged manually. Thus, unsurprisingly this lecture is regarded as the occasion that put forward the field of nanotechnology into the limelight. [2]

The vast field of nanotechnology has briskly garnered the eyes of the scientific community and since, has evolved into many defined sub-fields including wide applications in the fields of medicine, biotechnology, electronics, defense, in the industry and in the sectors. This work focuses on the applications of nanotechnology, and of nanorobots in the field of medicine (nanobiotechnology) and discuss the related factors and the scope for its application in the future. The essence of the field of nanobiotechnology is directly related to the creation of novel nanostructures which work on the scale of biomacromolecules and thus serves as a methodology for the treatment of cellular diseases and related medical treatments.

In the realm of wellbeing and medication, there is a practically immaterial window for blunders. Indeed, even a little misstep can turn deadly for patients or in some cases for specialists' vocations. Evidently the clinical experts are profoundly prepared and knowledgeable in their job and skills yet for some situation outrageous accuracy is the most extreme prerequisite. To arrive at this degree of precision, specialists and experts are

persistently doing broad exploration and progressed advancement in nanotechnology to locate the best employments of nanorobots and nanomachines in the clinical business. [3]

The core component of the field of nanotechnology and its applications are nanorobots. Nanorobots can be considered to be the direct fusion of the developments in the fields of nanotechnology and robotics as it refers to the applications provided by robotics on the nanoscale. Among other researchers, renowned nanotechnology scientist Robert Freitas Jr. has performed substantial work in exploring the multifarious applications provided by nanorobots. [4]

2. An Introduction to Nanorobots

As the core focus of this paper would focus on the applications and use of nanorobots it is pertinent to know the structure and functioning of nanorobots. Nanorobots could be termed as nanoscale machines composed of various parts such as sensors, motors, onboard computers and manipulators among others. [5] Various applications in the field of nanotechnology are often credited and well known for their novelty and uniqueness and nanorobots fall into the same category. [6] Nanorobots can be manufactured using both inorganic and organic materials. One of the most popular examples of inorganic materials is the use of diamonds, which are widely used in nanorobots as it increases their strength. Inorganic materials such as metals like Silver are also used in nanorobots due to the antibacterial effect provided by them. [7]

As nanorobots often act as the front-liners, fighting against microbes, and in most cases are directly in contact with cells and tissues, their surface characteristics and properties are of utmost importance. Properties of nanorobots such as their shape and their size have been shown to have a direct correlation with their reactivity, motion and permeabilization. [8] The core structure of nanorobots is based on performing two key functions – detection and mobility, that is, the nanorobot is expected to successfully reach, function, detect the problems, solve it and to communicate its progress. This fact shows how the two most essential pieces of equipment needed for this task are sensors and propulsion equipment. At the same time, it also suggests the need of specialized and task-specific equipment such as power supplies or molecular computers. [9]

As the sensors that work in nanorobots function on the nanoscale, they are termed as nanosensors. In the aid of performing tasks for nanorobots, nanosensors have been shown to perform various tasks such as being used as mechanical, magnetic, biological, chemical, thermal and optical sensors. ‘Organic’ nanosensors or biosensors take the aid of biological reactions in order to detect target analytes [10]. For example, nano cantilevers have been used in the Nano Electro Mechanical System (NEMS). This system is based on the principle that in its working, the biological material would adhere itself to a cantilever. This phenomenon would in turn cause a change in its surface tension or mass. In real-time applications, it is important that these nanosensors perform two key functions - detect the damage present at the location, and to perform a quick analysis of the situation. Cantilevers are widely used to do the same because of the high atomic resolution and sensitivity that they provide. These two extraordinary properties have led to them being used in Atomic Force Microscopy [11].

Another example of the use of nanosensors, include Carbon Paste Electrodes (CPE). These electrodes are manufactured using a pasting liquid and graphite, and are used in coulometry and electron transfer reactions. Various characteristics of CPE such as their ability to be miniaturized, good mechanical and electrical resistance properties, low cost, and ease of fabrication. [6] One of the most well-known applications of CPE, is in the detection of nucleic acid bases, based on their redox signals [12].

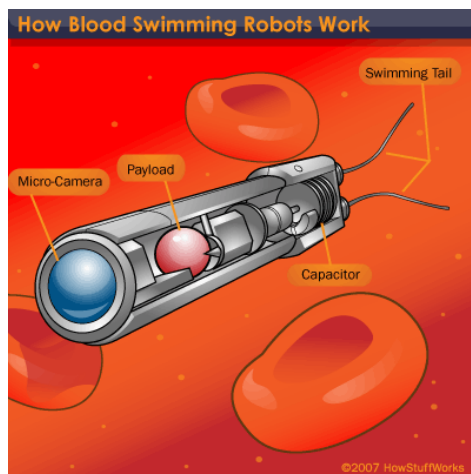


Fig. 1. Image Courtesy: How Stuff Works

Along with nanosensors, propulsion equipment is needed for the functioning of a nanorobot. Nanomotors are one of the examples of propulsion equipment that can be used for the same, as they are devices with their own propulsion and obtain their energy through methods such as chemical reactions in the medium or through the present acoustic, electric or magnetic fields. [13] Even though nanotechnology provides great advantages for functioning here, there are many challenges faced in the same which arise due to the phenomenon of Brownian Motion and viscosity, which act as a resistance to the mobility of nanorobots. [14]

In order to overcome this issue, two major techniques have been used, widely termed as Internal and External approaches. In the External approach, MRI devices are used as they pose several advantages such as the control of speed and direction by using an external computer (thereby reducing the risk in the approach), ability to receive a real-time feedback from the nanorobots and overcoming the need of power resources in nanorobots. In the internal approach, biomotors are used in which chemical energy is converted into mechanical energy which causes the body to move. This chemical energy can be provided through methods such as DNA transcription, cell division and protein synthesis among others. The field of biomotors continues to grow as better alternatives continue to come to the fore [14].

3. Directed Drug Delivery

Drug Delivery Systems have accomplished new statures during the last few years as a fundamental segment of medication advancement. The delivery of medications solely to the sick site is the main conceivable answer for expanding their viability and all the while diminishing the poisonous impacts. Drug Delivery System are created to advance the therapeutic properties of medication products. The local or site-directed delivery of medications utilizing drug systems has numerous advantages. These include targeted delivery of medications to different organ systems, delivery of therapeutic doses for continued period of time, minimization of systemic harmfulness, and capability of decreased medication costs and sometimes, empowering innovation for drugs [15].

Optimal pharmacological treatment is having the correct medication delivered to the correct site, in the perfect amount, at the correct time. Despite the fact that explicitness of site of activity may be inherent to a specific medication, accessing target space and keeping up a nearby and strong efficiency drug concentration over a long period of time requires a drug

delivery innovation. A drug delivery system is characterized as an independent complex of medication and drug delivery innovation, remarkably custom-made for a specific helpful need, giving consistent drug delivery in a systemic or site-explicit way. The prerequisites of a drug delivery system are that it provides a climate that guarantees drug strength, discharges drug in a controlled and unsurprising way, is protected and gives a preferred position over regular courses of medication delivery [16].

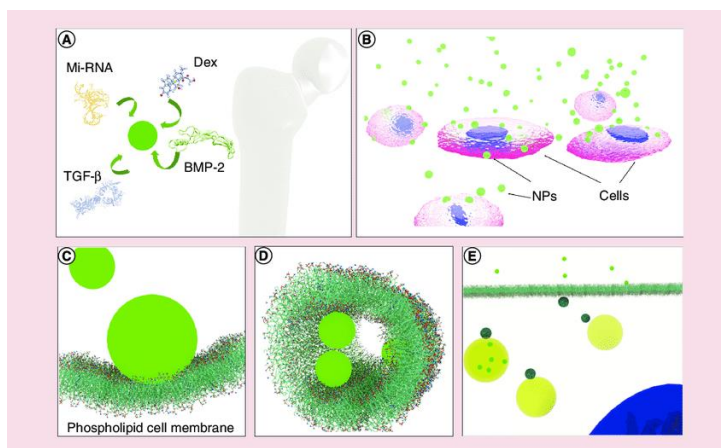


Fig. 2. Directed Drug Delivery

Ever since the disentangling of human genome in the start of the current century and ensuing development of proteomics and genomics as new disciplines has given another push to quality treatment which is pointed toward treating the reason instead of the manifestations dissimilar to the customary little particle drugs. The ideal quality is moved to the objective cell through a vector so the ideal protein itself is communicated in the patient's body. This methodology is a proper solution for the quick transformations happening in microorganisms. The vector is constantly an infection or might be a non-infection, along these lines, the novel drug delivery systems are either by means of viral or non-viral modes. The non-viral delivery systems might be either engineered vectors, drug stacked tumor cells as vectors, folates or it could be by applying physical or substance techniques [17].

4. Detoxification

Nanorobots have additionally been utilized as incredible detoxification tool as they have very high cleaning ability. Micro/Nanorobot detoxification approach is based on self-propelled 3D printed microfish containing polydiacetylene nanoparticles which are used to capture, kill, attract and neutralize the toxins by binding them. Self-propelled 3D microfishes brooded in the poison arrangement demonstrated higher fluorescence powers contrasted and static microfishes, featuring the significance of dynamic movement for improving the detoxification measures [18].

Among various other methods which are used to detoxify the blood, detoxification of blood with the help of nanorobots is one of the techniques. These small ultrasound-controlled robot-like structures can swim through the blood and eliminate toxin substances from it. These unsafe substances incorporate a few microorganisms, alongside the poisons they produce. Expulsion of these substances, thus, detoxifies blood [19].

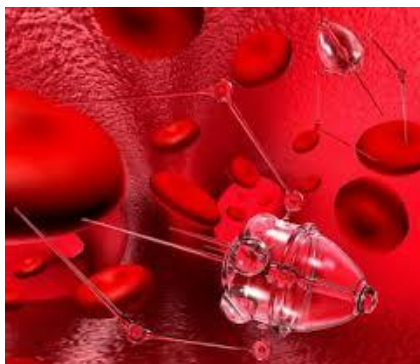


Fig. 3. Detoxification

The nanorobots were constructed utilizing gold slim wires, covered by half breed platelets and red platelet layers. The blend of platelets and red platelet films pull in the microorganisms and the poisons delivered, individually. Despite the fact that the nanorobots are multiple times more modest than the human hair, they can move at the speed of 35 micrometre/sec. Scientists have tried these nanorobots in blood tests which are defiled with MRSA and their poisons. It brought about the blood test being multiple times less debased. [20]

5. Minimally Invasive Surgery

Specialists/Doctors are continually searching for minimally invasive surgery to treat their patients, as recuperation is quicker when a lesser injury is delivered upon a patient, scarring is reduced and there are generally less confusions in the consequence of the activity. Such robot-helped a medical procedure is a quickly developing field that permits specialists to play out an assortment of minimally invasive surgery with high accuracy, adaptability, and control. Little robots can conceivably explore all through human body, work in some difficult to-reach tissue areas, and henceforth target numerous particular medical issues and cure numerous diseases without causing much pain or injury to a patient. [21]

The proof minimally invasive surgery are: a reduced physical issue to cells thus less scarring; less difficulties; less postoperative agony and quicker recovery. The main impetus these days is to make a medical procedure logically less intrusive. By creating another arrangement of apparatuses on the nanoscale, one can maybe envision a specialist having the option to make changes to and track singular cells. Today, the devices have been refined, and the climate, both in and around the patient, is deliberately controlled. These tools/instruments are presently predominately made of hardened steel or tungsten. Titanium instruments have likewise been presented, and a few advances have been made in precious stone covered edges. [22]

These tiny miniatures go in human body under the control of surgeons and perform action on diseased areas. The cavities where surgeons can't treat by themselves nanobots help in treating those cavities, tissues.

There are several tools made for minimal invasive surgery:

1. Nanocoated Blades for surgeries

These blades are use in complex surgeries such as cataract operation, stones in gall bladder removal operations. These blades help in reducing pain bearing trauma of the patient

and as the cuts/wound are of nanometer size healing is fast as so as is the recovery of the patient from surgery.



2. Catheters

They are the very small tubes like structure which are used to insert inside the human body cavity for clearing the passage. But this insertion leads to formation of thrombus and hence causing pain to patient. Carbon Nanotubes are added to catheters which are used in minimally invasive surgery and hence suppressing the thrombus effect.



3. Nanorobots

Very small robots are made to introduce into the human body. These little creatures go inside human body cavity and perform surgeries under the control of surgeons. These robots are made up of carbon atoms as carbon is chemically inert in nature. While constructing these nanorobots, scientist makes sure that the surface of a tool/instrument is not rough as it could trigger human immune system and hence end up with failure in surgery [23].



6. Nanorobots in Cancer Treatment

From eliminating the side effects of chemotherapy to treating Alzheimer's illness, the expected clinical uses of nanorobots are tremendous and eager. In the previous decade, scientists have made numerous enhancements for the various systems needed for creating pragmatic nanorobots, for example, sensors, energy flexibly, and information transmission. A couple of ages from now somebody determined to have disease will be offered another option in contrast to chemotherapy. [24] The conventional therapy of radiation that kills not just

cancer cells but as well as solid human cells too, causing balding, weariness, sickness, misery, and a large group of different indications. A specialist rehearsing nanomedicine would offer the patient an infusion of an extraordinary kind of nanorobot that would search out cancerous cells and decimate them, dispersing the illness at the source, leaving sound cells immaculate. The degree of the difficulty to the patient would basically be a prick to the arm. An individual going through a nanorobotic treatment could hope to have no attention to the atomic gadgets working inside them, other than quick advancement of their wellbeing.

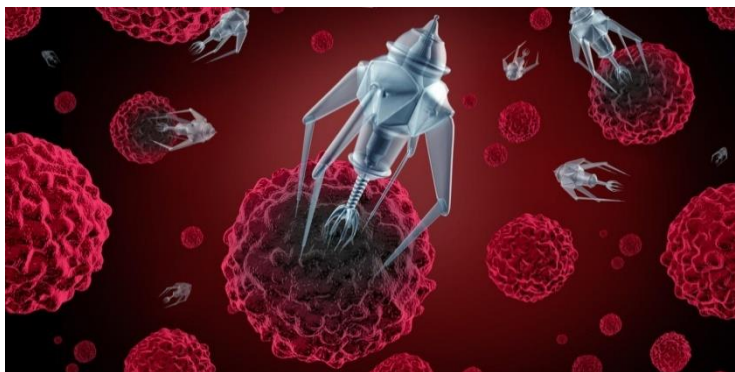


Fig. 4. Cancer Treatment using Nanorobots

The nanorobot is designed with blood energy collecting ability and the amassing of power in a capacitor, which frames the principle body of the nanorobot. Glucose hunger-based cancer finders immobilized with respect to a carbon nanotube sensor, lessens its electrical opposition when appended to a malignancy cell. This component thusly permits electric flow to initiate a nano-electrical-mechanical hand-off to break the chamber roof uncovering a medication distinguished by the invulnerable system for cell end. This idea is in accordance with the push to plan an independent computational nanorobot for in vivo clinical conclusion and treatment.[25]

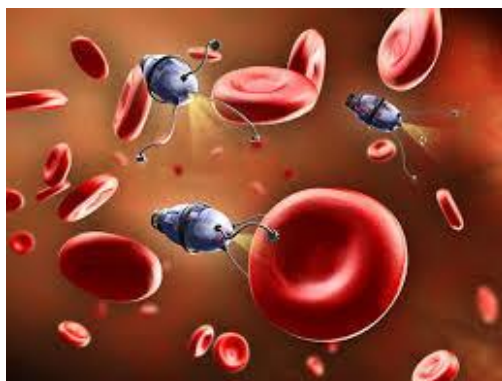
Cancer is perhaps the deadliest disease of this century. Monotonous and agonizing radiation treatment and chemotherapy are directed utilizing numerous medications counting antitumor anti-microbials, which cause a great deal of results. As a substitute, DNA nanorobots fill in as a potential disease treatment strategy which is a lot of more secure than different treatments and acts explicitly too. [26] DNA nanobots are said to set another achievement in the advancement of clinical contemplates. The essential goal of this nanorobot is to target and dispense with cancerous cells from the human body. These nanorobots are made of a solitary strand of DNA collapsed into the ideal shape. The nanorobots will have two states - an "off" position, where the clamshells are shut firmly to sidestep solid cells without any harm and an "on" position, where the clamshell opens up to open cancerous cells to the medication so the medication can take care of its responsibility to dispense with the disease cell. [27]

7. Commercial Applications of Nanorobots- da Vinci system

The da Vinci Surgical System (Intuitive Surgical Inc., Sunnyvale, CA) is the ruling robotic surgery platform because of the long-life span of its innovative work and man different uses in surgeries like —cardiovascular, colorectal, gynecologic, thoracic, and urologic—for which it is utilized. Since FDA endorsement in 2011 the da Vinci's utilization has expanded dramatically, turning into the most generally utilized robotic methodology in the

United States during its 8-year business accessibility. The da Vinci framework has been looked into somewhere else; nonetheless, since it is the norm of examination for other automated frameworks. [28]

Instinctive Surgical delivered the da Vinci's most recent model, the Xi, in 2014. Previously, the da Vinci have three arms to hold two tools and an endoscope but nowadays the most recent da Vinci have four arms (single arm unit accessible with the single port da Vinci model), a versatile stage, and an expert reassurance. Link driven joints consider control of the careful instruments situated on the distal closures of each automated arm. The mechanical arms themselves are blast mounted, with limit with respect to 3 levels of opportunity (DOF). Representation is accomplished through a flexible 8-mm camera fit for use in every one of the four ports, taking into account a more assorted collection of activities. The vivid expert support ("specialist comfort") gives an amplified, superior quality, three-dimensional (HD-3D) perspective on the careful field that is shut off to the remainder of the OR [29].



The da Vinci is a surgical robot having hundreds of programs installed in it. Da Vinci has been manufactured in 5 models so far: Standard (1999), S (2006), Si (2009), Si-e (2010) and Xi (2014). From Standard to Xi the visual resolution, instrument controllers and ease for the surgeon to provide input to the tools are improved.

The da Vinci framework offers high-goal 3D perception, movement scaling, and an agreeable UI to upgrade careful exactness and expertise. Significant downsides to this methodology are its expense at \$2 million for each careful framework, and size. The da Vinci's size frequently requires committed working theaters and limits the capacity to quickly switch instruments during a system as the comfort configuration isolates the specialist from the patient. The da Vinci likewise needs haptic criticism, which gives the client a feeling of touch. Powers are shown outwardly as opposed to being converted into material sensation. Studies show diminished confusions and length of remain comparative with open careful methodology, which may offer some money saving advantage for the medical clinics that can bear the cost of their framework and oblige its size. Clear advantage over laparoscopic approaches still can't seem to be seen. The huge size and significant expense of the da Vinci framework present critical obstructions to the use of automated a medical procedure in more modest, asset contracted zones.[30]

8. Gene Therapy

Fruitful quality treatment (gene therapy) relies upon two significant aspects.

(1) Coherent delivery of the Target cell in vitro and in vivo. To accomplish this objective, it is important to improve transduction effectiveness, viral titer when utilizing viral quality treatment, or transfection productivity when utilizing nucleic acids.[31]

(2) Effective checking of adjusted(modified) cells or altered cells by non-invasive imaging procedures. This helps in giving the status of delivered gene inside the human body by tracking the gene expression.

These viewpoints and others are being tended to in new methodologies, such as magnetic nanoparticles. In quality conveyance, the nanoparticles utilized in MRI present significant favorable circumstances over other imaging strategies, for example, fluorescence, iridescence, or PET, which have been likewise utilized in quality treatment.[32]

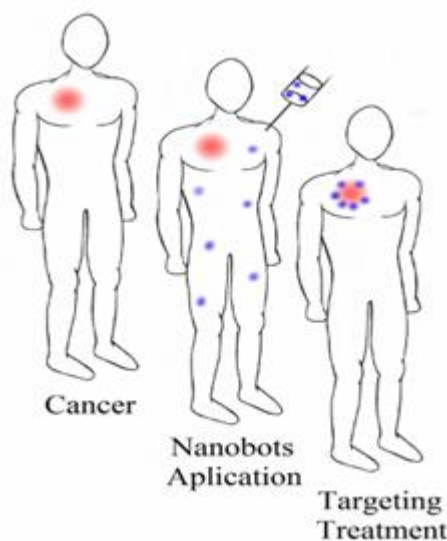
Over the most recent couple of years, numerous gatherings have revealed the utilization of nanoparticles to complex and convey viral vectors (e.g., adenoviruses, retroviruses) and nucleic acids, prompting the rise of new methodologies known as magnetofection and theragnostic. Magnetofection technique that uses superparamagnetic nanoparticles to improve quality conveyance under a magnetic field. Theragnostic joins therapeutics with diagnostics and covers a few fields, including customized medications and sub-atomic imaging to create proficient new focused on treatments with a sufficient danger/advantage proportion. Moreover, theragnostic means to screen the reaction to treatment and to expand adequacy and security.[33]

9. The Scope and Future of Nanorobots in Medicine

Nanorobots have proven to be a revolution in medicine and treatment and their relevance and significance in this field is expected to grow substantially with time. One of the major fields where nanorobots are touted to play the leading role is in cancer therapy. [34] Using the principles of Drug Delivery and Signaling, which have been vividly discussed above, a study aims to develop a nanorobot that will independently navigate inside a human body, detect a cancerous tissue and carry out drug delivery at the same place, as illustrated in the figure below. [6]

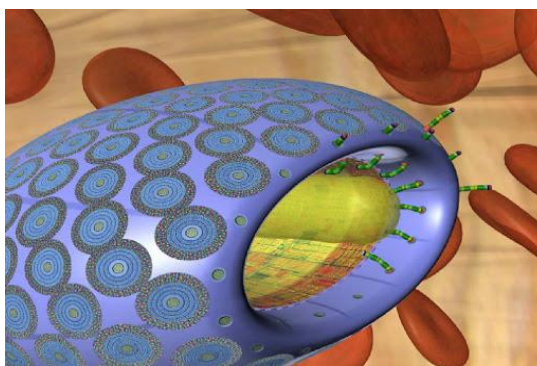
This will prevent the cancerous cells to multiply and spread across the body, and would thereby decrease its prevalence in the body. Another study is being conducted to manufacture nanorobots that will facilitate in the destruction of cancer cells using thermal necrosis. This can be done using magnetic beads that have the ability to identify, target and destroy cancerous tissues using a magnetic field [35].

Nanorobots are also proposed to being used in the treatment of other illnesses such as atherosclerosis, ischemic and arrhythmias. The latter two, being cardiovascular diseases, will feature the injection of the nanorobots in the circulatory system using intravenous fusion techniques to act against fatty deposits. On similar lines, nanorobots are also proposed to be used in the diagnosis and possible treatment of demyelination. Similarly, they can be used for the detection of Alzheimer's Disease on the basis of the deposits of the amyloid protein β . [36]



Detection of Cancer using Nanorobots

Special Nanorobots called as Dentifrobots are also in development, which are proposed to being used in the field of odontology. They are intended to act as an additional companion to dental products such as toothpastes and mouth washes and will carry out the metabolization of the stuck material and identify and destroy the pathogenic bacteria present in the mouth. [37] Another application of nanorobots involves their travel through a patient's gingiva and the delivery of an analgesic to the target site. Nanorobots have also shown promise in conducting surgeries in the retina and its surrounding regions and also in pregnant women.



One of the most exciting applications of nanorobots include Microbivores, which are Artificial Mechanical Phagocytes proposed by scientist Robert Freitas Jr.. The primary function of this device is to destroy pathogens present in the human bloodstream using the digest and discharge protocol. These devices are oblate spheroidal devices having a diameter of 3.4 microns along its major axis and a diameter of 2.0 microns along its minor axis. The device contains 610 billion meticulously arranged structural atoms and have a gross geometric volume of 12.1 micron^3 . [38] The structure of a Microbivore is shown in the figure.

10. Conclusion

Nanotechnology and Nanorobots are proving to be the technologies of the future. As the nanorobots, function on a completely different metric scale and operate in the range of 10^{-9} meters, they provide a goldmine of opportunities and provide possibilities for the development of novel technologies. As explored thoroughly in this paper, nanorobots have evolved to constitute as an integral part of the field of nanobiotechnology and medicine. The components of the nanorobots, their necessity and their function were discussed in order to bring to focus the process a nanorobot goes through when performing its operation and the role of electronics in the same.

Various applications of Nanorobots in medicine and their relevance was also deliberated with. Applications such as their use in critical fields of detoxification and gene therapy were discussed bringing to light how nanorobots have managed to overcome the drawbacks that were present earlier. Commercial Applications of nanorobot, which can arguably be considered as the more emphatic current applications were also described in the form of robotic systems such as the Da Vinci System. The history, advantages, and the disadvantages of the same were also noted and put against each other as a debate. Other existing industrial and commercial applications of nanorobots were also thoroughly discussed throughout the paper to show how nanorobots have made, and are expected to make, big strides from ideas in the lab to impacting personal lives.

The two key applications of nanorobots in the medical field, namely the drug delivery and the surgery systems were also descriptively. At the same time, the future advancements and pending patents on innovations related to the same concepts were also discussed. The paper has also included the core part of any scientific device, which is ensuring the accuracy and effectivity of any equipment—as the role of various factors such as accuracy and precision were discussed and the importance of little margins in a sensitive field such as medicine were brought up and deliberated upon.

The promise and excellence shown by nanorobots in their performance and wide array of applications has given the field of medicine, among others, a ray of hope of being able to treat dangerous diseases such as Cancer and Alzheimer's disease with the use of their unique properties. As related technologies continue to evolve and get better in the future, one can hope that the accuracy and applications of nanorobots in this field follow the same suit. With a rise in the use and accuracy of fields such as Artificial Intelligence and 3D printing, there is high promise for nanorobots to get better in performing their existing tasks and for seemingly impossible tasks to being performed with the aid of these technologies. Nanorobots have existed for only a few decades, but with their wide applications are here to stay.

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An Intelligent Bed Mat for Prevention of Pressure Ulcer

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Abstract. Human faces a lot of issues in regard with pressure ulcer like cost for the treatment. Here we propose a pressure sensing bed mat with an aim of alleviating bed pressure by means of detecting the pressure in order to prevent pressure ulcer. This bed mat is capable of recognizing the various pressure values in between the skin and the bed. It is made in such a way that its machinery consisting of a number of pressure sensors equipped on a bed with flexible thin sheet placed on it. When the patient lies down on the bed it starts working and displays the pressure being applied to the different parts of the body in an LCD. This mat with robotic extension/retraction mechanism made use of the pressure sensing and bid the necessary pressure in different parts of the body. This applied pressure will maintain and resolve the pressure at the top and ulcer region gets cured. This mat can alter the pressure on both sides of the bed, thereby resolving the pressure ulcer problem. This pressure mat is designed so as it can be used for an early stage treatment and to elders with pressure ulcer in a nursing home.

Keywords. Pressure Sensing Bed Mat, Pressure Sensors, Pressure Ulcer, LCD, Robotic Extension/Retraction.

1. Introduction

Pressure ulcer is a major health issue faced by people who have mobility disorders, like elders in acute care, long-term care and home care settings. It affects people with paraplegics, tetraplegics whom with burned injuries. Pressure ulcers may lead to unhealthfulness and deadliness. Human faces a lot of issues in regard with pressure ulcer like cost for the treatment. It is found that there are a number of factors affecting the development of ulcers and they have been grouped into two, intrinsic and extrinsic factors. Interface pressure, shear forces and friction are included in extrinsic whereas intrinsic factors includes age, diseases, nutritional state of the patient etc. Even it is agreed that formation of pressure sores is a complex procedure, but there is no evident facts regarding the formation. The trouble in prevention of ulcers is with the factors assessment. It is much needed to improve the preventive measures. Even though no parameters exist such that it can foretell the pressure ulcer formation.

2. Current Pressure Ulcer Prevention Methods

To get rid of problems from pressure ulcer, many techniques have been established for issuing cushion effect. One of them is water bed in which there is a heating chamber that circulates warm water which is maintained at a constant temperature. The main drawback of this water bed is that we cannot adjust the bed when needed.

Bed which was designed, so as the patient is able to lie down on it in an elevated manner, but it brings more depletion to the trunk and gluteal regions, which was due to more frictional forces and shear. There is a box which is in depth for the water bed, the design which was not attractive, to support the intermediate regions, it was designed so as its end will taper

away to a smaller depth and near ends. More development was carried out using buoyant force to get rid of pressure. It was not that much easy to maintain this water bed. To make it much more user friendly and simple, an air bed mattress system was developed, with an air reservoir and a gadget which will help to deliver instant and controlled air to the bed mattress. Later foam containers were designed so as to give out more cushioning. Again it was developed to a pulsating liquid foam container by which an air circulating system was impersonated. These ideas for the treatment had some drawbacks.

- Manual labor was needed.
- The position of the patient is not fixed at all times.
- The region which gets changed was not according to the pressure.
- It was not able to switch position to get rid of pressure.
- The produced skin was again turned to sores with the above drawbacks.

3. Methodology

Here I propose a pressure sensing mat for a bed which is capable of recognizing various pressure values between the skin and the bed. Its mechanism is such that there is a bed which will sense the pressure values applied between various spots of skin and bed. It contains a number of pressure sensors equipped on the bed with a flexible thin sheet placed on it. After the patient lain down it will start to work and measures the pressure being applied to different body parts and is displayed on an LCD screen.

The next is followed by combining the use of mat with the robotic extension/retraction mechanism. This robotic system is capable of giving required pressure at any point in the bottom side of the bed. This applied pressure will maintain and resolve the pressure at the top and ulcer region gets cured. In order to control the pressure at different regions the bed is controlled with an Arduino microcontroller which was extend or retract mechanism. The output pin of the Arduino board carried out the extension and retraction function of the extenders. A maximum of 5 V power is given at the output pin of the Arduino and direct power is given to the extenders. An external power supply with 24 V is used as the input of 5 V which is not adequate to run the motor.

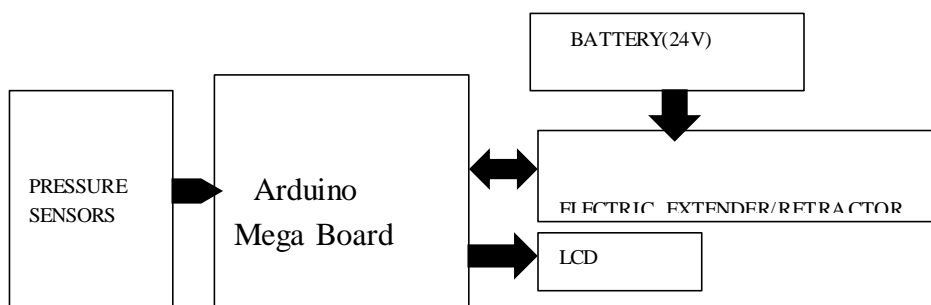


Fig. 1. Block diagram of the proposed system

If the average pressure is lesser than the normal threshold ie 32mmHg then it shows “Normal-No Change” on the LCD. This instruction is same for all the four parts. If the pressure value in the part 1 is greater than 32mmHg ,then the LED will light up and displays “High Pressure-PART 1” on the LCD. Then we can easily resolve the problem by adjusting part 1. If the pressure value in the part 2 is greater than 32mmHg ,then the LED will light up and displays “High Pressure-PART 2” on the LCD and so on for part 3 and part4 as shown in the fig (2) given below.

HIGH PRESS-PART 1	HIGH PRESS-PART 2
HIGH PRESS-PART 3	HIGH PRESS-PART 4

Fig. 2. Basic modal of commands displayed on the LCD

4. Result And Discussion

Distinct from area of bedding, interfacing unit area were also lesser than a square inch. To avail prompt and correct accomplishment of pressure in that area, it was provided with a sensor and an extractor (air bladder). Further the total area of the bed is subdivided into equal 4 parts and the average pressure on them is calculated. LCD is connected so as to display the text indications from the 4 different parts using 4 LCDs. Here I used only 1 LCD and connected first on the LED1, then LED2 and so on till LED4. If the average pressure is lesser than the normal threshold ie 32mmHg then it shows “Normal-No Change” on the LCD. This instruction is same for all the four parts. If the pressure value in the part 1 is greater than 32mmHg, then the LED will light up and displays “High Pressure-PART 1” on the LCD. Then we can easily resolve the problem by adjusting part 1. If the pressure value in the part 2 is greater than 32mmHg, then the LED will light up and displays “High Pressure-PART 2” on the LCD and so on for part 3 and part4. This improved and excellent design of pressure mat will help us to reduce or change the pressure of different regions. This pressure mat is an absolute well working treatment method for the pressure ulcer patients.

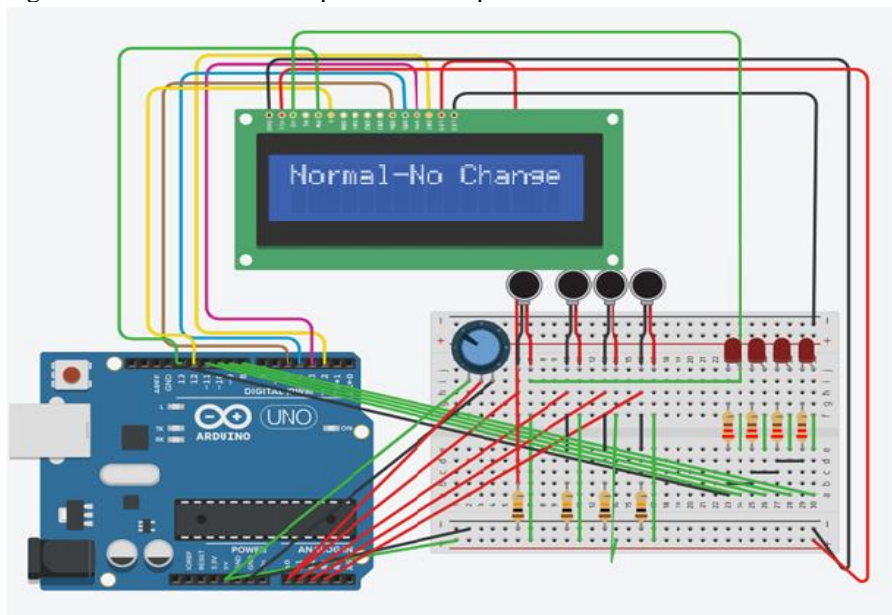


Fig. 3. Output when the average pressure is lesser than the normal threshold.

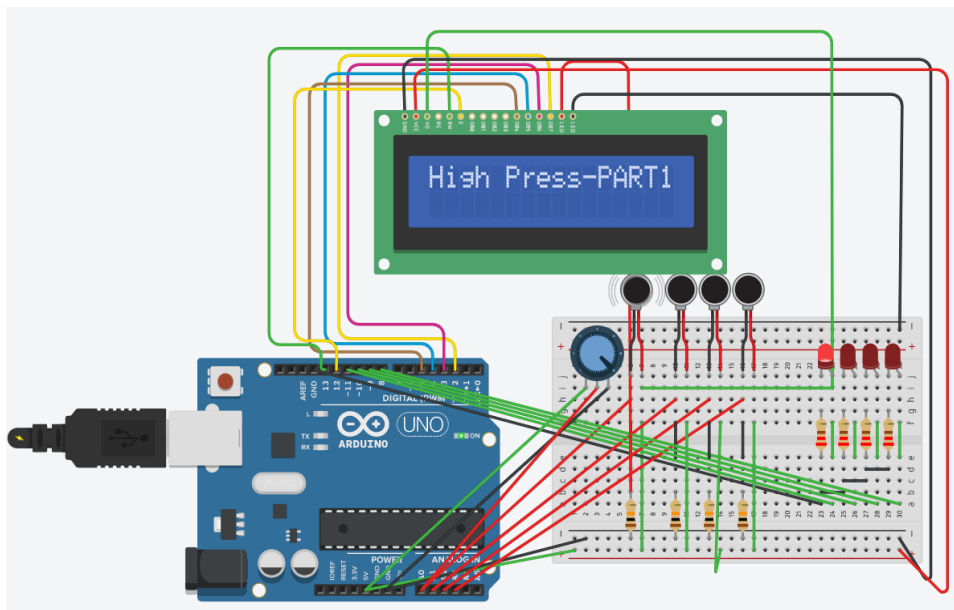


Fig. 4. Output when the average pressure is greater than the normal threshold in part 1.

5. Future Scope

- To change the pressure at the surface of the bed at different regions in favour of the user.
- To introduce advanced technologies for redistributing pressure regions.

6. Conclusion

A well designed pressure sensing mat is executed with the help of pressure sensors (FSR Sensors-Force sensitive resistor). The pressure values at the top surface of the bed is detected and is displayed with the help of an LCD screen. When the mat is placed on surface of bed, real-time pressure readings on the laying surface can be shown on an LCD screen. The surface pressure of the mat can be changed with a change at the bottom of the bed with the use of further gadgets. This pressure mat is designed so as it can be used for an early stage treatment and to elders with pressure ulcer in a nursing home.

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Variable Intensity & Distance Driven Projection Using Iterative Reconstruction, MAR Algorithm & Window Classification

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Abstract. The paper reviews current trends in research on imaging in CT scan. It shows how the concept was formed and developed. The general concept to provide a good or optimum value pack which can perform many functions. From above research article my thought is to combine some methods which will be integrated with each other, like methods like maximum intensity, minimum intensity, which is going to be called as variable intensity and back projection which is used for 3D geometrics can be integrated into each other and that machine can perform well over the previous one. MAR algorithm which is metal artefacts reduction and windowing method which is basically an image processing method comes under software process so these can be applicable to most of the systems in image processing. Iterative reconstruction is used for the use of reduced CT dose and less noise level. By applying these we can offer better healthcare service as well as better clinical experience to the society. Each system should have its own database and all systems should be cloud linked so that patient files can be accessed without investing any time.

Keywords. Variable intensity, Back projection, Windowing classification, Iterative reconstruction, MAR algorithm.

1. Introduction

As it is going to be the improved and combination of several techniques used in MRI imaging method, first we need to know about those techniques.

A. Variable Intensity

The Standard and micro dose CTs were done with an anthropomorphic chest photography using three reconstruction kernels (i30, i50, i70). Thirty-three solid nodules (5 mm, 8 mm, 10 mm, and 12 mm diameters) were put in 55 fantasies. The MIP images were evaluated by four blinded readers; one registered the CAD1 and CAD2 results. For each reconstruction kernel, CAD and MIP nodule sensitivities were calculated at the standard dose and CT micro dose. The use of iterative reconstruction models during image treatment is one approach to improving image quality for micro dose CT. The reconstructor of micro dosage CT kernels will differ in terms of the noise and spatial resolution differences among technologies from traditional kernels used in standard dose CT. New information indicates that smaller, softer reconstruction kernels could be preferable to CT micro doses compared to hard lung kernels typically used in low routine dose or CT chest diagnostics. Maximum intensity projection method is the most simplest method which best post processing and it will increase nodule detection rates precisely which can help in the CT scan of the abdomen region. CAD

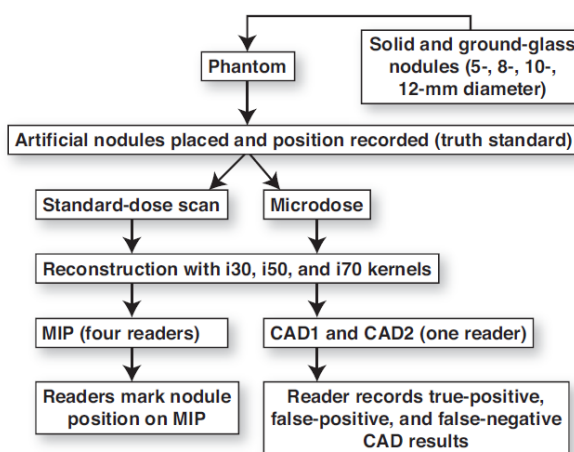
system can be integrated into this system which is very much helpful in detecting lung cancer because of its multi algorithm and auto nodule select system.

It is using standard CT scan with 3 reconstruction kernels (i30, i50, i70) after that 133 ground glass and 133 solid nodules placed with diameters f 5mm, 8mm, 10mm, 12mm). One image evaluated by 4 binders and other is evaluated by CAD1 and CAD2. Statically and computational analysis are done in this method for better outcome.

However, to our knowledge, no comprehensive investigation has included all of these multivariate factors and examined their effect on diagnostic accuracy. Four nodule diameters were 2 Solid and ground-glass nodules Artificial nodules placed and position recorded Standard-dose scan .Results Nodule Detection With Computer-Aided Detection and Maximum Intensity Projection Nodule detection sensitivities of the two different CAD systems and MIP at varying dose levels are outlined in where sensitivity is high in nodule selection the image detections also high.

Influence of Nodule Size and Composition The influence of nodule size on lung lesion sensitivity relative to CT dose and kernel reconstruction is following this rule given below: as the nodule size increases the standard and micro dose increases and the higher doses required in MIP followed by CAD1 and CAD2.

The application of CAD1 performed as well for small nodules as it did for large nodules in standard and micro dose technique. No statistically significant difference was seen in CAD1 performance for nodule detection between standard and micro dose CT. In comparing CAD systems, CAD1 performed significantly better than CAD2 for all nodule sizes irrespective of dose or kernel. An i30 kernel was significantly better than an i70 kernel for detection of nodules that measured 5 mm when using MIP reconstructions for micro dose CT. No statistically significant difference was seen between kernels for larger nodules. Satisfaction of Search in Maximum-Intensity Projection Readings to address the relationship of the number of missed nodules and the number of nodules embedded in the phantom, we separately analysed sensitivity on the basis of nodules per phantom .Many parameters influence the accuracy and efficiency of pulmonary nodule detection on chest CT.

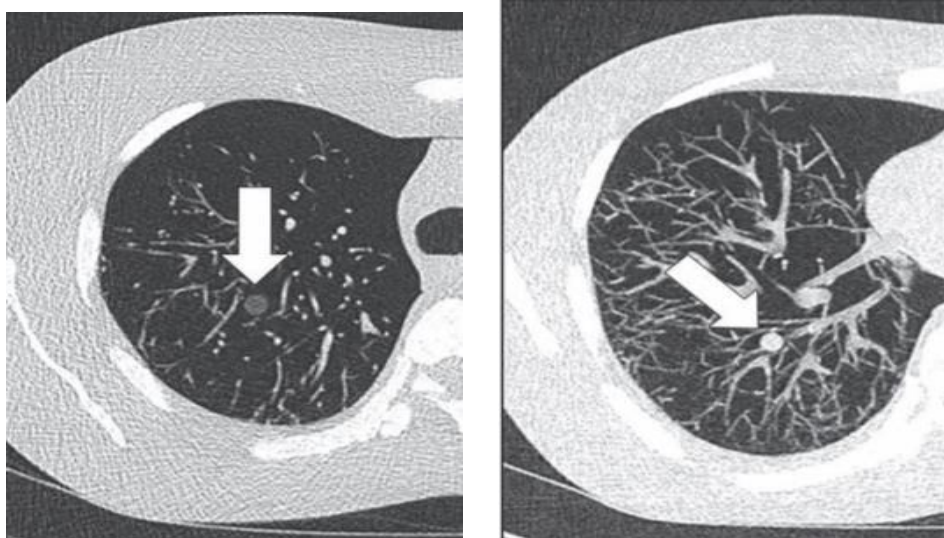


This study compared the detection rate of solid and ground-glass pulmonary nodules of variable size using different CT dose levels and reconstruction kernels using one of two different CAD systems or MIP processing for interpretation. CAD2 performed best with standard-dose CT and a hard lung kernel, which likely reflects the most common imaging

parameters for routine clinical diagnostic chest CT, but the performance of CAD2 on lower dose exami- 6 TABLE 3: Satisfaction of Search and Impact on Reader Performance No. of Nodules per Phantom Sensitivity p vs Single-Nodule Phantom a 100.0 NA 2 79.2 0.007 b 3 93.3 0.22 4 93.6 0.23 5 95.2 0.35 6 91.7 0.14 7 94.0 0.28 8 93.0 0.19 Note -The number of images read of phantoms containing four nodules or fewer was 912. In our study, using a CAD system or MIP reconstructions best facilitated detection of solid and ground-glass nodules on CT. Because the CAD systems we evaluated did not perform similarly, we conclude that sensitivities of CAD algorithms can be improved with respect to nodule size and sub-solid features. Computer-aided nodule detection and volumetric to reduce variability between radiologists in the interpretation of lung nodules at low-dose screening computed tomography. Effect of CAD on radiologists detection of lung nodules on thoracic CT scans.

Minimum intensity projection is a visualization method to detect the low density structure. Algorithm uses all the info to create a single bi-dimensional image (high voxel and low attenuation) & this algorithm is called as MINLP. By this algorithm we can determine the hypo dense (vein. Artery) tissue region with high voxel density and low attenuation. Recently, volume statistics can be acquired from the area of interest in high spatial and temporal resolution with the expanded use of multi detector computed tomography (MDCT). One of the biggest advantages of MDCT is the ability to manipulate computer workstations to display images in different ways with volumetrically data collected by scanning a patient. In addition to reconstructions on various planes, a number of images can be obtained with their normal, low or high density values. Parenchymal conditions which occur when the patient is hypo attenuated, mosaic attenuated or air trapped. Precise delineation of these focuses helps to prepare and track disease accurately. The technique is particularly useful in the case of patients with chronic obstructive airway disease, pneumonia of hypersensitivity and lungs to differentiate bronchogenic traction from honeycombing. - It act as virtual endoscopy and it can use in respiratory diseases due to good imaging quality in low density tissue region.

Combination of maximum and minimum projection method will enhance the efficiency as well as the usability of a CT machine as the machine can be useful for the soft tissue and hard tissue detection, chronic disorder and cancer etc.



a. Ct scan either with maximum or minimum intensity method; **b.** with variable intensity

B. Distance Driven Projection

It is the distance driven with high sequential memory access pattern, this algorithm is called as Filtered back projection (FBP). In this algorithm for each region of interest, radial, azimuthal, longitudinal resolution are calculated then geometric average calculated, then resolution are matched in each 3 directions. There are numerous, well-established examples of the x-ray transform in medical imaging, including computed tomography, single photon emission computed tomography, positron emission tomography, tom synthesis and projection mode 2D magnetic resonance imaging. If the image is decomposed into a set of images, each of a single material, then line integral projections of these single material images can be combined with the appropriate spectral weights to compute the polychromatic response. Another application back projection is in iterative reconstruction, in which repeated applications of the forward and backward model are used to process for the image that best fits the measurements according to an appropriate objective functions and requirements, and in iterative correction schemes, an example of which is the reduction of beam hardening artefacts. These methods work by spacing and tracing rays through the image, essentially discretizing the line integral directly, and thus approximating each line integral as a weighted sum of all image pixels that lie close to the ideal expected line.

Ray-driven projection-back projection works by connecting a line from the focal spot through the image to the centre of the detector cell of interest. For each image row, the pixel centres are mapped into the detector, followed by the 1D re-sampling operation defined in equation for better interpretation. Ray-driven projection, a location of intersection is calculated, a value is obtained from the image row, typically by linear interpolation, and the result is accumulated in the detector cell.

For each image row, the detector centres are mapped onto the image row, followed by the 1D re-sampling operation defined in equation. To clearly understand the new method, one should first realize that every view defines a bisection between the position on the detector and the position within an image row. One aspect is the fact that the main loop is not over image pixels or detector cells, but over x intercepts, hence the name distance-driven. 3D distance-driven method: we map all horizontal and vertical boundaries of the image voxels and detector cells onto a common plane according to the requirement.

In practice we only map the horizontal and vertical boundaries of the image voxels and detector cells, approximating their shape by a rectangle. The pixel-driven projection shows interpolation artefacts, both in the in-plane and z directions and show the centre image slab in the resulting 3D distance-driven.

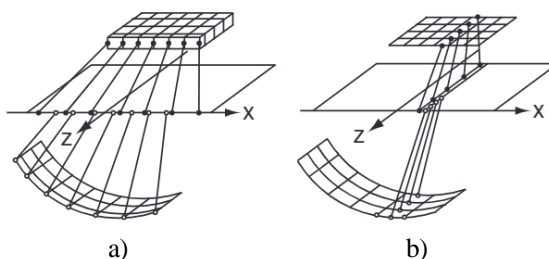


Fig. 2. a) 3D pixel-driven and distance-driven projection of a uniform slab;
b) 3D ray-driven and distance-driven back projection of one uniform view.

Even if at its centre, the image pixel size is perfectly matched to the effective detector aperture, the ratio between the two sizes changes as a function of position in the image. For analysis of the image noise, based on an air scan intensity of 106 photons per view per detector cell. We have performed 3D distance-driven and pixel-driven FDK reconstructions of software phantom simulations to show the benefit of the distance-driven method for FBP reconstruction in terms of image noise and spatial resolution. In addition to its image quality and performance benefits, the distance-driven method is well suited for hardware implementation and flexible in terms of allowable imaging geometries.

C. Iterative Reconstruction

The main idea is to improve the image quality in certain cases and this method is a type of method which includes an image assumption and comparison to the real time image while making constant alignment until two are in same alignment. The FBP image is used for the initial condition in adaptive statistical iterative reconstruction for the following reasons: it is presumably close to the final optimized solution; it is a valid indicator of certain-slice image noise; and it can be quickly obtained. Images were reconstructed with both FBP and multiple values of adaptive statistical iterative reconstruction ranging from 10% to 100%. abdomen had been imaged, and in six, only the abdomen and pelvis. Assume C, Linear combination of A and B produces blended image, which has less noise than filtered back projection image but without artificial smoothing of 100% adaptive statistical iterative reconstruction image. Reconstructing images with 30% adaptive statistical iterative reconstruction for half-dose acquisitions produces images with noise nearly equivalent to that of full-dose images without adaptive statistical iterative reconstruction.

The basis of results of the phantom analysis, which indicated that 40% adaptive statistical iterative reconstruction should produce a diagnostically acceptable image with less noise than a full-dose FBP image.

A score of 1 meant that the image was better than expected at routine-dose CT, 2 meant the image was equivalent to that expected at routine-dose CT, 3 meant the image was worse than expected at routine-dose CT, and 4 meant the image was non-diagnostic. The noise indexes were nearly identical for low-dose CT with adaptive statistical iterative reconstruction and routine-dose CT. Qualitative comparisons-Low-dose CT without adaptive statistical iterative reconstruction had the worst scores for visually assessed image noise, image quality, spatial resolution, and low-contrast resolution. Low- A B dose FBP images and low-dose CT images with adaptive statistical iterative reconstruction were nearly identical. verged scores from both readers in the comparison of routine-dose CT and low-dose CT with adaptive statistical iterative reconstruction were equivalent or nearly equivalent for image quality and low-contrast resolution. The only difference was that the averaged image quality grade was slightly higher for low-dose CT with adaptive statistical iterative reconstruction than for routine dose CT. In the overall analysis, routine-dose CT had slightly better overall image quality.

The ability to selectively reduce image noise allows generation of a higher-quality image at a lower radiation dose with adaptive statistical iterative reconstruction than with FBP techniques. Reader assessments of overall image quality and low-contrast resolution were nearly identical for low-dose CT scans with adaptive statistical iterative reconstruction and routine-dose images, further supporting the potential of this technique for routine imaging. Image quality similar to or better than those of routine-dose CT. Compared with those of conventional imaging, with adaptive statistical iterative reconstruction, CTDI and DLP both were reduced an average of nearly 50% and up to 65% in some patients using adaptive statistical iterative reconstruction when compared with common dose imaging.

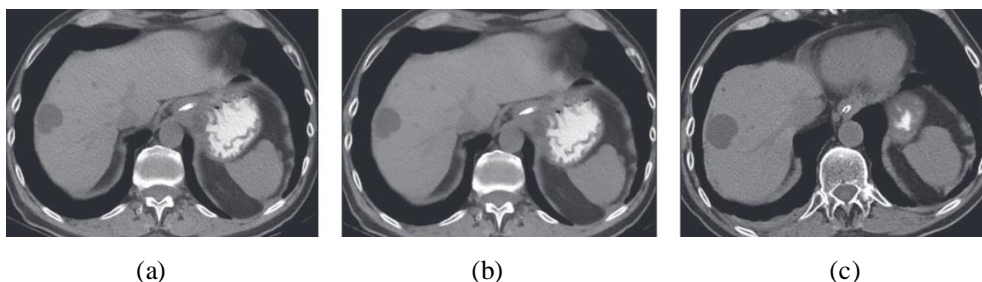


Fig. 3. a) low dose CT image; b) high dose CT image; c) after adaptive iterative method

D. MAR Algorithm

In the region adjacent to the implanted metal object and 3 cm from the metal object, metal objects were reduced significantly in the decreasing-correct flat-panel CT images. Reduction of metal objects is an efficient way to improve CT images damaged by metal objects by a flat panel detector. The acquired FDCT images are degraded by objects produced by endovascular and surgical radio density implants, including coils, stents and clips that restrict the use of FDCT for the purposes of postoperative imagery. Photo Acquisition In normal clinical care the images of the FDCT were acquired by using a 20 second scanning procedure with the following parameters on a biplane Axiom Artis zee angiography system: 70 kV, 200 ° rotation, 496 projectors, 1.2 Gy / frame. The initial photo recovery for each case was performed on Syngo X Workplace, VB15 or VB21 models. Section thickness, 0,46 mm; "Natural" reconstruction kernel; full FOV; 512 512 matrix, resulting in the isotropic voxel dimension, 0,3 mm to 3 mm, were the parameters used to recompose the FDCT images.

An uncorrected picture of the volume of the acquired imaging data was initially recovered. Rating used to measure metal objects Description 0 No metal artefacts; related anatomical well-visualised anatomy 1 Medium metal artefacts; anatomy appropriate, visible to the spectator but subject to the impact of artefacts 2 Severe anatomical anatomy; corresponding not visible anatomy.

Relative metal artefact frequencies assigned for FDCT scans immediately-69.2% of uncorrected images. The median p value for the pairs of images which were not corrected or corrected by the MAR adjacent to a metal of 25.9%, and 4.8% for the MAR object was P to.05 with a median P value for the pair of images 3 cm away, being P to.03. At 3 cm from the Onyx cast, 23.8 percent, 19.0 percent, and 57.1 % for non-corrected images and 52.4%, 19.0%, and 28.6 percent for MAR corrected images, respectively, were relative frequencies for objects not found in their presence, as moderate or extreme.

Technical improvements have enhanced the FDCT imaging efficiency in the acquisition and post-processing of images. FDCT imagery has a better spatial resolution, 1,10 in relation to CT multi detector imagery, making it easiest to visualize the fine geometrical details of metal stents and spirals used in neuroendovascular intervention procedures¹¹ and fine anatomy in the brain.¹² The metal alloys in the implants degrade FDCT imaging's image quality and restrict its use as a post-procedural procedure. An effective way to decrease metal implant materials will make the visualization of FDCT a perfect post-procedural technique to imagine problems such as intracranial bloating, residual aneurysm filling or thrombus in newly implanted stents. Despite these limitations, the FDCT image quality is significantly improved through MAR algorithm and the FDCT value increases as a technique of post-neurointervention imaging.

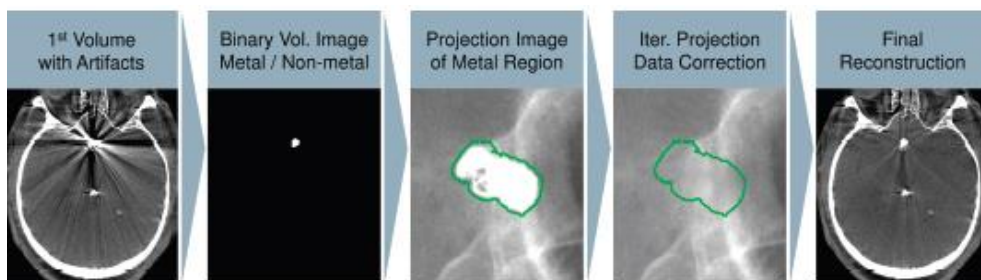


Fig. 4.

E. Window Classification

Our algorithm is based in photographs of the bone and non-bone windows on the contrasting presence of soft tissue. HU-to-gray mapping optimizes bone windows for the thick tissue, but the specifics of less dense soft tissue are lost in this optimization. When contrast to brain windows, which display soft tissue specifics of the soft tissues are much more evident, the area of soft tissues in a Bone Window has comparatively homogenic strength. We use three main steps of our method: 1) division of the area of interest of soft tissue; 2) regional extraction; and 3) classification of supporting vector machine

a) Segmentation of soft tissues:- The segmentation of soft tissue is critical; the precision of the final classification is dependent on the performance of the segmented results. This is also the step in dealing with the broad variability of the data input. Each stage involves the pre-processing, image clustering and post processing sub-steps. The following sub-steps are listed.

1) Pre-processing :-As a broad range of intensity is present in the image dataset, we normalize and improve the contrasts of the images to make comparisons between images when possible with a specific dynamic range and contrast environment.

2) Image clustering:-The objective of this sub-step is to segregate the picture into three types of areas: filled areas with air-fluids, high-density areas and regions of soft tissues. The air-fluid-filled areas may exist outside the brain or inside the brain (nasal cavity or ventricle) and are low (dark, black) in size. The areas of high density (for example, bones or calcified structures) are highly strong (high white). There are intensities that occur between the regions of soft tissue (which are regions of interest). We tested two methods to identify image pixels: k-means clustering and thresholding at several stages.

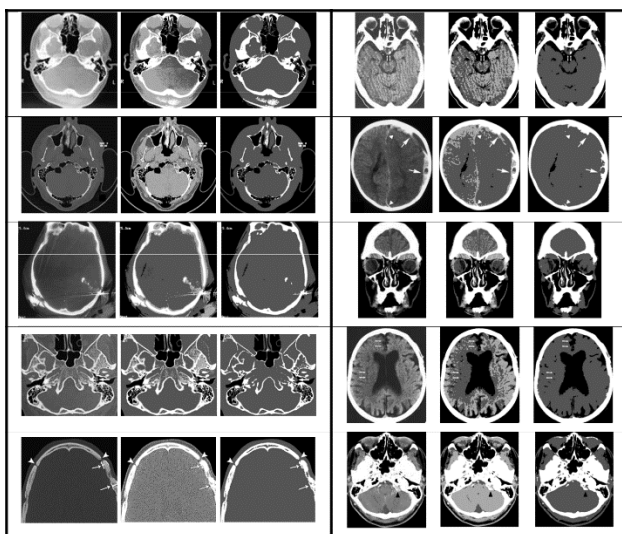
3) Post-processing The final binary mask of the region of interest of soft tissue is generated by the (a) rebellion into the soft tissue areas of small low intensity and (b) relabeling into the areas of soft tissue of small high intensity.

b) Region feature extraction:- Using the pixels in the most connected region of the segmented regions of soft tissue, we calculate the gray-level histogram (a vector with a length 256) of the pre-processed image. Until measuring features, we use a median filter to reduce the effect of noise. The effectiveness of the histogram alone can be explained in part by the efficacy of the sectioning process in the extractor of soft tissues and by the apparent fact that it is an effective discriminator between bone windows and other forms of windows in its distribution of soft tissue area.

c) Classification:- For each image, the ROI soft tissue is identified and the histogram is extracted. We construct a binary classifier using the Support-Vector Machine (SVM) [8] in order to classify the image into one of 2 categories (bone vs. non-bone window), which is supervised

and common because of its overall performance. Given a subset of data (training data), SVM is able to find an ideal high dimension plane which is used to divide data into two classes.

Methods	Training	Testing	LOO
K-means clustering	Sens.= 1, Spec.= 1	Sens. = 0.875, Spec.= 0.875	Accuracy = 90.9%
Multilevel threshold.	Sens. = 1, Spec.= 1	Sens. = 0.79, Spec. = 0.85	Accuracy = 87.5%



a) bone window image

b) non window image

F. Working

Implementing so many method is a time bearing process and create a lot of problem for users. In recent days technologies changing in everyday and every one has some disadvantages, so my thought is how we provide a good or optimum value pack which can perform many functions. From above research article my thought is to combine some methods which will be integrated with each other, like methods like maximum intensity, minimum intensity and back projection can integrated into each other and that machine can perform well over the previous one. MAR algorithm and windowing method comes under software process so they can applicable to most of the system in image processing part. By applying these type of technologies we can provide a better service in healthcare. Every system should have their own database and all should be connected through cloud by which we can access any patients file by spending no time.

G. Advantages

I. Maintain uniformity between high and low dose. Image quality increases up to 2.1-2.2%. Spatial resolution is better with 0.004% and noise level reduced by 2%. The main advantage is also need low CT dose reduced by 32-65%.

II. By using FBP and FDK algorithm we get $512 \times 512 \times 16$ grid with voxel size of 0.84mm isotropic ally take 6% less time compared to ray driven. It also reduces artefacts and has performance benefits for 3D geometrics. It has achieved 20% less noise compared to ray driven.

III. Dose of micro dose is significantly less than normal . Better time accuracy and sensitivity can controlled by both CAD1 and CAD2. Highest sensitivity for lung nodule detection.

IV. It act as virtual endoscopy and it can use in respiratory diseases due to good imaging quality in low density tissue region.

V. MAR algorithm reduces artefacts without image quality degradation. The no of voxel count is more compared to the normal one, that's improve imaging quality. In MAR, relative frequencies are used so frequencies aberration prohibited.

VI. It gives a risk free radiation to high vulnerable patient and it has best possible way to avoid noise during processing period. Lung cancer is the leading cause of death so it is the perfect method for detection of lung cancer by using CAD1 and CAD2

VII. It has its own database and can collect up-to 50 bone window image and 160 non-bone window image but only half of the image get processed. It is best method in CT that is safe and easy in function wise with cloud system so we can store unlimited data.

H. Disadvantages

As this system is going to be the integration of many technology and it will hold a complex structure during manufacture. After the manufacturing the maintenance and usability can create problem for the hospital. It required high skilled human resource for operation of the equipment. Use of many software and cloud based storage can also create a problem. There is no such disadvantages but due many options it can create a confusion among users.

Conclusion

This is the method which is far better than the previous one and has advantage in all cases over that old technologies. It has less noise, less time taken for the image processing part and the image quality and performance is well suited for hardware implementation and flexible to imaging geometry. It has higher image quality due to use of 3D geometry for image reconstruction. It gives optimize patient care and reduced substantial efforts. It is very much useful in chest, abdominal, neck region CT. It gives a risk free radiation to high vulnerable patient and it has best possible way to avoid noise during processing period. Lung cancer is the leading cause of death so it is the perfect method for detection of lung cancer by using CAD1 and CAD2. It also diversifying the user experience by the presence of 2 method for clinical assessments. It has certain limitations, it requires more optimize ground glass nodules and the actual performance of CAD1, CAD2 & MPI also

Affect clinical settings in a substantial manner. - It is one of the best method to address any kind of issue in abdominal and lung region and it mostly use in case of angiography to know the position of arteries and veins. MAR algorithm is heavily effective in case of metallic implants and it produced a clear image without the distortions. Increases vessel and voxel count results more image quality in case of cerebrovascular region and acute haemorrhage cases. Leads to the easy evaluation of intra cranial abnormalities. Its algorithm proposes robustness and variability according to the imaging view. It shows the output in bone and non-bone window manner that help the doctor to analyse and it has more clinical. Advances compared to the previous techniques.

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TEG Smart Bin Model (The Blackhole) for “Green City”

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Abstract: The Black Hole is a smart bin that has been engineered to convert waste into electricity by employing the Seebeck effect in order to contribute to the flourishing “smart” industry, and to reduce the pollution caused due to waste dumps by the complete elimination of waste, at disposal itself. The Seebeck effect is the principle employed in this model. The Seebeck effect is a phenomenon in which a temperature difference between two dissimilar electrical conductors or semiconductors produces a voltage difference between the two substances. They serve as energy resource pools, which can be further used by the public as charging portals for their electric vehicles and other electrical appliances. It aids in tackling the current growth and demand of electric vehicles by serving as electricity power stations/banks and thus promoting the “green” trend of trying to reduce the usage of fuels like petrol and diesel. It also employs technologies involved in Industry 4.0 such as IOT for the model’s amelioration. The BlackHole can be further improved by increasing its efficiency to produce higher quantity of electricity and completely eradicating residue formation after waste reduction. Alter Dime aims towards global implementation of the model and aims to help the general public by reducing waste and giving them energy in the form of electricity.

Keywords: Black Hole, smart bin, Seebeck effect, electricity, energy resource pools, Industry 4.0, electric vehicles, IOT, reduce pollution, green city, smart industry, reduce usage of fuels, electricity power stations/banks, petrol, diesel.

1. Introduction

The chief aim of Alter Dime is to achieve the complete eradication of waste dumping and pollution caused due to that, eventually replacing fossil fuels for power generation with waste powered electricity. The BlackHole is a Smart Bin that has been engineered to convert waste into electricity by employing the Seebeck effect using Thermo Electric Generators.

We strive to implement our model globally by collaborating with various governments and private organizations and offer maximum efficiency, reduce pollution, improve global safety, harness sustainable energy and lay out Electric Power Stations that can be easily accessed by public. The implementation of IOT and cloud applications eases out the process and provides the user maximum comfort.

With further designing and building, Alter Dime works towards obtaining high mechanical and electrical efficiency while also producing a cost-efficient product. Alter Dime also plans in the building of domestic usage bins in the future.

2. Core Technical Aspects

The complete prototype modelling is under construction by the usage of the Machine Drawing software SolidWorks. The base material for the construction of BlackHole bears the high amount of heat generated while the medium material between heating area and the

Thermo Electric Generator would be a heat conducting material to transfer maximum heat while not breaking down.

Fans will be placed in the heat transfer area for maximum heat generation efficiency. On the other side of the TEG a heat sink will be attached. The electricity generated from the TEG will be transferred to a battery attached externally.

The BlackHole working process is defined as follows: Waste input into the waste chamber-Waste breakdown and moisture removal using rotational blades carbon sponges and other moisture removers- Reducing of waste in combustion chamber by burning-Heat caused due to burning sent to heat chamber-TEG placed between heat chamber and heat sink develops electricity due to difference in temperature created-Electricity stored in external power bank for use by public (IOT enabled control with sensors for electricity detection by indirect means, connected through cloud application in the mobile application of the user to check on the status of the bin's energy availability)

3. Electrical Aspects

Once the TEG has converted the heat flux into electrical energy, we connect them to the voltage regulator, which in turn is connected the the device to be charged using an appropriate cable.

In order to track the amount of energy available for use, we use appropriate mathematical calculations by taking into consideration the volume of organic material at dispense.

This value is then stored onto the database with the help of the microcontroller and wifi module, in real-time using appropriate protocols.

The amount of energy available is then displayed on the app, for the user to be informed regarding the availability.

The user can then enter his amount required, and receive authentication for the same. Once done, the desired energy will be available to procure if available, and the same amount will be subtracted from the existing total electricity availability.

Keeping in mind that our test case here will be a phone, which means that about 5V is sufficient to charge the device

Business Aspects

Market Analysis

Customer Need Identification

A customer's needs are the most integral part for the success of any product. In the case of BlackHole, what does it satisfy that is part of the customer's "needs" and not "wants"? A clean, green, disease free environment, with the added advantage of energy production in the form of electricity from waste. Many countries have been trying to implement electric cars in order to eliminate the fossil fuel usage. But the main issue that arises is the unavailability of electricity banks like petrol/diesel banks. With BlackHole in picture, we have public electricity banks powered by nothing but waste.

BlackHole also targets large industries, neighborhoods, schools, universities, hotels, restaurants and more commercial areas where whatever waste they generate can we converted into electricity for their own use instead of waste dumping and pollution.

With growing concerns over climate change, we would like to highlight the power generation using fossil fuels as one of the major contributing factors. Blackhole serves to reduce this impact by generating electricity from waste that is dumped. It is a social responsibility venture which solves the persisting problems and also generates revenue.

An article in India Today read out as “India is getting buried in its own garbage as a huge quantity of solid waste generated daily is never picked up and poisons land, air and water. Over 80% of 1.5 lakh metric tonne daily garbage remains exposed, untreated.”

As of October 2018, India ranked second amongst the emerging economies to lead to transition to clean energy in 2018. BlackHole will serve as a tool to boost this rate.

Major Government Initiatives towards waste management:

1. Swacha Bharat Mission
2. Mahatma Gandhi Swachhata Mission
3. Swachhata App
4. Swachhata Helpline
5. Swachha Survekshan
6. Municipal Solid Waste Management Manual

Amongst the above mentioned schemes / initiatives, BlackHole will support the cause with an added advantage of electricity generation.

Serviceable Addressable Market (SAM) Identification & Justification

SAM deals with a certain target audience who could buy our product specifically, regardless of vendor. BlackHole can readily serve any organisation, firm, Government which is keen to reduce the environmental pollution and generate energy. Industries that are looking forward to generate electricity from the waste they produce can easily find the advantages in our product. Social Campaigns and the need to rebuild a green environment pushes our product in the market.

4. Product Differentiation

- The Smart Bin works on the principle of Seebeck effect.
- BlackHole gears up to completely eradicate waste generated in the organic & inorganic domain.
- Production of Power Banks to charge acts as a unique feature to our product

There exists waste to electricity plants that are not successfully operational due to the methodology and weak management. Black Hole is a compact device in terms of these WTE plants and is completely sustainable in itself. Other Start-ups in the waste management domain have restricted themselves to efficient disposal, recycling and composting whereas waste generation using Thermo-Electric Generators is the driving force behind BlackHole.

BlackHole is a Smart Bin since the applications of IoT comes to play. The DAQ system in place will record the energy stored in the bin and this data will be communicated online through our android application. This establishes transparency and customer service.

5. Understanding the Customer and Consumer

Alter Dime aims to start off with consumer service where the general public act as consumers but not customers, and the industry, business, institution, management or the Government which buys the product acts as the customer. With further development, Alter Dime aims to make BlackHole a paid service for the general public, where the customer pays to consume electricity provided by BlackHole. Alter Dime has therefore identified two

different customers. One buys the product. In the other case, the customer pays to just use the product. But the second case hasn't been developed for implementation to its full potential.

6. Distribution Channel Identification

Alter Dime intends to distribute BlackHole in parts which will be mostly shipped to the customer and it can be fitted easily without external help. Complete process of the distribution is still to be researched upon to identify better and efficient methods.

7. Conclusion

Team Alter Dime hopes to build an efficient Smart Bin to support the growing Smart City and promote the "Go Green" trend. We strive to implement our model globally and offer maximum efficiency. We also aim to reduce pollution and improve global safety and harness useful energy in the process. One of our goals is to lay out Electric Power Stations that can be easily accessed by public. The implementation of IOT and cloud applications eases out the process and provides the user maximum comfort. Overall, our motto is to eradicate waste dumping and reduce the usage of fossil fuels so as to lower pollution caused due to fossil fuel usage and promote electricity powered vehicles and other appliances.

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Converting Black and White X-ray Image into Colored Image

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Abstract. This paper focuses on converting the common black and white X-ray image into the colored form so that it becomes easy for the common people to understand the structure of bone as it differentiates between different regions using red, green and blue color. The gray colored X-ray image is converted into a colored image using an image processing algorithm in MATLAB. Here the gray colored image will be enhanced using different processes and also color image enhancement will be done. The major processes involved will be filtering, getting a threshold value, segmentation, Fourier Transform and also gray to RGB conversion. Also this paper tries to review the existing methods and processes that have been used on different images like MRI and X-ray. The methodologies used are discussed in detail including their drawbacks.

Keywords. Colored X-ray image, image processing, MATLAB, image enhancement, segmentation, filtering, threshold value, Fourier Transform, gray to RGB.

1. Introduction

Computer aided medical imaging is one of the important rapidly developing research area in the computer and medical industry. Medical image analysis is applied in various imaging systems such as CT scanning, X – ray imaging, MRI and etc. But these all imaging systems are developed based on the common steps that are image filtering, segmentation, feature extraction, classification and image analysis.

The gray level image detection of different medical images like X-ray and MRI are done to study the different structures of the body parts where X-ray mainly focuses on the hard tissues like bones and MRI on soft tissues of the body. The information obtained from these images help doctors to identify any kind of abnormality. However, most of the times these images are very complex to understand, so for the ease of doctors and patients these images can be converted into colored images using different methods.

2. Definition of Digital Image Processing

Image is defined as a 2-D function image, where x and y are spatial or plane coordinates, and the amplitude of ' f ' at any pair of coordinates (x,y) is called intensity or gray level of the image at that point. When (x,y) and the intensity values are all finite, discrete quantities it forms a digital image. Processing digital images by means of a digital computer is called digital image processing.

Image has limited amount of points called pixels. According to the pixel values, image is categorized into several types like gray image 0 to 255 pixel values, color image having amount of red, green and blue (RGB) and binary image having 0 and 1 pixel values. The function $f(x,y)$ should be greater than 0 and less than infinity.

$$f(x,y)=i(x,y)r(x,y)$$

$$0 < i(x,y) < \infty$$

$$0 < r(x,y) < 1$$

'i' is the illumination component and 'r' is the reflectance component.

$i(x,y)$ is determined by the illumination source and $r(x,y)$ is determined by the characteristics of the imaged objects.

The source of imaging machine ranges from gamma to radio waves of electromagnetic (EM) spectrum. Now a days image processing is being widely used in many areas such as bio medical industry, space program, robotics, etc. As an example, in biomedical industry image processing is used to enhance the X-ray image for getting clarification. The same process is used in geographical regions to identify pollution patterns from satellite images. Also now a days the mobile developers are trying to enhance the picture quality of their mobile phone. But according to Kamal K. et al. (2013), the major area of the image processing is solving problems with machine perception. Example for machine perception techniques are Fourier transform coefficients, statically movements and multi-dimensional distance measures. The machine perception is commonly involved in automatic shape and character recognition, automatic biometric recognition, weather prediction and etc.

3. Image enhancement, color image processing and segmentation

Image enhancement is the process of manipulating an image so that the result is more suitable than the original for a specific application. The goal of image enhancement is removing noises, sharpening of image edges and blurring the image. These enhancements are achieved by using spatial domain filtering like high pass and low pass filters.

The goal of image segmentation is to find regions that represent objects or meaningful parts of object. In other words, it is the procedure of separating an image into number of non-overlapping sections which are consistent to objects, background and other image parts. The image segmentation is based on gray level, histogram of the image, edges and regions of the image and textural features of the image. It can be done using different methods like intensity thresholding, region growing method, split method or split and merge method.

According to Sir Isaac Newton's observation the sunlight color spectrum is divided into six color regions (red, orange, yellow, green, blue and violet). According to the Rafael C. et al (2009), human eye can divide the billion different colors into three main types of color channels Red, Green and Blue based on light sensitive. Human eye distinguish one color from another based on the color's hue a characteristic which is associated with the prevailing wavelength in a combination of light waves, saturation which is mentioned to the amount of white light mixed with hue and brightness which represents intensity of achromatic notation.

Color image processing is a color specifying approach. It presents color arrangement as a function of x for red, y for green and z for blue where any value of x and y, the equivalent value of z is defined as

$$z=1-(x+y)$$

We can use color models also called color space. The purpose of using color models is to simplify the colors in standard approach. RGB (Red, green and Blue) is most commonly used.

4. Pseudo coloring

Human visual system is more responsive to color images rather than gray image. Hence the color imaging is a best way to visually improve an image quality. According to Abidi.et al (2005), human can only distinguish a few of gray level values while the human distinguish thousands of colors. Therefore, pseudo coloring technique can be used for enhancing a monochrome image for human viewing purposes (Marques O (2010)).

According to Jakia A. et al., (2010), Pseudo color or false color technique is used to convert gray image to red, green and blue color image. According to Zhou X. et al (2008), gray scale images have 60 to 90 just noticeable difference (JND) while the pseudo color scale images might give up to 500 JNDs based on CIE LAB. Hot color map, warm color map, sin color map are the 3 types of color maps used in pseudo coloring algorithm.

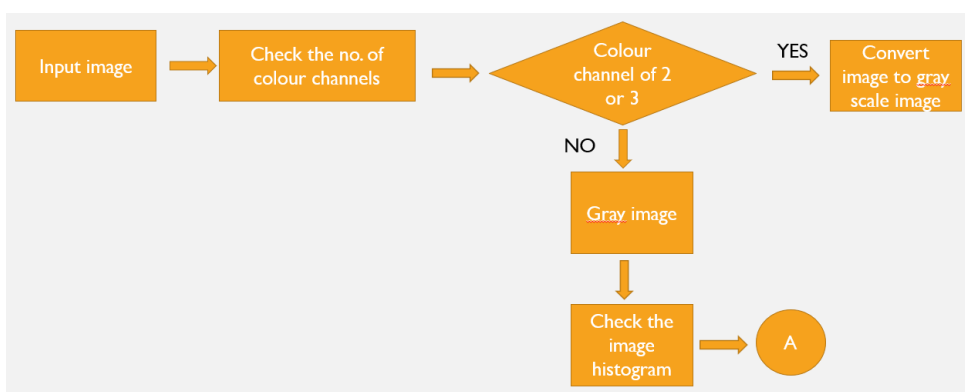
5. Methodologies

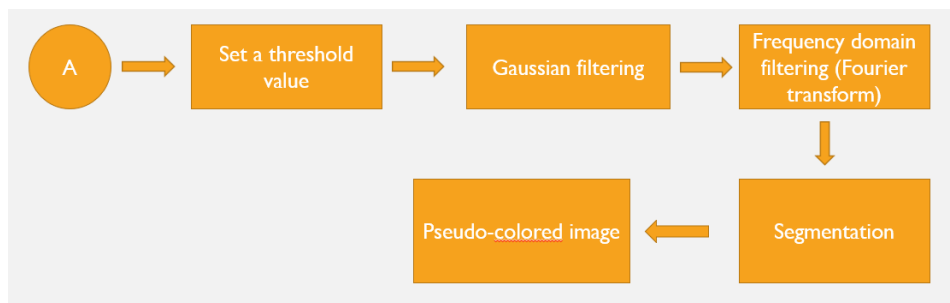
In this paper, we are going to review three research papers which have helped us gain more insight about this topic by doing research in the related aspects- color enhancing and intensification.

- **MRI pseudo coloring using MATLAB based image processing**

Functional MRIs are used to understand the functionality of the brain. In this process, contrast agent like Barium or Iodine is injected into the body and using the principle of MRI flow of these contrasting agent is viewed. This method however has disadvantages like high cost and invasive technique. Instead without using contrast agents, gray levels can be used for analyzing the functionality of the human brain. It can be used to distinguish the different parts of the brain using the gray scale to pseudo colored conversion using an IP algorithm and thus distinguish the abnormal part of the brain (like a tumor). The algorithm colors the MRI based on the blood density variations in different parts of the brain. The limitation of this research however was that since the sample MRIs were taken from the internet, there was no 100% accuracy.

IP algorithm used:





- **TEDDI (Tomographic Energy Dispersive Diffraction Imaging)**

In this research paper, they used a scale of 300µm for diffraction pattern at each voxel. This method is limited to a thin sample of approx. 1-2mm. It has been tested on nylon-6, aluminum powder and deer antler bone. Full pattern refinement method was used for simultaneous spatially resolved data collection across a plane of the sample. Light atoms owing to very low detection efficiency of the Si detector were used at α-ray energies above 25keV. A full-scale color imaging modality needs spectroscopy-grade pixelated solid state detectors and corresponding high aspect ratio collimators, which are not available. This acts as a reason for one of the limitations in this approach. The already existing Ge-TEDDI was time consuming but the one being used currently has faster X-ray color images and at a lower dose of X-rays.

- **Intensification and colour enhancing for chest X-ray medical images by MATLAB program**

To counter the problems being faced in X-rays: noise, low contrast, blurring and unwanted information, this research paper came up with the solution of intensification of basic features and color enhancement. The research paper is mainly focused on making the Hydatid cyst in the chest X-ray more visible, the problem with normal X-rays being there is variation in density, size and the visual diagnosis conducted by different radiologists. They came up with a general formula image enhancement formula given as:

$$I_E(x, y) = \left[\frac{|2\pi F I_z(x, y)|}{|2\pi F I_z(x, y) + NP|} \dots \dots \dots (1) \right]$$

Where, $I_E(x, y)$ is the Enhancing image (the output image).

$I_z(x, y)$ is the Processed image (the image before applying any equation on it).

F is the Frequency coefficient.

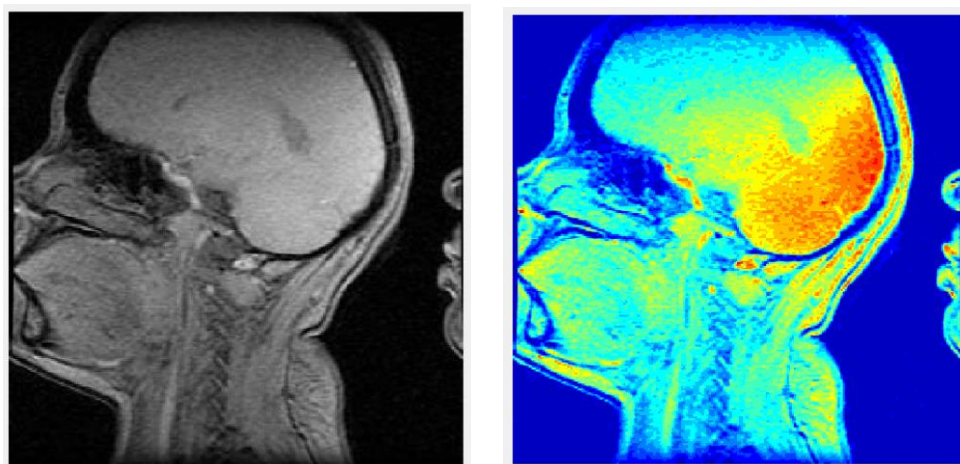
P is the Phase coefficient.

N is the Optional empirical coefficient.

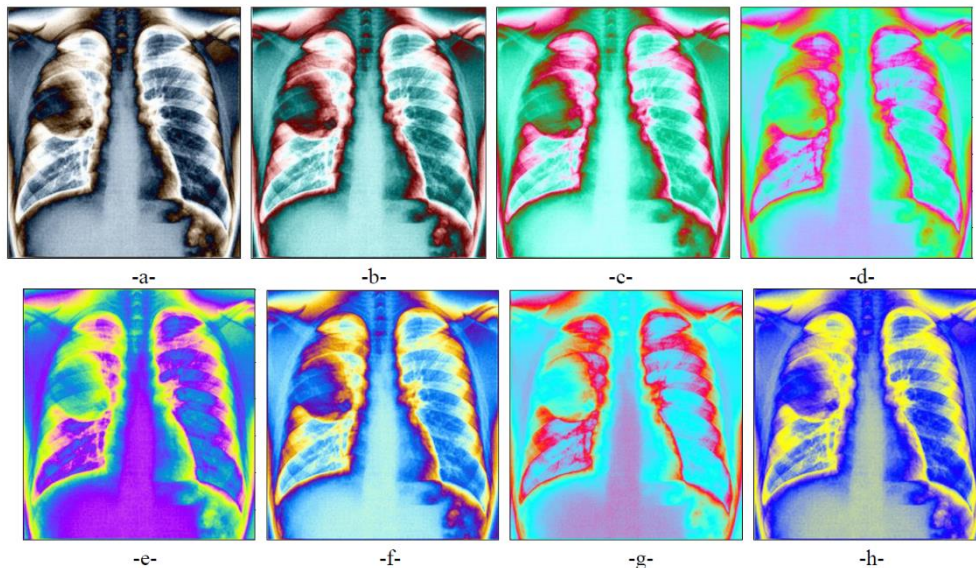
The conclusion obtained was that when trigonometric functions when applied to the given general formula resulted in generation of images of distinct colors making the rib cage and its content more noticeable. The organs stand out in the chest area depending on the trigonometric function used and the coefficient changed. This algorithm has also been able to give the appearance of a three-dimensional image to the X-ray.

6. Results

Given below is the result for **MRI pseudo coloring using MATLAB based image processing** : the original X-ray given the first image and its processed version in the second.



Given below are results for different intensity values and color variations due to different values and combinations of F, N and P obtained in **Intensification and colour enhancing for chest X-ray medical images by MATLAB program**.



7. Conclusion

Since all the methods and approaches discussed and analysed above had some limitation, keeping this in consideration we aim at developing an algorithm, which provides

clearer, more intensified, and non-invasive method. Once the black and white X-Ray image is given as an input, the software will convert the image into a coloured image using the pseudo-colouring technique where:

brown or dark red → muscles

yellow → bones

blue → to show abnormality in the structure scanned

Thus, it will help in providing clearer and more accurate pictures and help doctors give their patients more accurate diagnoses.

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Diagnosis of Raider Capture to Ensure Business Entities Economic Security in the Conditions of Modern Challenges

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Abstract: The analysis of economic entities interaction for counteraction to raiding is carried out, stages of raiding development in Ukraine and their characteristics are determined, resonant raider attacks in Ukraine during various global challenges and imbalances are analyzed. The aggregation of factors and parameters of threats to economic entities security in relation to raiding counteraction is carried out. The approaches and estimation methods of factors and parameters of raider capture threats are analyzed. The influence of threat parameters on the enterprises raider capture risk is assessed and the influence of parameters which characterize the raiding threats on the q-Tobin index, which characterizes the investment attractiveness, is determined.

Keywords: Assessment of factors and parameters, Business entities, Global challenges and imbalances, Interaction of business entities, Raider attacks, Raiding counteraction, Threats

1. Introduction

Trends in Ukraine economy economic development, which are characterized not only by changes in the regulatory framework of economic entities taking into account of European legislation requirements, but also the negative impact of destabilizing factors of external and internal environment especially in the face of global challenges, increasing the number of raids in various fields, which requires, on the one hand, improving the mechanism of economic security to combat raiding in the direction of maintaining sustainable operation and development, protection of property interests, strengthening the financial situation in time and space, on the other hand – quality scientific and methodological tools for assessing the impact of raider capture threats which should be based on a complex, multidimensional approach. In this regard, the existence of the problem of enterprise raider attacks threats is due to internal circumstances (the state of corporate governance, the state of ownership of shares and assets, etc.).

2. Analysis of the recent research and problem definition

The various aspects of threats (risks or factors) of unfriendly takeovers (raider attacks threats) were devoted papers of such scientists as O.A. Burbelo [1], Z.S. Varnaliy [2], B.M. Grek [3], I.A. Dmitriev [4], S.S. Molodetsky [6], M.I. Pisarevsky [7] and others.

The study of the scientific literature in this direction [1-7] and analysis of TOP-10 raider attacks during Ukraine Independence [8] made possible to identify the main characteristics of raider attacks threats assessment and criteria of their identification. However, the analysis of

the literature requires the processing of all sets of parameters that can be set on the basis of indicators of the machine-building enterprises dependence on raider capture possibilities. Thus, the purpose of this research is assessment and analysis of machine-building enterprises raider capture threats which is especially relevant in the context of global challenges and imbalances.

3. Research results

On the bases of scientific approaches generalization and systematization, the parameters for assessing the machine-building enterprises raider capture threats were developed. Parameters that form the raider capture threats are grouped by status: group 1 is the state of shares and assets ownership; group 2 is the state of corporate governance; group 3 is the state of securities issue registration and owner publicity; group 4 is financial and economic state (bankruptcy probability). The difference of this approach is the inclusion of such parameter as the state of corporate governance; other parameters are formed taking into account the previous methodological support. The most important criterion for coefficients inclusion is the availability and reliability of information to determine these coefficients values.

To assess the coefficients significance, it is proposed to use the values of points from 0 to 1 (Tab. 1). The number of points is determined by dividing 1 on the according coefficient values number. Points are assigned in direct proportion to the coefficients value in terms of enterprise raider capture threats.

Score (expert) assessment of possible threats (economic and market) made possible to assess different scenarios, where the threats level by coefficients is determined by the indicator x from 0 to 1.

It is advisable to use the q-Tobin coefficient to select machine-building enterprises that can be the object of raider capture. The q-Tobin ratio is an analytical ratio that characterizes the investment attractiveness of firm (enterprise), named after the American economist James Tobin. This indicator is universal and estimates the market value of enterprise capital. There are two approaches to its definition [9]:

$$1) \quad q_{-T} = \frac{K_{market}}{NA}, \quad (1)$$

where K_{market} – enterprise market capitalization; NA – net assets.

$$2) \quad q_{-T} = \frac{P_{shares}}{A_{re}}, \quad (2)$$

where P_{shares} – total market price of enterprise shares and bonds; A_{re} – recoverable amount of assets.

The paper uses the first option for evaluation. Both options have exactly the same interpretation of the obtained values of q-Tobin coefficient:

1) if $q_{-T} < 1$ – the market value of the company's assets is less than their book value, which means that the market underestimates the company; an indication that the enterprise may be the object of unfriendly takeovers or raider capture;

2) if $Q_{-T} = 1$ – this is an ambiguous situation in terms of enterprise raider capture possibility.

Table 1. Indicators for the machine-building enterprises raider capture threats assessing according to the established parameters

Parameter 1	Indicators (coefficients) 2	Values 3	Point 4
The state of shares and assets ownership	K1 – the degree of "dispersion" / consolidation of shares:	a) shares are scattered ("dispersed") more than 75%	1
		b) shares are scattered more than 51 %	0,75
		c) shares are scattered on 25-51 %	0,50
		d) shares are scattered less than 25 %	0,25
	K2 – asset ownership centers:	a) asset and profit centers are divided	0,5
		b) all assets are concentrated in one center	1
	K3 – the share of real estate market value in assets:	a) above 50 %	1
		b) 25-50 %	0,75
		c) 10-25 %	0,50
		d) less than 10 %	0,25
The state of corporate governance	K4 – the decision on reorganization was made:	a) yes	1
		b) no	0,5
	K5 – the decision on an additional shares issue was made:	a) yes	0,5
		b) no	1
	K6 – the decision to amend the statute (anti-raider barriers) was made:	a) yes	0,5
		b) no	1
	K7 – the decision to elect or terminate the powers of the chairman and members of the supervisory board, executive body was made:	a) yes	1
		b) no	0,5
	K8 – presence of committees in the supervisory board (strategic planning, audit, investment, others):	a) available	0,5
		b) missing	1
	K9 – the presence in the statute items about conflict of interest, i.e. the contradiction between the personal interests of the official and the obligation to act in the company interests:	a) available	0,5
		b) missing	1
	K10 – openness of information about the joint stock company activity:	a) open	0,5
		b) confidential	1
		a) yes	1

	K11 – planning by the joint-stock company to include its own shares in the listing of stock exchanges for the next three years	b) no	0,5
	K12 – availability of own codex (principles, rules) of corporate governance	a) yes	0,5
		b) no	1
	K13 – violation of the procedure for holding shareholders' meetings and board meetings	a) happened	1
		b) did not happen	0,5
The state of securities issue registration and owner publicity	K14 – maintaining the register of the company	a) the register of shareholders is maintained by the corporation itself	0,5
		b) other (register kept by the depository)	1
	K15 – publicity of the real owner	a) the owner is known	0,5
		b) the owner is hidden	1
	K16 – reliability of the registrar	a) in the registrar sure	0,5
		b) there is no clear and reliable information about the registrar	1
The financial and economic state (bankruptcy probability)	K17 – probability of financial and economic insolvency	a) probability of bankruptcy less than 50%	0,25
		b) probability of bankruptcy more than 50%	1
		c) the probability of bankruptcy is 50%	0,5

3) if $Q_{-T} > 1$ – the market value exceeds the book value of the company's assets. This means that the market value reflects some assets of the enterprise that cannot be accounted for; the high value of the coefficient q-Tobin pushes investors to decide to invest more in the company capital, because it is more expensive than it is paid;

The q-Tobin ratio is an indicator of raider capture risk. The results of the calculation of raider capture risk of selected machine-building enterprises are presented in Table 2.

On the bases of the presented information, from ten analyzed enterprises, only seven have q-Tobin coefficient value less than 1: PJSC Kharkiv Machine-Building Plant "Svytlo Shakhtarya"; PJSC "Novokramatorsk Machine-Building Plant"; PJSC "Kryukiv Carriage Plant"; PJSC "Beryslav Machine-Building Plant"; PJSC "Druzhkivka Machine-Building Plant"; PJSC "Dnipropetrovsk Aggregate Plant"; PJSC "Poltava Aggregate Plant".

The results of the calculation are given in Table 3, which shows the arithmetic mean values for each threat parameter.

The approach to estimating the impact of raider capture threats parameters on the indicator of machine-building enterprise market value assessment is based on methods of correlation and regression analysis, econometric modeling. Parameters that form raider capture threats are grouped by state:

group 1 – shares and assets ownership (x1);

group 2 – corporate governance (x2);

group 3 – securities issue registration and owner publicity (x3);

group 4 – securities issue registration and owner publicity – (x4).

Table 2. Dynamics of the q-Tobin coefficient

Year	Net assets, thousand UAH	Capitalization, thousand UAH	q-Tobin coefficient
PJSC Kharkiv Machine-Building Plant "Svytlo Shakhtarya"			
2016	656467	33533,3	0,05
2017	738248,5	50299,9	0,07
2018	811654,5	50299,9	0,06
2019	967715,6	50299,9	0,05
PJSC "Novokramatorsk Machine-Building Plant"			
2016	3670586,0	893256	0,24
2017	3958748,5	893256	0,23
2018	9887635,0	893256	0,09
2019	10678534,0	1228227	0,12
PJSC "Starokramatorsk Machine-Building Plant"			
2016	159003,0	2899931,92	1,82
2017	144684,0	2899931,92	2,0
2018	148786,0	3426269,70	2,30
2019	142574,0	3056260,70	2,14
PJSC "Dniprovagonmash"			
2016	1577296	100768,0	0,06
2017	1600158	2611820,6	1,63
2018	1505275	1996296,0	1,33
2019	1533315	1780030,6	1,15
PJSC "Kryukiv Carriage Plant"			
2016	2769053	2637629,696	0,95
2017	2442384	2064231,936	0,84
2018	2054358	1295878,938	0,63
2019	2367861	1541224,478	0,65
PJSC "Dnieper Machine-Building Plant"			
2016	67325	125495,92	1,86
2017	45468	85565,40	1,88
2018	39531	85565,40	2,17
2019	35172	85565,40	2,43
PJSC "Beryslav Machine-Building Plant"			
2016	27438,0	15275,29	0,56
2017	-3585,0	15911,76	-4,44
2018	-54333,0	15911,76	-0,27
2019	-53362,0	15911,76	-0,30
PJSC "Druzhkivka Machine-Building Plant"			
2016	716107	118830,921	0,17
2017	405015	51883,921	0,13
2018	283357	51883,921	0,18
2019	322511	51883,921	0,16
PJSC "Dnipropetrovsk Aggregate Plant"			
2016	76350	65199,64	0,85
2017	63055	65199,64	1,03
2018	69850	65199,64	0,93
2019	97590	65199,64	0,69
PJSC "Poltava Aggregate Plant"			
2016	1120	201726	18,1
2017	-87136	201726	-23,1
2018	-122896	201726	-1,64
2019	-104525	201726	-1,92

Table 3. Assessment of machine-building enterprises raider capture threats

Enterprise	Year	Parameters for assessing the raider capture threats			
		The state of shares and assets ownership	The state of corporate governance	The state of securities issue registration and owner publicity	The financial and economic state (bankruptcy probability)
PJSC Kharkiv Machine-Building Plant "Svytlo Shakhtarya"	2016	0,7	0,75	0,8	0,25
	2017	0,7	0,75	0,8	0,25
	2018	0,7	0,75	0,8	0,25
	2019	0,7	0,75	0,8	0,25
PJSC "Novokramatorsk Machine-Building Plant"	2016	0,83	0,8	1	0,25
	2017	0,5	0,8	1	0,25
	2018	0,5	0,8	1	0,25
	2019	0,5	0,8	1	0,25
PJSC "Kryukiv Carriage Plant"	2016	0,7	0,75	0,83	0,25
	2017	0,7	0,75	0,83	0,25
	2018	0,7	0,75	0,83	0,25
	2019	0,7	0,75	0,83	0,25
PJSC "Beryslav Machine-Building Plant"	2016	0,83	0,7	1	0,25
	2017	0,83	0,7	1	0,25
	2018	0,83	0,7	1	1
	2019	0,83	0,7	1	1
PJSC "Druzhkivka Machine-Building Plant"	2016	0,6	0,7	1	0,25
	2017	0,75	0,7	1	0,25
	2018	0,75	0,7	1	0,25
	2019	0,75	0,7	1	0,25
PJSC "Dnipropetrovsk Aggregate Plant"	2016	0,5	0,7	1	0,25
	2017	0,5	0,7	1	0,25
	2018	0,63	0,7	1	0,25
	2019	0,63	0,7	1	0,25
PJSC "Poltava Aggregate Plant"	2016	0,5	0,7	1	0,25
	2017	0,5	0,7	1	0,25
	2018	0,5	0,7	1	0,25
	2019	0,5	0,7	1	0,25

To build econometric models we take the indicators of the q-Tobin coefficient value, which less than 1 and the arithmetic mean values of the coefficients, which characterize the machine-building enterprises raider capture threats in 2016-2019.

It is possible to state significant differences in the value of machine-building enterprises indicators, therefore for further estimation the grouping of enterprises by the level of q-Tobin coefficient was carried out, which further made possible: to generalize general tendencies of state of machine-building enterprises; to allocate groups of the machine-building enterprises on the investigated indicators of raider capture threats; to analyze the peculiarities of sectoral development taking into account the spatial and dynamic characteristics; determine the nature of the impact of parameters that characterize the raider capture threats; to develop targeted management measures to prevent and counteract raider attacks on the factors and parameters of threats.

The results of calculations for the 1st group of enterprises (Fig. 1) show that the direct regressive nature of interconnection is observed only between the q-Tobin coefficient and the

parameters of the machine-building enterprises raider capture threats in the direction of the state of shares and assets ownership. The progressive direct nature of the interconnection is observed between q-Tobin coefficient and: the state of securities issue registration and owner publicity; the financial and economic state (bankruptcy probability). Progressive feedback is established between the q-Tobin coefficient and the state of corporate governance.

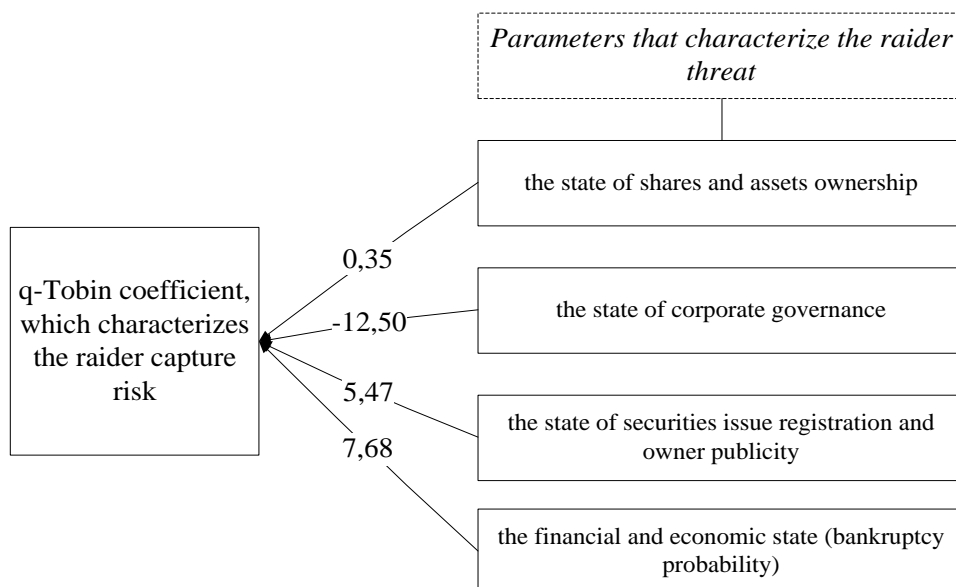


Fig. 1. The nature of the parameters influence characterizing the raider capture threats on the q-Tobin index (in terms of elasticity coefficient) for machine-building enterprises of the 1st group

From the results of calculations for the 2nd group of machine-building enterprises (Fig. 2) it is established that for PJSC "Beryslav Machine-Building Plant" the increase of the q-Tobin coefficient by 1% will be observed in case of decline of the financial and economic state indicator (bankruptcy probability) on 2,3% (progressive feedback), and for PJSC "Poltava Aggregate Plant" – in the case of increase on 152,7% (progressive direct nature of interconnection).

The nature of the influence of the parameters of the state of shares and assets ownership on the coefficient q-Tobin is determined by the following values of the elasticity coefficient (Fig. 3): progressive direct character of growth for PJSC "Beryslav Machine-Building Plant" of q-Tobin by 1% will be observed in case of increase of the indicator of the state of shares and assets ownership by 232,4%; for PJSC "Poltava Aggregate Plant" – in case of reduction by 22.79% – progressive feedback.

Thus, the proposed assessment of the impact of the parameters of raider capture threats on the q-Tobin indicator of machine-building enterprise will make possible to assess the threats impact level on the enterprise market value, to identify the factors which have the greatest impact on its formation, to determine development priorities and will be a tool to support management decisions within the mechanism of ensuring the economic security of the machine-building enterprise to combat raiding.

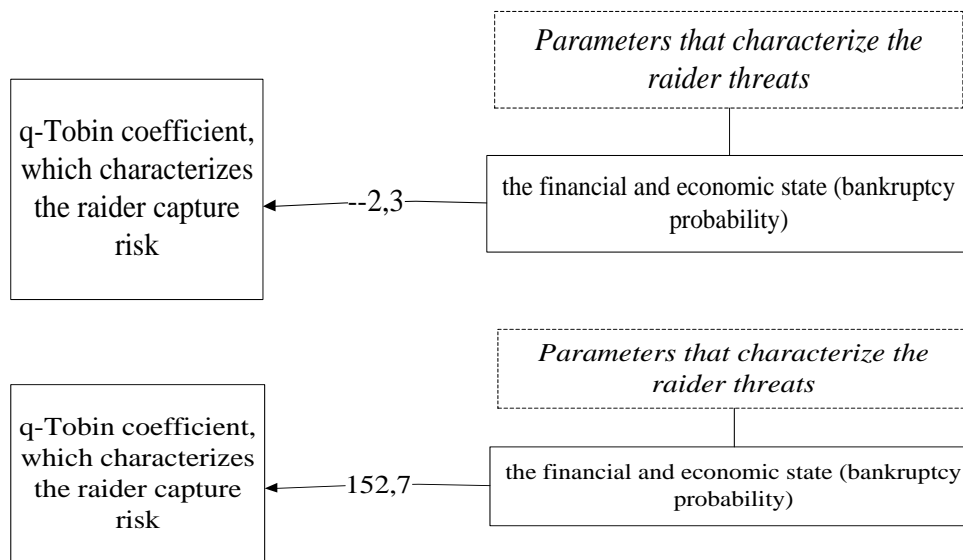


Fig. 2. The nature of the parameters influence characterizing the raider capture threats on the q-Tobin index (in terms of elasticity coefficient) for machine-building enterprises of the 2nd group

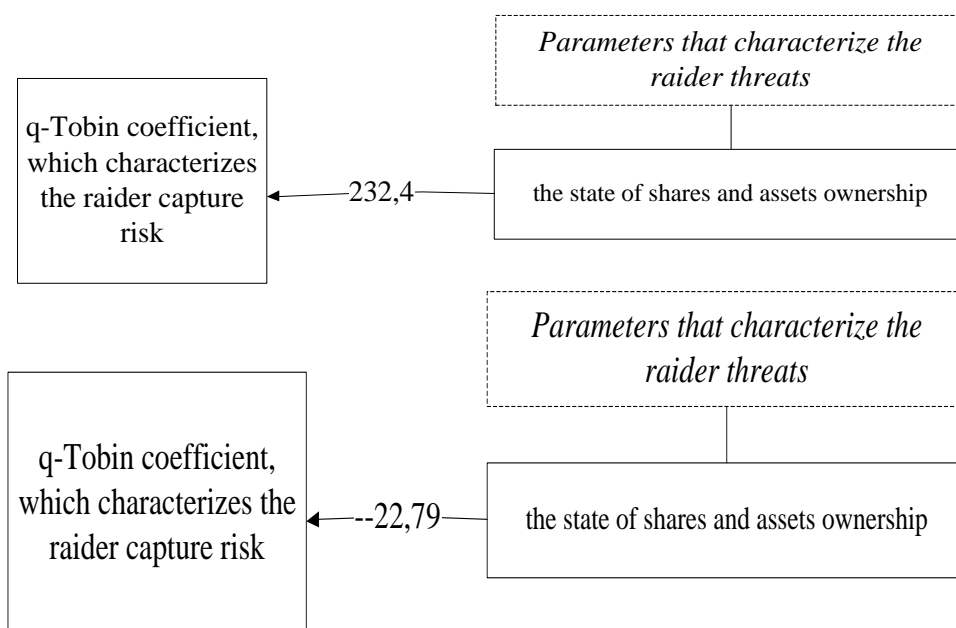


Fig. 3. The nature of the parameters influence characterizing the raider capture threats on the q-Tobin index (in terms of elasticity coefficient) for machine-building enterprises of the 2nd group

4. Conclusion

Thus, the evaluation toolkit is proposed taking into account the parameters that form the raider capture threats by groups (the state of shares and assets ownership, the state of corporate governance, the state of securities issue registration and owner publicity, the financial and economic state (bankruptcy probability) which are evaluated on the basis of appropriate coefficients, which creates an information base for effective management decisions in conditions of limited access and reliability of special statistics.

The analysis of machine-building enterprises raider capture risk is carried out by calculating the indicator – q-Tobin coefficient, which reflects the assessment of the enterprise market value and is an indicator of raider capture risk.

The influence of the established parameters of threats on the machine-building enterprises raider capture risk (q-Tobin coefficient) is analyzed, which provides the econometric model construction and characterizes the dependence of the q-Tobin coefficient level from the set of indicators that are parameters of raider capture threats for two selected groups of machine-building enterprises, which differ in the dependent variable value.

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Digital Transformation of Serbian Banking Sector: Case Study of Bank's Strategic Planning for a Creation of Digital Roadmap

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Abstract. Modern trends, due to increased competition and technological development, represent new challenges for the banking sector. The application of new technologies has led to the digital transformation of Serbian banking sector. New digital services were developed, which was accompanied by changes in demand in the banking products market. At the same time, digital transformation has led to productivity growth in the banking sector. The aim of this paper is to analyze the digital transformation process in the Serbian banking sector. The paper will analyze the procedures and processes, implemented in Serbian banking sector, for the development of new digital functionalities, other digital initiatives, that is, for creation of a digital roadmap. The creation of a digital road map standardizes the process of digital transformation in the banking sector, the development of new and amendment of existing applications, and ensures the quality of monitoring of all segments of digital transformation process. The process of digital roadmap creation will be analyzed through a case study investigation of Addiko bank AD. The findings of this study will be beneficial for organizations operating in the banking and finance sector, for improvement of their digital transformation processes, and preparation for new market trends.

Keywords. Banking sector, Digital transformation, Digitalization, Digital roadmap, Republic of Serbia.

1. Introduction

Digital transformation is a process that has fundamentally changed the business environment, a new reality to which the banking sector must adapt. Digital environment has posed new challenges to the banking sector, and new competitors in the form of FinTech companies that perform once traditional banking operations, such as payments and money transfers [1]. The new way of life, supported by modern technological solutions, has contributed to the creation of new habits and expectations of customers. Customers want to get the service quickly, easily, via Internet, on computer or a mobile app, they “want the type and quality of service they receive from industries that place significant focus on customer experience” [2]. That is why online banking was one of the first significant steps taken by the banking sector in the digitalization process.

Banking sector is focused on the digitization of existing and simpler products such as cash loans, although they are also introducing new products such as digital wallets. Digitization also leads to the repositioning of organizational units in charge of IT, since IT became an integral part of competitiveness, productivity and efficiency in banking sector [3]. There is a significant difference between traditional and new, innovative banks [4]. Namely,

traditional banks are digitizing their operations much more extensively, either by cooperating with FinTech start-ups or by their own innovation hubs [4]. New, non-traditional banks, on the other hand, use new technologies for financial services, but the volume of their operations is still almost negligible compared to traditional banks [4].

Extremely rapid technological development in the last ten years - primarily due to the development and capabilities of mobile phones - in many banks creates a widening gap between the ever-growing expectations of customers and the limited ability of banks to meet those expectations. On the other hand, financial services - which have traditionally been exclusively in the domain of banking financial institutions - are increasingly provided by smaller, more agile and less regulated organizations, but also by global technology giants [5].

In the context of these changes, the banking sector everywhere in the world, including the Republic of Serbia, intensively initiates and implements projects to digitize its business. Digitalization is necessary in order to monitor changes in the environment, reduce operating costs, increase profitability and remain competitive in the market. These digitalization projects and the changes they bring significantly change the business models of banks, but also affect their risk profile. The Covid-19 pandemic, which hit the world in 2020, is expected to further direct the banking sector towards innovation, digitalization and the search for creative and sustainable business solutions.

2. Digital transformation in Serbian banking sector

The concept of digital transformation in banking sector is significantly broader than the concept of e-banking and mobile banking, and implies “generating the supply, distribution and sales of financial products and services via digital channels” [6, p.4]. Classic banking operations will gradually change and will never be the same again, but the process of digital transformation itself can never be finally completed. The main changes that characterize the banking sector due to the process of digital transformation are presented in Table 1.

Table 1. The main changes of banking model due to digitalization [7]

Optimizing the customer experience	<ul style="list-style-type: none"> • More interactivity, continuity of service and ease of use • Towards more disintermediation • Customization
Transformation of process	<ul style="list-style-type: none"> • Automation of processes • Dematerialization and non-materialization • Data mining
Modification of organizations	<ul style="list-style-type: none"> • Information sharing • Digital marketing • Open Data and Open API
Transformation of business models of banks	<ul style="list-style-type: none"> • Erosion of margins • Regulatory pressure • Regulatory developments

As shown in Table 1, thanks to the process of digital transformation, the customer experience after doing business with the bank is optimized (business such as payment transaction, loan application, opening an account...). Banking customers communicate more easily with a commercial bank, the bank adapts to their needs. A large number of processes in the banking sector are being automated; the organizational structure is being modified, with introduction of digital marketing, open banking and information sharing. Banks are

transforming their business models, along with changes in legal framework that regulates the banks' operations (see more in [7]).

In the Republic of Serbia, the process of digital transformation began almost 20 years ago, with the first payment cards. Five years later, banks began to introduce the first digital solutions - Internet banking and SMS services, and another five years were to pass to display the first ecommerce services. In the past three years, we have witnessed significantly more frequent changes and faster digital transformation of banks. Serbian banking sector has made digital transformation a strategic priority. Modern solutions for e-banking and mobile banking, mobile wallets and various forms of mobile payments, online chat, applications for loans and other products have been introduced. On the other hand, customers expect and want to use modern digital banking solutions and mobile applications are replacing bank branch visits.

Almost all banks in the Republic of Serbia today offer e-banking and mobile banking with similar basic functionalities, such as review of accounts, loans, deposits and cards, domestic and international payment transactions, currency conversions, and the like. In addition to this, digital solutions have emerged that keep pace with the most developed markets in Europe. Raiffeisen Bank AD enabled loan disbursement in just eight minutes completely online, and introduced an electronic assistant based on artificial intelligence [8]. Eurobank AD, in addition to e-banking and m-banking, has introduced a service that allows customers to make or accept instant payments at points of sale by scanning the Quick Response (QR) code [9]. Erste Bank AD offers its clients e-banking and mobile banking, online purchasing of bank products, cash loans via NetBanking or mBanking application [10]. The number of Erste mBanking users increased by 16% in the period 2019-2020, while the growth in the number of transactions via mBanking amounted to 36% in the period May 2020 - February 2020, or 13% when it comes to the number of transactions via NetBanking in the same period [11]. Addiko bank AD has enabled all its clients, who are users of Addiko e-bank and Addiko mobile banking, a unique method of payment - Addiko Chat Banking on Viber, and opening an account completely online, through the process of video identification [12, 13]. From November 30th 2020, clients of ProCredit bank AD can perform all operations exclusively online, without coming to the bank, such as savings, loans, payment cards, overdraft, domestic and international payments [14]. ProCredit bank AD also offers the Apple Pay service of contactless payment with an Apple mobile device or an Apple watch [15].

The instant payments system (IPS), which was introduced by the National Bank of Serbia (NBS) in 2018 in order to support digitalization and development of non-cash payments in Serbia, additionally popularized payments within mobile banking applications [16]. In the period October 22nd 2018 – October 22nd 2020, there were 27,071,755 instant payments via IPS system, with a total value of 269,976,560,375.45 dinars, with an average execution time of about 1.2 seconds [16]. In the Republic of Serbia, non-cash methods of payment are becoming increasingly important, and mobile banking and e-banking are becoming more common, which can be seen from the data shown in Table 2.

The growing importance of non-cash payment transactions, with the use of mobile banking and e-banking, can be represented by the number and value of transactions made with payment cards at POS terminals and on the Internet (Table 3).

Table 2. Number of payments using mobile banking and number of payments via cards and electronic money in dinars on the Internet, in Republic of Serbia [16]

	Q2 2019	Q2 2020	Change in %
Number of e-banking and mobile banking users (legal entities and private individuals)	2.588.196	2.933.227	13,33%
Number of mobile banking users (legal entities and private individuals)	1.580.538	1.921.347	21,56%
Number of e-banking users (private individuals)	2.333.836	2.651.509	13,61%
Number of e-banking users (legal entities and entrepreneurs)	254.360	281.718	10,76%
Number of mobile banking users (private individuals)	1.549.612	1.880.854	21,38%
Number of mobile banking users (legal entities and entrepreneurs)	30.926	40.493	30,94%
Number of executed payment transactions via mobile banking	6.062.250	9.060.021	49,45%
Number of executed payment transactions via mobile banking (private individuals)	5.383.833	8.200.356	52,31%
Number of executed payment transactions via mobile banking (legal entities and entrepreneurs)	678.417	859.665	26,72%
Number of executed payment transactions via e-banking	34.566.346	33.656.918	-2,63%
Number of executed payment transactions via e-banking (private individuals)	5.515.814	6.189.897	12,22%
Number of executed payment transactions via e-banking (legal entities and entrepreneurs)	29.050.532	27.467.021	-5,45%

Table 3. Number and value of payment transactions with payment cards at POS terminals and the Internet, in Republic of Serbia [16]

	Q2 2020	Change in %
Number of transactions at POS terminals (using cards issued by provider from Serbia)	69.887.676	14,73%
Number of transactions at POS terminals (using cards not issued by provider from Serbia)	2.355.639	-47,12%
Number of transactions by cards and e-money on the Internet in all currencies	4.899.888	64,23%
Number of transactions by cards and e-money on the Internet in dinars	3,205.385	105,59%
Number of transactions by cards and e-money on the Internet in EUR	791.847	7,88%
Value of transactions by cards and e-money on the Internet in dinars	7,3 billion dinars	77,92%
Value of transactions by cards and e-money on the Internet in EUR	24,6 million EUR	-26,8%
Number of transactions by cards and e-money on the Internet in USD	756.664	44,49%
Value of transactions by cards and e-money on the Internet in USD	12,6 million USD	-6,57%

3. The process of digital roadmap in Addiko Bank AD

Addiko bank AD has defined the process of new applications' development and improvement of existing ones through the process scheme of digital roadmap. The digital roadmap implies the standardization of these processes, which includes certain interconnected and dependent activities, each of which has its own performers. These are the following activities:

- Customers' requirement
- Determining and analysis of requirement
- Ranking requirements
- Software development
- Quality control and testing
- Production



Fig. 1. Digital roadmap in Addiko Bank AD
(Source: Authors' presentation)

Customers' requirement is the initial activity within digital roadmap, because the basic goal of digital product development is an improved customers' experience. Requirements relate to business process improvement, cost reduction, introduction of new products, etc.

Determining and analysis of requirement is the next stage in the process of new applications' development or improvements to existing ones. The requirement should be detailed and clear, and contain a clear profitability analysis that justifies implementation. Each request should contain a title, a detailed description of the request, and the description of improvements achieved by request implementation, business case for requests involving large financial investments, and additional elements, depending on the specifics of request. Request analysis includes verification of compliance with the digital strategy, cost-benefit analysis, analysis of compliance with the bank's processes and procedures, defining the design of specific requirements, activity diagrams, etc. For realization of a certain request it is necessary to hire external development teams. External development teams should also estimate the costs

and time required for the development of certain application or finishing the existing one. The Determining and analyzing of requirement phase is the most important phase within the process of digital roadmap. Based on the assessment of internal and external development teams, a decision is made regarding the further realization of a specific customer request.

Ranking requirements is performed after the end of Determining and analysis of requirement phase, i.e. after obtaining the necessary information, available capacities, costs, deadlines, time of realization of the request. The goal of Ranking requirements phase is to prioritize requirements by relevance to business goals and customer satisfaction. Parameters for ranking requirements are also deadline, cost and other indirect benefits, based on which all requirements are divided into four groups: Must, Should, Could, Wouldn't.

Software development phase and Quality control and testing phase include contracting with internal and external development teams, detailed planning of new application development or improvements to existing ones, quality control and testing after the development phase.

Production phase is the final stage in the digital roadmap process. After successfully completing the phases of Software development and Quality control and testing, Addiko bank AD starts the process of production and defining all necessary activities for the implementation of new or improved applications in real environment. The process of digital roadmap continues, with further consideration and analysis of customers' requirements.

4. Conclusion

There are several important changes that digital transformation process has brought to banking sector in the Republic of Serbia: CRM for personalized offers to customers, automation of all transactions in branches using modern devices, business based on electronic documents with digital signing, expanding e-banking and m-banking services to savings and loan products, a new website role with the ability to apply online for different products.

The digital transformation in banking sector in the Republic of Serbia follows the trend of the most developed countries, thanks to banks in majority foreign ownership. Majority foreign-owned banks have contributed to accelerating the process of digital transformation, taking over the positive experiences of their parent banks. Positive practice that is transferred to banking sector of the Republic of Serbia is especially present in the segment of e-banking, payment card systems, ATM services, mobile banking, etc. Commercial banks in the Republic of Serbia are introducing online branches, they have enabled the performance of simple financial transactions via viber, and they are introducing robotization of some processes.

The growing number of requests for the development of new digital solutions, and the shorter deadlines set for commercial banks, has led to special digital transformation procedures, the so-called digital roadmaps. Addiko bank AD has placed the satisfaction of its customers with digital banking at the center of business activities. Defining a digital roadmap in Addiko bank AD is based on an initial activity that involves improving the user experience - Customers' requirement. The digital roadmap, through precisely defined and interconnected activities - customers' requirement, determining and analysis of requirement, ranking requirements, software development, quality control and testing, production, enabled Addiko Bank AD to standardize the digitization process. With the introduction of digital roadmap, Addiko bank AD enabled the standardization of new applications' development, improved existing ones, improved monitoring of all segments of digitalization process, and defined responsibilities in the process of requirements' realization.

It is realistic to expect that commercial banks in the Republic of Serbia will focus on further development of procedural solutions for developing digital banking applications, with a focus on customer experience. Improving the customer experience within the digital

transformation process implies a simplified user interface, without banking terminology and functionality that are not necessarily banking, but have value for the customer. The future period will be marked by further research and development in the banking sector, development of new digital technologies and digital skills in the field of financial banking services in the Republic of Serbia.

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A Comparative Study of Patient Safety Culture of Three Hospitals from Viewpoints of Physicians and Nurses

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Abstract. The development of safety culture is essential to improve patient safety in each healthcare organization. In the field of medical industry, the culture of measuring patient safety is booming. The reliability and validity of the safety attitudes questionnaire (SAQ) is the most suitable for the research in Taiwan. In this study, the perception of the patient safety culture from the viewpoints of physicians and nurses from a medical center and two regional teaching hospitals (A and B) in central Taiwan was investigated based on the Chinese version of the SAQ in 2016 and 2017. The questionnaire filled out by physicians and nurses was analyzed by descriptive statistics, independent sample t test, and analysis of variance with a significant level of 0.05. The results showed that physicians and nurses in medical center have better perceptions in stress recognition and perceptions of management, indicating they are more satisfied about the managerial philosophy and might feel more stressful as well. Physicians and nurses in regional teaching hospital A have higher average scores in teamwork climate and emotional exhaustion, whereas physicians and nurses in regional teaching hospital B feel less satisfied in managerial philosophy. The commitment of hospital management to provide high-quality working environments for hospital staff can improve job satisfaction. In contrast, if medical staff feel more stressful, the performance would be decreased. Therefore, the support and encouragement of hospital management for physicians and nurses will lead to have a greater significance for patient safety.

Keywords. Safety attitudes questionnaire, Chinese version of the safety attitudes questionnaire, Patient safety culture, Analysis of variance, Regional teaching hospital, Medical center.

1. Introduction

Studies have shown that medical errors which are commonly seen in healthcare organizations have been recognized as a significant threat to patient safety and the quality of provided healthcare [1-3].

National Patient Safety Agency in England said that there was a need to establish a patient safety culture to detect, lessen, and prevent harms to patients by regularly assessing the existing patient safety culture [4-6]. The safety attitudes questionnaire (SAQ) developed by Sexton et al. [7] has good psychometric properties with good validity and reliability and has been widely used throughout the world to assess the patient safety culture from the viewpoints of medical staffs in healthcare organizations [6, 8]. In Taiwan, the Joint Commission of Taiwan developed the Chinese version of the SAQ based upon the SAQ and has requested the healthcare organizations to assess their patient safety culture by the Chinese version of the SAQ annually [6, 8].

Physicians and nurses are the core staffs who need to contact patients very often in healthcare organizations [9]. Their attitudes toward the patient safety culture are essential for each healthcare organization. In addition, different hospitals have different patient safety culture. It is critically important to compare safety culture based upon the benchmarking philosophy for further continuous improvement. Therefore, the purpose of this study is to compare the perception differences of the patient safety culture from a medical center and two regional teaching hospitals in central Taiwan based on the Chinese version of the SAQ in 2016 and 2017 by the viewpoints of physicians and nurses.

2. Review of the Patient Safety Culture and Safety Attitudes Questionnaire

Patient safety has been recognized as a global health concern due to a staggering number of healthcare related injuries and deaths [10]. In order to ensure a better patient safety in healthcare organizations, there has been a growing trend to assess the patient safety culture [11]. Safety climate can be defined as the shared perceptions, attitudes, and beliefs of employees about the way where a hospital manages and achieves patient safety and can be viewed as a snapshot of the safety culture in healthcare organizations [11]. Wagner et al. [12] pointed out that safety culture is a fundamental factor that influences system safety in an organization. Besides, a positive patient safety culture allows healthcare staffs to reduce medical errors, learn from failures, and commit to safer care [12]. Therefore, Allen et al. [13] depicted that reviewing and enhancing safety culture in healthcare organizations continuously is of importance to enhance patient safety.

The safety attitudes questionnaire was derived from flight management attitudes questionnaire by Sexton et al. [7] with six dimensions and 30 questions. The descriptions of these dimensions are as follows. Teamwork climate is defined as the perceived quality of collaboration between personnel. Safety climate is the perceptions of a strong and proactive organizational commitment to safety. Perceptions of management is the approval of managerial action. Job satisfaction is the positivity about the work experience. Working conditions are the perceived quality of the work environment and logistical support. Finally, stress recognition is defined as the acknowledgement of how performance is influenced by stressors [7].

The Chinese version of the SAQ was developed by the Joint Commission of Taiwan in 2008 by using forward and backward translation based on the SAQ to examine the quality of the translation [9]. The original questionnaire has six dimensions and 30 questions, but the current form since 2014 has eight dimensions and 46 questions [6]. Two additional dimensions have been added to the original Chinese version of the SAQ, namely emotional exhaustion and work-life balance with the respective nine and seven questions as shown in Table 1 [9]. Except for work-life balance using a four-point scale to measure the frequency of each question, the others use a five-point Likert's scale ranging from strongly agree to strongly disagree. Physicians and nurses are requested to answer these 46 questions [6, 9].

Table 1. The Chinese version of the SAQ with eight dimensions and 46 questions

Dimension	Item
Teamwork Climate	1. Nurse input is well received in this clinical area. 2. In this clinical area, it is difficult to speak up if I perceive a problem with patient care.* 3. Disagreements in this clinical area are resolved appropriately (i.e., not who is right, but what is best for the patient). 4. I have the support I need from other personnel to care for patients. 5. It is easy for personnel here to ask questions when there is something that they do not understand. 6. The physicians and nurses here work together as a well-coordinated team.
Safety Climate	7. I would feel safe being treated here as a patient. 8. Medical errors are handled appropriately in this clinical area. 9. I know the proper channels to direct questions regarding patient safety in this clinical area. 10. I receive appropriate feedback about my performance. 11. In this clinical area, it is difficult to discuss errors.* 12. I am encouraged by my colleagues to report any patient safety concerns I may have. 13. The culture in this clinical area makes it easy to learn from the errors of others.
Job Satisfaction	14. I like my job. 15. Working here is like being part of a large family. 16. This is a good place to work. 17. I am proud to work in this clinical area. 18. Morale in this clinical area is high.
Stress Recognition	19. When my workload becomes excessive, my performance is impaired. 21. I am less effective at work when fatigued. 25. I am more likely to make errors in tense or hostile situations. 26. Fatigue impairs my performance during emergency situations (e.g. emergency resuscitation, seizure).
Perceptions of Management	27. Management supports my daily efforts. 28. Management doesn't knowingly compromise patient safety. 29. I get adequate, timely information about events that might affect my work. 30. The levels of staffing in this clinical area are sufficient to handle the number of patients.
Working Conditions	31. Problem personnel are dealt with constructively by our unit. 32. This hospital does a good job of training new personnel. 33. All the necessary information for diagnostic and therapeutic decisions is routinely available to me. 34. Trainees in my discipline are adequately supervised.
Emotional Exhaustion	20. I feel like I'm at the end of my rope.* 22. I feel burned out from my work.* 23. I feel frustrated by my job.* 24. I feel I'm working too hard on my job.* 35. I feel emotionally drained from my work.*

	36. I feel used up at the end of the workday.* 37. I feel fatigued when I get up in the morning and have to face another day on the job.* 38. Working with people all day is really a strain for me.* 39. Working with people directly puts too much stress on me.*
Work-Life Balance	40. Miss meals. 41. Have a hasty meal. 42. Work all day without break. 43. Change the individual or family plan because of the work. 44. Could not sleep well. 45. Sleep less than five hours at night. 46. Work overtime.

*reversed question

3. Research Method

The purpose of this study is to evaluate if physicians and nurses perceive the patient safety culture differently when they are in different hospitals, namely one medical center and two regional teaching hospitals. The Chinese version of the SAQ in Table 1 is used to examine the patient safety culture from viewpoints of physicians and nurses. The score for each dimension is to sum up the scores from individual questions under the same dimension.

Analysis of variance is applied to test if the perception differences exist in six dimensions excluding emotional exhaustion and work-life balance among three hospitals from viewpoints of physicians and nurses in 2016 and 2017. Since regional teaching hospital B does not have data in emotional exhaustion and work-life balance, independent sample t test is employed to evaluate if the perception differences exist in emotional exhaustion and work-life balance between medical center and regional teaching hospital A from viewpoints of physicians and nurses in 2016 and 2017.

The internal survey results among three hospitals are conducted in 2016 and 2017. By removing incomplete questionnaires, the numbers of the effective questionnaire in 2016 in medical center, regional teaching hospital (denoted as A), and regional teaching hospital (denoted as B) are 921, 432, and 308, respectively. In 2017, the numbers of the effective questionnaire in medical center, regional teaching hospital A, and regional teaching hospital B are 1036, 514, and 283, respectively.

4. Results

The mean scores and their respective standard deviations of eight dimensions among three hospitals in 2016 and 2017 are provided in Table 2 and Table 3, respectively. In 2016, regional teaching hospital A has the highest mean score in teamwork climate, safety climate, emotional exhaustion, and work-life balance. Regional teaching hospital B has the highest mean score in working conditions, whereas medical center has the highest mean score in job satisfaction, perceptions of management, and stress recognition. In 2017, regional teaching hospital A has the highest mean score in teamwork climate and emotional exhaustion. On the other hand, medical center has the highest mean score in safety climate, job satisfaction, stress recognition, perceptions of management, working conditions, and work-life balance.

Table 2. Descriptive statistics of eight dimensions among three hospitals in 2016

Year of 2016	Hospital	Mean	Standard Deviation
Teamwork Climate	Medical Center	3.675	.544
	Regional Teaching Hospital A	3.887	.724
	Regional Teaching Hospital B	3.732	.776
Safety Climate	Medical Center	3.716	.531
	Regional Teaching Hospital A	3.730	.708
	Regional Teaching Hospital B	3.642	.705
Job Satisfaction	Medical Center	3.808	.877
	Regional Teaching Hospital A	3.708	.808
	Regional Teaching Hospital B	3.610	.871
Stress Recognition	Medical Center	3.845	.875
	Regional Teaching Hospital A	3.566	.859
	Regional Teaching Hospital B	3.668	.940
Perceptions of Management	Medical Center	3.789	.833
	Regional Teaching Hospital A	3.598	.718
	Regional Teaching Hospital B	2.707	.634
Working Conditions	Medical Center	3.885	.791
	Regional Teaching Hospital A	3.593	.733
	Regional Teaching Hospital B	4.198	1.020
Emotional Exhaustion	Medical Center	2.627	.900
	Regional Teaching Hospital A	3.024	.646
Work-Life Balance	Medical Center	2.916	.624
	Regional Teaching Hospital A	2.939	.578

Table 3. Descriptive statistics of eight dimensions among three hospitals in 2017

Year of 2017	Hospital	Mean	Standard Deviation
Teamwork Climate	Medical Center	3.704	.543
	Regional Teaching Hospital A	3.891	.760
	Regional Teaching Hospital B	3.588	.705
Safety Climate	Medical Center	3.744	.539
	Regional Teaching Hospital A	3.724	.715
	Regional Teaching Hospital B	3.629	.660
Job Satisfaction	Medical Center	3.868	.851
	Regional Teaching Hospital A	3.658	.798
	Regional Teaching Hospital B	3.745	.901
Stress Recognition	Medical Center	3.867	.877
	Regional Teaching Hospital A	3.628	.861
	Regional Teaching Hospital B	3.769	.940
Perceptions of Management	Medical Center	3.845	.786
	Regional Teaching Hospital A	3.546	.767
	Regional Teaching Hospital B	3.598	.815
Working Conditions	Medical Center	3.920	.761
	Regional Teaching Hospital A	3.676	.687

	Regional Teaching Hospital B	3.600	.848
Emotional	Medical Center	2.643	.866
Exhaustion	Regional Teaching Hospital A	2.977	.662
Work-Life	Medical Center	2.919	.625
Balance	Regional Teaching Hospital A	2.131	.629

Table 4 summarizes the differences of six dimensions among three hospitals in 2016 by analysis of variance, where regional teaching hospital A, regional teaching hospital B, and medical center are denoted as RTH A, RTH B, and MC, respectively. Except for safety climate, physicians and nurses in these three hospitals have significant perceptions in teamwork climate, job satisfaction, stress recognition, perceptions of management, and working conditions. Regional teaching hospital A performs best in teamwork climate statistically, while regional teaching hospital B outperforms the others in working conditions. On the contrary, medical center has the best stress recognition and perceptions of management. It is worth to note that physicians and nurses in medical center feel more stressful than those at two regional teaching hospitals.

Table 4 A Comparison of six dimensions among three hospitals in 2016

Dimension	F	Significance	Post Hoc Analysis
Teamwork Climate	16.205	< .001	RTH A > MC; RTH A > RTH B
Safety Climate	2.141	.118	
Job Satisfaction	6.760	.001	MC > RTH B
Stress Recognition	15.974	< .001	MC > RTH A; MC > RTH B
Perceptions of Management	230.301	< .001	MC > RTH A; MC > RTH B; RTH A > RTH B
Working Conditions	48.972	< .001	MC > RTH A; RTH B > MC; RTH B > RTH A

Table 5 provides the differences of six dimensions among three hospitals in 2017. Physicians and nurses in these three hospitals have statistically different perceptions on six dimensions. Regional teaching hospital A has the best in teamwork climate, whereas medical center performs best in perceptions of management and working conditions.

Table 5. A Comparison of six dimensions among three hospitals in 2017

Dimension	F	Significance	Post Hoc Analysis
Teamwork Climate	24.139	< .001	RTH A > MC; MC > RTH B; RTH A > RTH B
Safety Climate	3.904	.020	MC > RTH B
Job Satisfaction	11.108	< .001	MC > RTH A
Stress Recognition	12.608	< .001	MC > RTH A
Perceptions of Management	29.144	< .001	MC > RTH A; MC > RTH B
Working Conditions	30.022	< .001	MC > RTH A; MC > RTH B

Because regional teaching hospital B does not have the data in emotional exhaustion and work-life balance in 2016 and 2017, independent sample t test is employed to compare if physicians and nurses in regional teaching hospital A and medical center perceive emotional exhaustion and work-life balance statistically different. Table 6 shows that regional teaching

hospital A outperforms medical center in emotional exhaustion in 2016, but these two hospitals do not have a significant difference in work-life balance. In 2017, regional teaching hospital A also outperforms medical center in emotional exhaustion statistically as shown in Table 7. However, the difference in work-life balance is not significant.

Table 6. Perception differences in emotional exhaustion and work-life balance in 2016

Dimension	Hospital	Mean Score	t	p value
Emotional Exhaustion	Medical Center	2.627	-9.243	< .001
	RTH A	3.024		
Work-Life Balance	Medical Center	2.916	-6.44	.207
	RTH A	2.939		

Table 7. Perception differences in emotional exhaustion and work-life balance in 2017

Dimension	Hospital	Mean Score	t	p value
Emotional Exhaustion	Medical Center	2.643	-8.423	< .001
	RTH A	2.977		
Work-Life Balance	Medical Center	2.919	23.330	.965
	RTH A	2.131		

5. Conclusions

Based upon the data sets in 2016 and 2017, regional teaching hospital A outperforms both regional teaching hospital B and medical center in teamwork climate in both years. Physicians and nurses in these three hospitals do not have significantly different perceptions in safety climate in 2016. However, medical center outperforms regional teaching hospital B in 2017 in safety climate. Medical center outperforms regional teaching hospital B in 2016 and regional teaching hospital A in 2017 in job satisfaction. Physicians and nurses in medical center feel more stressful (stress recognition) than regional teaching hospital A. Medical center has the best perceptions of management in both years statistically. In working conditions, regional teaching hospital B is the best in 2016, but medical center becomes the best in 2017. Finally, regional teaching hospital A outperforms medical center in emotional exhaustion in both years. Physicians and nurses in medical center and regional teaching hospital A do not have different behaviors in work-life balance in both years.

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Assessment of Patient Safety Culture during COVID-19: A Cross-Sectional Study in a Tertiary Hospital in China

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Abstract. Since December 2019, coronavirus disease 2019 (COVID-19) has appeared in many countries, seriously threatening people's lives and health. Medical staff in China are under immense pressure that greatly affects their physical and psychological health and their attitude toward patient safety. The current study investigated the status of patient safety culture in a tertiary hospital during the COVID-19 pandemic in Wuhan, China. Patient safety culture was assessed with the Chinese version of the Safety Attitudes Questionnaire. Confirmatory factor analysis was conducted to validate the structure of the data (i.e., reliability and validity), and Pearson's correlation analysis was performed to identify relationships between safety-related dimensions. Safety climate was strongly associated with working conditions and teamwork climate. In addition, working conditions was highly correlated with perceptions of management, safety climate, and job satisfaction, respectively. In sum, safety climate, working conditions, support for hospital management, and stress management are four key drivers of a good patient safety culture. To continuously improve the quality and safety of patient care, experts should periodically assess the patient safety culture.

Keywords. COVID-19, Patient safety culture, Safety Attitudes Questionnaire, Medical care, Medical staff.

1. Introduction

The hospital culture is closely related to social responsibility, an important factor among hospitals. Culture affects behavior, and social responsibility is a concrete manifestation of cultural characteristics of practical actions [1,2]. Medical staff are usually the first and most frequent contact for patients, and thus they are the core personnel behind the practice of social responsibility and the delivery of medical services. Therefore, implementing a patient safety culture is of great significance. Through this internalization of values, concepts, and attitudes, staff can take more active care of patients receiving medical services, which can effectively reduce possible doctor–patient disputes, promote the development of harmonious doctor–patient relationships, and promote the survival and sustainable development of the hospital [3].

Since December 2019, coronavirus disease 2019 (COVID-19) has appeared in China and many other countries and regions, seriously threatening people's lives and health. As witnesses to this major public health emergency, medical staff are under immense pressure that greatly affects their physical and mental health and their attitude toward patient safety. Hospital managers should become aware of the patient safety culture and pay attention to the emotions of staff during this epidemic. This paper integrates the emotional state of medical staff into an evaluation of patient safety culture to provide insights into effective medical management systems and countermeasures.

2. Literature Review

2.1 Patient safety culture

In recent years, building a good patient safety culture has become an effective way of improving the quality of medical care, and thus many medical institutions have taken notice of this idea. The concept of a safety culture can be traced back to the rise of industrial science and technology, when high-risk work environments made people's safety more uncertain. Since then, various industries have gradually tried to establish safety cultures to reduce the occurrence of disasters and accidents. Therefore, a safety culture began to be valued [4]. In the medical industry, patient safety culture is usually defined as common attitudes, beliefs, and values around patient safety held by all employees of a medical institution. This core concept of the medical institution determines the behavior, thinking, and attitudes of the institution to ensure the safety of patients [5]. Patient safety is an important issue around the world and has been widely discussed in many countries and by the World Health Organization. The creation of a patient safety culture can improve the safety of medical services, improve the attitudes and values of medical staff toward patient safety, and fundamentally improve patient safety. When staff have a proper awareness of patient safety, many negative outcomes can be reduced, including patient complaints, medical negligence, medical disputes, patient deaths, and so on [12,13].

Evaluating patient safety culture is an important part of improving patient safety, as such evaluations can identify key areas for improvement in patient safety in medical institutions and provide a practical basis for the formulation of management measures [6]. Scholars in China and abroad have used many scales to evaluate patient safety culture, such as the Hospital Survey on Patient Safety Culture, Patient Safety Climate in Healthcare Organizations Survey, Safety Attitude Questionnaire (SAQ), and Safety Culture Interaction Model [7–9]. The SAQ, developed by American scholars Sexton et al. [14], is widely used by medical institutions all over the world. The scale has six dimensions: teamwork climate, safety climate, job satisfaction, stress recognition, perceptions of management, and working conditions. Empirical studies indicate that the SAQ can effectively detect deficiencies in the creation of a patient safety culture in medical institutions and promote continuous improvement in institutions' management systems. However, the questionnaire does not fully consider the emotions of medical staff.

2.2 Emotional exhaustion

The extent to which medical staff are emotionally exhausted reflects how well they can stabilize their emotions and think properly in the work environment. Emotional exhaustion has a significant impact on the job satisfaction, work pressure, mental health, workload, and so on, of medical staff [10,11]; affects the importance of patient safety at the center of medical tasks [15]; and affects the creation of patient safety culture in medical institutions. Burnout among medical staff may lead to a loss of enthusiasm for work, emotional exhaustion, and personal

cognitive impairment [16, 17]. Excessive burnout can affect the health and work–life balance of staff, leading to a decline in the quality of medical care [16–18, 22]. Chen et al. [19] showed that doctors are generally overworked and tired, which may lead to many risks and errors, including medical accidents and a shortage of human resources. All of these negative factors seriously threaten the safety of patients. Similarly, illness, absence, medical errors, and job dissatisfaction are associated with burnout among nurses [20–22]. Lee et al. [22] integrated emotional exhaustion into an evaluation of patient safety culture and proved that the emotional state of medical staff significantly affects their attention to patient safety. Hospital managers can improve their adaptability and reduce potential medical errors by implementing appropriate measures to combat high job burnout among staff. In sum, the physical and emotional condition of staff must be considered to provide patients with high-quality medical services. The Maslach Burnout Inventory–Human Services Survey (MBI-HSS) is a validated tool for assessing burnout. It contains 22 questions on three dimensions: emotional exhaustion, personal accomplishment, and depersonalization [23, 24]. Research in various fields provides strong support for the MBI-HSS for assessing burnout.

3. Research Method

3.1 Data collection

Medical staff at a third-level grade A hospital in Wuhan, China, participated in this research. The hospital is a comprehensive facility that integrates medical treatment, teaching, research, and rehabilitation. At present, it has more than 60 medical departments, more than 2000 beds, and 2156 medical staff. A small-scale pretest was conducted on 20 medical and nursing staff to confirm the accuracy and authenticity of the questionnaire [25]. Convenience sampling and anonymous methods were used to collect the questionnaires. A total of 450 questionnaires were distributed. The final number of usable questionnaires was 255, representing a response rate of 56.66%.

3.2 Data analysis

Confirmatory factor analysis was used to verify the questions retained in the project analysis and testing. To this end, we conducted maximum likelihood estimation in structural equation analysis and reconstructed the model by looking at factor loadings with small index values (estimated load < 0.7) [25,26]. In addition, following Gerbing and Anderson [27], we evaluated two different types of validity (convergent and discriminant) to confirm the dimensions of patient safety culture. After confirming the structure of the dimensions, we performed Pearson correlation analysis to test the strength and directions of the relationships between the dimensions of medical staff and patient safety culture [28].

3.3 Measurement of variables

The patient safety culture questionnaire used in this study was a combination of the SAQ, developed by Sexton et al., and the MBI-HSS, developed by Maslach. It has seven dimensions: teamwork climate, safety climate, job satisfaction, stress recognition, perceptions of management, working conditions, and emotional exhaustion. Teamwork climate (six items) measures relationships and the degree of cooperation among staff, safety climate (seven items) measures organizational commitment to patient safety, job satisfaction (five items) measures positive feelings about work, stress recognition (four items) measures stress linked to work performance, perceptions of management (four items) measures administrator approval, working conditions (four items) measures the perceived quality of the work environment, and

emotional exhaustion (nine items) measures the degree to which medical staff feel stable and are able to think appropriately in the work environment. Five-point Likert scales anchored by 1 (strongly disagree) and 5 (strongly agree) are used throughout the questionnaire.

4. Results

4.1 Sample characteristics

Most of the medical staff were female (78.8%), and most were 18 to 30 years old (68.6%). The education level of the staff was mainly undergraduate (68.6%). Among the staff with relevant work experience, about half (49.3%) had worked in the hospital for more than 5 years. In addition, the results showed that safety climate (total mean = 4.12), working conditions (total mean = 4.11), and teamwork climate (total mean = 4.09) had high means, whereas stress recognition had the lowest mean (total mean = 3.87). Generally speaking, the medical staff had a good understanding of patient safety and team cooperation, which indicates that the hospital had a high commitment to patient safety. Overall, the medical staff attached great importance to patient safety, team cooperation among various departments was high, and staff were satisfied with the work environment provided by the hospital. It is worth noting that the stress and emotional exhaustion of the medical staff during this epidemic were high and needed attention.

4.2 Correlation analysis

To identify correlations between dimensions, we performed Pearson correlation analysis. Safety climate was highly positively correlated with working conditions and teamwork climate; working conditions was highly positively correlated with perceptions of management, safety climate, and job satisfaction (Table 1). It is worth noting that emotional exhaustion was positively correlated with stress recognition and negatively correlated with the other five dimensions. This shows that a good work environment and resources and the degree of cooperation among colleagues are of great significance in improving safety. Whether or not hospital managers support the creation of a patient safety culture, the degree of cooperation among colleagues and the importance of patient safety in the hospital have an important impact on improving the working conditions of medical staff. In addition, if hospital administrators want to increase staff's awareness of patient safety, they need to pay attention to their physical and mental health, especially emotional exhaustion.

Table 1. Correlation Analysis of dimensions (n = 255)

Construct	1	2	3	4	5	6
1.Teamwork climate						
2.Safety climate	0.71**					
3.Job satisfaction	0.57**	0.64**				
4.Stress recognition	0.06	0.06	-0.19**			
5.Perceptions of management	0.54**	0.67**	0.66**	-0.15**		
6.Working condition	0.55**	0.75**	0.67**	-0.13**	0.78**	
7.Emotional exhaustion	-0.24**	0.22**	-0.45**	0.51**	-0.26**	-0.26**

5. Discussion and Conclusion

Understanding the thoughts of medical staff on patient safety is key to medical institutions being able to improve the hospital culture and social responsibility. The following are some suggestions to consider.

First, improve the culture around safety. According to the results of the Pearson correlation analysis, if medical staff care more about the safety of patients, then more collaboration will take place among team members, and vice versa. Relevant studies have confirmed that a good safety culture can reduce the occurrence of adverse events such as medical accidents, disputes, and errors and that good medical service depends on the efforts of all staff. Therefore, medical institutions should pay attention to patient safety, create a team culture in which staff can support and talk to one another, and carry out more team-building activities (formal or informal) so that staff are more likely to pay attention to safety issues. In addition, every staff person should think in a different place, serve the patient with feeling, and attempt to eliminate negative emotions and conflicts caused by work. In this way, staff can establish good doctor–patient relationships built on mutual trust, and the quality of medical services can be improved for every patient.

Second, improve working conditions. The results show the importance of good working conditions. When working conditions are good, employees will have more satisfaction with their work and will care more about patient safety, which will help shape a good safety culture in the institution and build a high-quality medical service system. To improve working conditions, institutions can establish good internal incentives, such as reasonable internal performance appraisal mechanisms, so that employees are more motivated to take their work seriously. Institutions can also stimulate employees' strong desire for challenging work. For example, if medical staff think nursing work is valuable and meaningful, they will work more actively. In contrast, if they think nursing work is meaningless, they will be more negative and perfunctory. Human and material resources can also be improved, which will in turn bring about improvements in working conditions. In clinical practice, a shortage of human resources, old equipment, and other problems all create inconvenience and dissatisfaction among medical staff, seriously affecting their enthusiasm to perform medical tasks and the quality of the services they provide. It is necessary to determine the appropriate allocation of personnel through long-term observation and update instruments and equipment in a timely manner. In addition, reasonable salary management systems should be established to make staff aware of the rewards of their hard work, especially their selfless dedication during an epidemic. This will help increase their initiative and job satisfaction and reduce turnover and the occurrence of adverse events.

Third, increase support to managers. The support of hospital managers is very important for promoting a safety culture. If there is no strong top-down commitment to patient safety, such a culture cannot be sustained. Support for management can be substantive (including subsidies, feedback, and job knowledge) or emotional (involving encouragement, concern, empathy, and trust). Substantive and emotional support can reduce the work pressure experienced by medical staff, promote good physical and mental health, and help create a positive attitude toward patient safety, which will help the hospital fulfill its social responsibility. Hospital managers should also provide regular and unimpeded communication to eliminate opposition between units, which is an important way to strengthen a culture of patient safety among staff. In addition, hospital managers should be trained in multiple leadership skills, such as negotiation, motivation, conflict resolution, and empowerment, to help staff integrate into the hospital culture faster and more actively and to ensure the implementation of various policies and measures.

Fourth, improve the drainage channel. This study shows a strong correlation between negative emotions and stress among medical staff, and this is also closely related to indicators of patient safety culture. How to reduce negative emotions and pressure among medical staff is an important issue worthy of deep consideration by hospital managers. Especially during an epidemic, medical staff need to be in close contact with patients, yet some patients are highly infectious. In addition, medical staff inevitably come into contact with the bodily fluids and blood of patients in clinical work, and the threat of stabbing injuries with sharp instruments such as needles may wear on their physical and mental health, creating more pressure. To alleviate this pressure, hospital managers should reasonably allocate human resources according to a given situation, flexibly arrange the number of people, and make sure that people do their duty and make the best use of everything. They should actively improve the work environment of medical staff, improve the salary of clinical staff, and safeguard their vital interests. In addition, medical institutions should pay attention to methods of relieving emotions and stress, provide staff with multiple channels to relieve pressure, and set up special psychological counseling to address their negative emotions. They should regularly evaluate the physical and mental status of team members, enabling them to communicate with colleagues and friends, share ways to relieve the pressure, encourage one another, and actively face the various pressures and conditions of the work environment.

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New Segment of the Shadow Digital Economy

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Abstract. The article presents the results of the analysis of the threat landscape in the shadow digital economy. The development of industrialization and digitalization of the economy is associated with the emergence of qualitatively new threats. It was concluded that, along with such traditional segments as the development and implementation of cyber weapons, targeted attacks and ATR groups, identity theft, etc., attacks on crypto-exchanges, crypto exchangers and money laundering using cryptocurrencies are emerging.

Keywords. Shadow digital economy, Segments of the shadow digital economy, Cryptoeconomics, Attacks on crypto-exchanges.

1. Introduction

Shadow activity attracts the attention of specialists in many countries. In this work, an attempt is made to outline the landscape of the shadow digital economy, highlight its main segments and describe a new field for counteraction, targeted at new emerging threats, such as criminal operations on cryptocurrency exchange and crypto exchanges.

This work is a logical continuation of the authors' publications on the topic of research related to the definition of the shadow digital economy (SDE) category, segmentation of the spheres of illegal activity, etc.

As a result of the research, the authors propose the following definitions of the shadow digital economy:

- shadow digital economy is a specific domain of economic activity with its inherent structure and system of economic relations. Specificity is determined by the illegality, informality, as well as the criminal nature of economic activity and concealment of income;
- from an economic point of view - the sector of economic relations, covering all types of production and economic activities, which in their direction, content, nature and form contradict the requirements of the existing legislation and are carried out in spite of state regulation of the economy and bypassing control over it;
- from a technological point of view, it is an individual and collective activity that is illegal, associated with the design, development, distribution, support and use of information and communication technology components, hidden from society.

Thus, SDE is all the illegal and hidden products and services that use and are based on information technology. The most important economic elements in this area are the following: illegal economic relations, illegal activities related to the production, distribution and use of prohibited products and services. Advances in information technology are creating new threats:

- Attacks are becoming more sophisticated through automation and the use of artificial intelligence and machine learning methods;
- Connection of a huge number of new unprotected devices (industrial Internet or Internet of things, as a data transfer network between physical objects, which are equipped

with built-in means and technologies of interaction with each other or with the external environment). Hackers use devices such as video cameras, coffee machines, etc to enter the network;

- As a result, the number of targets for attacks increases sharply.

It should be noted that blockchain technology instills trust in customers and proves the security of cryptocurrency transactions. However, the development of the cryptocurrency business has attracted attention of computer fraudsters. They paid attention and efforts to the activities of exchanges that specialized in buying and selling cryptocurrencies.

2. Main segments of the shadow digital economy

The authors examined the composition of the main criminal products and services related to SDE. However, their spectrum is constantly changing, new segments appear that require research and description. In previous articles, the following segments were considered: cyber weapons, as the concentration of all the achievements of information and communication technologies at the level of counteraction between states; targeted attacks and ATR groups; identity theft, etc.

It seems necessary to analyze the existing approaches to the classification of products and services, as well as to consider the segmentation of SDE. The generalized structure provides for the division into products and services, taking into account their constant variability. This property is decisive, since the achievements of scientific and technological progress and innovations in the field of information and communication technologies provide a rapid changeover of hardware and software platforms. In the information realm, tangible products are extremely few in number and usually refer to hardware, while most of this definition refers to software that is generally considered intangible. It should be noted that many classifications are used in information security practice.

The malware created is targeted at the following industries: hospitality and catering; educational services; finance and insurance; healthcare; information; production; public administration; retail, etc. The same Verizon report suggests a classification of incidents: Crimeware, Cyber-Espionage, Denial-of-Service, Insider and Privilege Misuse, Miscellaneous Errors, Payment Card Skimmers, Point of Sale Intrusions, Physical Theft and Loss, Web Application Attacks and others.

The study by Brandon Levine uses a different classification. There are four groups of malware:

- Banker. This is a kind of malware specially designed to manipulate online banking. Programs in this category use WebInjects (a set of HTML and JavaScript code that displays forms for entering credentials of remote banking systems (RBS) and WebFakes (using fake web pages to trick users into entering confidential information as a method of social engineering);
- Ransomware. This is software used to lock a computer or personal files of a user with the subsequent demand for a ransom for restoring access;
- Stealer. Malicious programs designed to steal passwords stored in the system. May include keylogging malware;
- Miner. Malicious software that uses the resources of an infected information system to generate cryptocurrencies without the knowledge and permission of the system owner.

In addition, the report analyzes a wide range of malware and criminal programs, including GameOver Zeus, Cryptolocker, Dridex, Dyre, Trickbot, Ramnit. The main findings of this study are as follows:

First, it notes that the risk of using malware is clearly underestimated, making it difficult to protect against. This leads to the fact that the losses from the impact of criminal software grow, the countermeasures taken reduce the effectiveness of the confrontation. The impact of criminal software is enormous, and if countering efforts are not significantly increased, the consequences can be more serious and widespread in scope and cost.

Second, the growth of criminal software is steady; the frequency of distribution of new variants is growing from year to year. As a result, criminal software is a more serious threat to business impact than targeted attacks on information systems.

Third, the implementation of criminal software is not expensive and does not require a lot of effort on the part of motivated participants, which ensures that attacks are optimized to achieve profitable goals. The ability to increase agility and change strategies has led to increasingly sophisticated and targeted business assault programs.

Fourth, it is noted that the effectiveness of the efforts of law enforcement agencies to counter criminal software decreases over time. The ability of developers and attackers traditionally outstrips the capabilities of law enforcement agencies in searching, finding and prosecuting by adapting to changing conditions. The attacker models the risk of prosecution based on the practice of law enforcement agencies and is entirely based on the possibility of making a profit. As a result, taking into account such factors as time, geographic location and others, the activities of law enforcement agencies are seriously limited and efforts are reduced to scanty results. At the same time, these factors allow developers and analyzers of criminal software to have spare time to adapt new versions and make their software more "effective" and harmful in relation to users of information systems.

Fifth, it is recognized that crimeware is serious business. Developers model their activities in accordance with corporate standards to maximize profits. An example is the emergence of "crimeware-as-a-service" as a demonstration of its capabilities. Cybercriminals are dramatically changing their toolkits over a three-month period to achieve new results. An additional example is also Cryptomining as an operation. The cryptocurrency market initially peaked at the end of 2017 and began to decline by February 2018. The downward trend in the Bitcoin index was directly reflected in the activity of "Cryptomining as an operation", which fell by more than 50% during the year. The statistical correlation between bitcoin index jumps and the popularity of "Cryptomining as an operation" can be seen as a highly profitable tool for influencing business.

Finally, the goals of cyber fraudsters have changed. Whereas previously the target was the user of a personal computer, now the corporations and corporate victims are the targets. As the danger of real threats grows, organized crime groups have turned to corporations.

Another confirmation of the thesis that crimeware is a serious business is the publication in July 2020 of information that Cerberus is the world's first malware with the function of stealing two-factor authentication codes. The developers of the Android banking Trojan Cerberus intend to sell their entire project.

Bidding will be held in the form of an auction, and the starting price is \$ 50 thousand. For \$ 100 thousand, the developers are ready to part with their brainchild without haggling. For their money, the buyer will receive the source code of the Trojan, APK, modules, an administration panel, servers, and lists of current and potential customers, an installation guide and scripts necessary for the smooth operation of all components.

For at least one year, Cerberus developers have been actively promoting their services and renting out malware for \$ 12,000 a year. Clients also had access to rent for a shorter period (\$ 4 thousand for 3 months and \$ 7 thousand for 6 months). According to the seller's

publication on one of the Russian-language cybercriminal forums, the business currently generates income of \$ 10 thousand per month. According to them, the Cerberus team has disintegrated, and the remaining developers do not have enough time to support the Trojan 24/7.

3. A new segment of the shadow digital economy

A relatively new trend is the attack on crypto exchanges, theft of cryptocurrencies and money laundering. The high market capitalization of certain cryptocurrencies attracts hackers. Consider the main trends in cryptocurrency capitalization as of 01/09/21. As an example, we use the data shown in Table 1.

Table 1. Top 10 cryptocurrencies by market capitalization as of January 9, 2021

Cryptocurrency	Price per coin	Market capitalization
Bitcoin	40 542,52 \$	754 321 316 827 \$
Ethereum	1 218,19 \$	138 640 801 067 \$
Tether	0,992037 \$	23 477 377 980 \$
XPR	0,324559 \$	14 590 916 168 \$
Litecoin	169,84 \$	11 200 359 477 \$
Cardano	0,322639 \$	9 958 280 954 \$
Polkadot	9,37 \$	8 909 423 935 \$
Bitcoin Cash	454,28 \$	8 416 703 785 \$
Stellar	0,305411 \$	6 672 633 057 \$
Chainlink	16,10 \$	6 418 005 819 \$

Source: Top 100 currencies by market capitalization (<https://www.coingecko.com/ru>) and CoinMarketCap website (<https://coinmarketcap.com/>)

For comparison, you can give the data of cryptocurrency quotes as of December 23, 2020. The leaders were the following cryptocurrencies.

Table 2. Current data on the cost of major cryptocurrencies (as of 23.12.2020).

Name	Ticker	Price per coin	Market capitalization
Bitcoin	BTC	23.570	439,57B\$
Ethereum	ETH	609,25	69,76B\$
Tether	USDT	0,9997	20,47B\$
Ripple	XRP	0,31428	14,57B\$
Litecoin	LTC	105,212	7,07B\$
Bitcoin Cash	BCH	291,12	5,46B\$
Chainlink	LINK	11,82	4,74B\$

Source: Leading Cryptocurrencies. <https://ru.investing.com/crypto/>

Increased criminal interest is caused, first, by the increased capitalization of bitcoin. The rise in price to \$ 40,000 and above significantly increased the capitalization of the first cryptocurrency, bringing the indicator a little closer to the market value of gold. For example, on January 9, 2021, the cost of bitcoin was \$ 40,951. The approximate market value of all mined gold is \$ 10.6 trillion. The market capitalization of bitcoin at the end of 2020 is \$ 736.3 billion, which is 6.94% of the total value of the precious metal. Bitcoin has surpassed Tencent and Alibaba in market capitalization and is now competing with Facebook. For example, Facebook's market capitalization at the beginning of 2021 is \$ 763.644.814.249 versus \$ 747.716.811.296 for Bitcoin. The capitalization of the entire cryptocurrency market at the end of 2020 is \$ 1.06 trillion. Analysts are wondering about Bitcoin's ability to climb to \$ 100,000 per coin before it depreciates. Leading experts do not give an accurate prediction, but agree that the enthusiasm for bitcoin and cryptocurrencies will fade over time, but that it may take another two, three or even four decades before that. Bitcoin is predicted to rise to \$ 500,000 and become a new store of value that can surpass gold, but for this, the price of bitcoin must increase 25 times.

One of the relatively new types of attacks or a new direction of the criminal business is the organization of attacks on crypto exchanges and crypto exchangers. The latter appeared about 10 years ago and were used to exchange virtual coins for dollars, euros or another currency at the request of the owner. After a while, a peak in the activity of cryptocurrencies was registered and bitcoin became more popular than the leading currencies.

Group-IB experts analyzed attacks on cryptocurrency exchanges over the past two years and revealed total losses of \$882 million. The report indicates that crypto exchanges will become a new target for aggressive hacker groups in 2019, and their efforts will shift from attacks to commercial banks. However, not only crypto exchanges, but also cryptocurrency companies that organize the launch of the ICO, raise funds and provide for the sale of tokens to private investors are put forward as goals.

Table 3. The top 10 cryptocurrencies by capitalization as of October 2020.

Name	Ticker	Price per coin	Market capitalization (billion)
Bitcoin	BTC	\$10 610	\$196,4
Ethereum	ETH	\$340	\$38,3
Tether	USDT	\$1,00	\$15,6
Ripple	XRP	\$0,24	\$11,1
Bitcoin Cash	BCH	\$219,01	\$4,05
Binance Coin	BNB	\$27,45	\$3,9
Polkadot	DOT	\$3,81	\$3,2
Chainlink	LINK	\$8,80	\$3,08
Crypto.com Coin	CRO	\$0,14	\$3,02
Litecoin	LTC	\$45,89	\$3,01

Source: Cryptocurrency Capitalization: Features and How It Affects Trading.

Cryptocurrency market capitalization exceeded \$ 400 billion. The most attention of investors and traders is focused on those cryptocurrencies that have the highest capitalization.

Despite the fact that the comparison of cryptocurrencies in this indicator is considered by some to be not completely objective, it is capitalization that is the main factor determining the interest in a separate coin from not only buyers, but also cyber fraudsters. For comparison, we present data on 10 cryptocurrencies by capitalization at the beginning of October 2020, which are represented in the following table.

During the analysis of the data obtained, Group-IB specialists discovered that more than 10% of the funds raised during the ICO were stolen. This is the period from 2017 to September 2018. More than half of the funds stolen from ICOs were associated with phishing attacks. The goal of the hacker groups was not only the virtual currency itself, but also lists of investors interested in ICOs for the implementation in the future of such actions as blackmail or targeted phishing attacks.

Hacker attacks on exchanges and crypto exchanges can be roughly divided into two stages. The first covers the interval from 2010 to 2016, and is characterized by relatively simple mechanisms of action and, accordingly, the results obtained. For example, in the summer of 2010, Bitcion was hacked and the hacker managed to create a transaction of 184 million bitcoins, with a limited volume of 21 million, which was detected and fixed. In the spring of 2014, Mt.Gox, the third largest exchange in the cryptocurrency market, was hacked. Almost \$ 480 million was stolen from the attack, leading to bankruptcy. In early 2015, the BitStamp exchange was hacked and the hackers received only \$ 5 million. In the summer of 2016, The DAO, an organization specializing in another cryptocurrency, Ethereum, was hacked. The cybercriminals managed to find a bug in the software, which ensured the theft of \$ 50 million in this cryptocurrency. July 2016. Steemit.com is hacked. Hackers who hacked over 250 accounts and stole \$ 85,000 in cryptocurrency attacked the social network Steem. August 2016. More than \$ 72 million in cryptocurrency was stolen from Bitfinex. The hackers took advantage of the vulnerabilities in the wallets of this exchange.

The second stage is characterized by the use of advanced attack mechanisms and the work of specialized teams. Examples of successful attacks on crypto exchanges and the corresponding losses are shown in the following table.

Table 4. Examples of successful attacks on crypto exchanges in 2017-2018.

Date	Project	Country	Group	Damage in crypto	Damage in billion \$
Feb. 2017	Bithumb	South Korea	-	-	7
Apr. 2017	YouBit	South Korea	-	-	5,6
Apr. 2017	Yapizon	South Korea	Lazarus	3,816 BTC	5,3
Apr. 2017	Ether Delta	-	Unknown	-	0,225
Aug. 2017	OKEx	Hong-Kong	Unknown	-	3
Sep. 2017	Coinis	South Korea	Lazarus	-	-
Dec. 2017	YouBit	South Korea	Lazarus	17% of assets	-
Jan. 2018	Bitstamp	Luxemburg	Unknown	18.000 BTC	5
Jan. 2018	Coincheck	Japan	Lazarus	532.000.000 NEM	534
Feb. 2018	Bitgrail	Italy	Unknown	17.000.000 NANO	170
June 2018	Bithumb	South Korea	Lazarus	-	32
June 2018	Coinrail	South Korea	Unknown	-	37
June 2018	Bancor	-	Unknown	-	23
Sep. 2018	Zaif	Japan	Unknown	-	60
				Total	882

Source: Report: Cryptocurrency Exchanges Lost \$882 Million to Hackers.

The growing interest in cryptocurrencies has given rise to the development of massive attacks on these services. Thus, from 2016 to 2017, the number of compromised user accounts of cryptocurrency exchanges increased by 369%. In January 2018, the number of incidents increased by 689% compared to the 2017 monthly average. Group-IB experts analyzed the thefts of 720 user accounts of the 19 largest cryptocurrency exchanges and found that the USA, Russia and China became the leaders in terms of the number of victims of cyber-attacks (see Table 6).

Table 5. Distribution of victims of crypto-exchanges by country

№	Country	% of stolen assets
1	USA	34,3
2	Russia	10,5
3	China	5,0
4	Indonesia	4,5
5	Germany	3,6
6	Ukraine	2,8
7	Iran	2,8
8	Slovakia	2,6
9	Hong-Kong	2,6
10	Vietnam	2,4
11	Turkey	2,4
12	Other	11,1

Source: Number of hacked accounts on bitcoin exchanges in early 2018 increased by 689%.

It is impossible to ignore the functioning of specialized groups in this SDE segment.

Additional information on the activities of such groups can be obtained from the contents of the following table.

Table 6. Hacker group activities.

Country	Group	Codename	Activity
China (9 groups)	APT1	Unit 61398, Comment Crew	Information technology, aerospace industry, government, satellites and telecommunications, scientific research and consultations, energy, transport, construction and production, etc.
	APT3	UPS Team	Aerospace and defense industry, construction and engineering, high technology, telecommunications, transport.
	APT10	Menupass Team	Construction and engineering, aerospace and telecommunications companies, as well as the governments of the USA, Europe, and Japan.
	APT12	Calc Team	Journalists, government, defense industry base.

	APT15	Ke3chang, Mirage, Metushy, Vixen Panda	Government ministries throughout Europe.
	APT16		Japanese and Taiwanese organizations in the field of high technology, public services, media and financial services.
	APT17	Tailgator Team, Deputy Dog	US government, international law firms and IT companies.
	APT18	Wekby	Aerospace and defense industry, construction and engineering, education, healthcare and biotechnology, high technology, telecommunications, transport.
	APT30	-	Members of the Association of Southeast Asian Nations.
Russia (3 groups)	APT28	Fancy Bear, Sofacy, Pawn Storm, Tsar Team	The Caucasus, in particular Georgia, countries and military of Eastern Europe, NATO and other European security organizations and defense firms.
	APT29	Cozy Bear, the Dukes	Targeted invasions of the US National Democratic Committee, Governments of Western Europe, foreign policy groups and other similar organizations.
		Turla, Snake, Uroburos, Venomous Bear	A likely campaign against federal institutions in Germany, including the Foreign Ministry.
North Korea (3 groups)	APT37	Reaper, Group123, ScarCruft	First of all, South Korea, as well as Japan, Vietnam and the Middle East - in the chemical, electronic, industrial, aerospace, automotive and medical fields.
	-	Lazarus, BlueNoroff , Hidden Cobra	Suspected on hacking of Sony.
Iran (2 groups)	APT33		Several industries are headquartered in the United States, Saudi Arabia, and South Korea.

	APT34		A variety of industries, including financial, government, energy, chemical, and telecommunications in the Middle East.
	-	Charming Kitten, Flying Kitten	Persons of interest to Iran in the fields of research, human rights and the media.

Source: Pennino A, Bromiley M (2019) Threat Research. GAME OVER: Detecting and Stopping an APT41 Operation.

4. Technologies

One of the most popular schemes for stealing cryptocurrency assets is the following. First, a DDoS attack is organized and the site is blocked. This is followed by sending out phishing emails with fake addresses. Fake addresses are used to redirect to a phishing site, which is used to steal passwords and logins. Based on the stolen logins and passwords, electronic wallets are opened and the withdrawal and cashing of assets is performed.

In addition, with the help of hacker attacks, cryptocurrency exchange rates are changed to gigantic values. Therefore, in December 2020, hackers took control of the infrastructure of Livecoin and the Bitcoin exchange rate increased from \$23,000 per unit to \$450,000, Ethereum increased in price from \$600 to \$15,000 in the exchange, and the price of Ripple's XRP token increased from \$0.27 up to more than \$17.

The technologies used in this segment require in-depth research. The main reason for the lag is the use of elements of artificial intelligence and machine learning.

5. Conclusion

Over the past few years, cybercrime has stepped over many technical and software barriers and moved from a highly specialized niche into one of the most significant strategic risks facing the world today. The development of digital forms of fraud (cryptocurrencies and ICOs, ransomware infection, installation of an application on a smartphone, phishing, etc.) largely contributes to the development of technical progress.

According to the forecasts of the results of the study of global risks, cybersecurity and other factors related to IT will remain and will have a significant impact. Thus, short-term risks in the 0-2 year interval are assessed and are associated with failures in cyber security systems (39% of respondents noted) and digital inequality (38%). In turn, medium-term risks (3-5 years) are associated with a breach of the IT infrastructure (53.3%), failures in cybersecurity systems (49.0%), failures in technology management (48.1). Existential threats, taking into account long-term risks (5-10 years), are associated with unfavorable technical achievements (50.2% of respondents).

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Analytical Modelling & Multicriteria Interactive Assessment of 2D/3D Virtual Representations & Their Effects on the Trainees Cognitive Skills Transformation

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Abstract. Digital transformation fostered by pandemic as nowadays catalyst of change is inevitably adding technological innovations to all dimensions of our lifestyle, ranging from work to entertainment and especially education. Apart of this, the people cognitive capabilities are constantly being challenged by the informational dynamics overload of the overspeeded and data-flooded, mixed cyber-physical ultraconnected hyper reality of mobile smart gadgets, people & biotope. The paper is addressing an analytical model of the digital training transformation, that is further experimentally evaluated by 2D/3D virtual reality system and a multicriteria interactive assessment approach. The study is mainly addressing the abstract imaginary and memory capabilities of a selected trainees' focus group. A threefold (Y-, Z-, & Alpha-) generation experiments, encompassing both initial subjects' training and further evaluation is implemented. Finally, some useful findings, concerning both positive and negative effects of the virtual training with 2D/3D representations are discussed.

Keywords. Virtual training, 2D/3D representation, Analytical modeling, Multicriteria assessment, Cognitive skills, Digital transformation

1. Introduction

Understanding the future transformational trends from the present perspective is a quite challenging task. In this sense the outlines towards year 2033 in the recent book "Future Digital Society Resilience in the Informational Age" [1] and other related comprehensive studies [2], [3] are giving priorities to multiple assets of future digital society. Ranging from AI & IoTs towards education via digital currencies, economic, tech innovations, medias and security, all of these are still connected at the level of broadband Internet, wireless standards, Bluetooth, NFC, multiple sensors meshes standards and probably in the future – at a new quantum level.

What however stands uncertain is naturally the biotope and human factor, both influenced by external phenomena like: global warming, natural disasters, the new COVID-19 pandemic [4], [5], manmade or natural disasters and space cataclysms [6].

Discussing this transformation is however important to be properly understood from the cognitive skills perspective of the new, transformed humans. The technological addressing of the human consciousness and memory being the unique user and hopefully mentor of this new reality (for the not so far future of 10-15 years ahead, though the singularity idea of AI superstition [7]), is getting more progress [8], together with the hybrid human-machine extended mixing [9], [10].

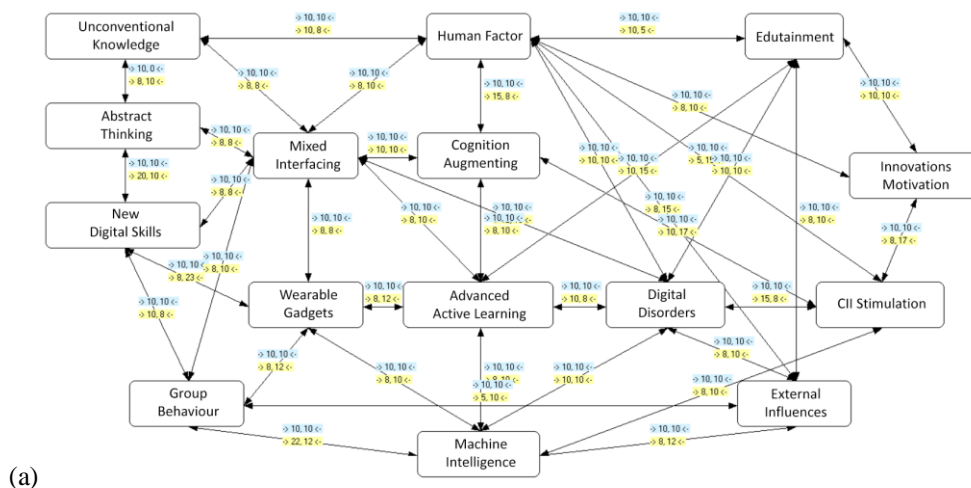
An important moment hereafter is the educational process in itself that needs to adequately address the new transformed reality, implementing innovations and enriching the present reality with new simulated capabilities (like: digital twins, imaginary models, machine

generated & stimulated cognitions). Here it should be noted that the new Z- & Alpha-generations [11], [12] are naturally expected to better cope with innovative solutions like: “Virtual Reality”, “Active Learning” & “Advanced Digital Training” that are actually giving quite different approach to the future of education, fostering the human imagination, advanced literacy, skills and cognitive capabilities.

Further the paper is presenting an analytical system model of the future training risks identification due to digital transformation. A followed-up by an experimental user-based multicriteria battery cognitive effects assessment approach is given for an ad-hoc environment set up (handling both 2D & 3D data representation in an interactive manner) with preliminary training and real feedbacks measurement. Some positive and negative trends on the resulting effects of virtual 2D/3D future training are finally discussed.

2. Analytical Modelling

The ideas behind the proposed analytical modelling is to establish a future risks system-of-systems a priori assessment, encompassing a graph-based interpretation, following the ideas from [13]. Being somewhat prognostic this solution is using both reference and new expert/crowdsourcing data gathered recently in the framework of “Secure Digital Future 21” forum initiative [14]. The process of model creation (implementing 15 entities, marked with labeled round rectangles), interconnected with 39 bi-directional relations (noted as dual labeled arrows), see Figure 1a) and results aggregation towards year 2030, have been performed in I-SCIP-SA environment. The entities (marked in Figure 1b with indexed balls) classification is graphically organized in a fourfold “3D Sensitivity Diagram” (producing: “Buffering” – “Green”, “Active” – “Red”, “Passive” – “Blue”, “Critical” – “Yellow” classes with both “active” – “White”, $Z > 0$ and “passive” – “Grey”, $Z < 0$ entities roles), using an advanced fuzzy weighted relations’ representation (marked in yellow) of the triplet: Influence – X, Dependence – Y & Sensitivity – Z, after [15].



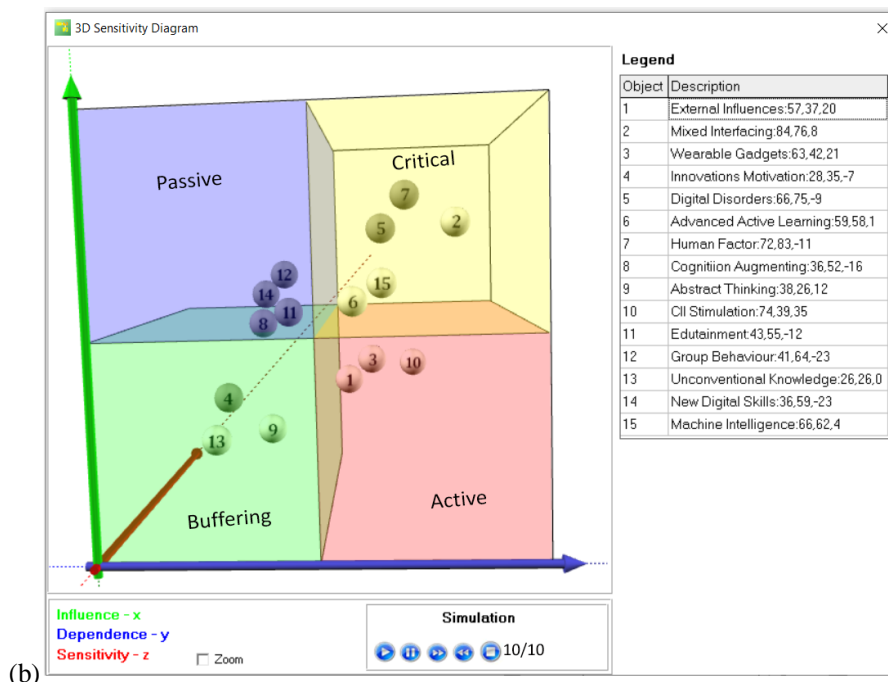


Fig. 1. Analytical model (a) & expected system risk results in a 3D Sensitivity Diagram (b) from I-SCIP-SA environment of future training effects' changes due to digital transformation, towards year 2030.

The results from Figure 1 are showing the aggregated system risks expectations towards year 2030 (interpreted in 10 steps annually (marked with blue labels above the relations), i.e.: 1 – 2020, 2 – 2021, ..., 10 – 2030), concerning the future training effects' changes due to digital transformation that could be briefly outlined as follows:

Active: 1 – “External Influences”, 3 – “Wearable Gadgets”, 10 – “CII Stimulation” (“Creativity, Imagination, Intuition Stimulation”) – (all active);

Buffering: 4 – “Innovations Motivation” (passive), 9 – “Abstract Thinking” (active), 13 – “Unconventional Knowledge” (active);

Passive: 8 – “Cognition Augmenting”, 11 – “Edutainment”, 12 – “Group Behaviour”, 14 – “New Digital Skills” (all passive);

Critical: 2 – “Mixed Interfacing” (active), 6 – “Advanced Active Learning” (active), 15 – “Machine Intelligence” (active); 5 – “Digital Disorders” (passive), 7 – “Human Factor” (passive).

The resulting analytical system model classification could be summarized into several holistic key finding, concerning the future risks related to the training effects' digital transformation:

(i) The socio-technological realities digital mixing is going naturally to enter the learning process, cultivating new advanced digital literacy, skills [10] and group behaviour (enabled with new social networks, e. g. Horizon VR, connected to Facebook via Oculus headset [16]) for the trainees with augmented cognitive capabilities and fast, ingenuine learning results;

(ii) The technological evolution fostered by external influences (pandemic dynamics, climate changes, other natural or manmade cataclysms) will embed wearable gadgets steadily (smart googles, headphones, phones, watches, bands, rings, etc.), together with other IoTs hyperconnectivity for the biotope and human factor observation, establishing a new edutainment hyperreality that is stimulating creativity, imagination & intuition but ambiguates the decision making and choice in general to the future lifestyle;

(iii) The machine intelligence transformation aiming singularity will try to keep us most of our time into the new transformed reality (for different advanced learning motivations & skills, e.g.: economic benefits, remote behaviour control, new discoveries) though this will produce multiple digital disorders (see e. g. [17], [18]) and will not stimulate properly enough the abstract thinking enabling and unconventional knowledge gathering.

Regulating all these expectations for the future training effects transformation will be definitely quite challenging. So, further experimental set-up, using futuristic lab like cabinet environment with user response multicriteria assessment for going deeper in the problem has been organized.

3. Experimental Environment Set-Up

The training was organized in a cabinet environment, using the VR system HTC Vive Pro Full Kit, with two handy joystick controllers for an ad-hoc created (by two base stations with regulated tripods) parallelepiped gaming box of approximately the following size: 4.5m x 2.5m x 2m. A wired DisplayPort 1.2 wearable, ergonomically adjustable smart VR googles with built-in headphones (Dual AMOLED 3.5", 90 Hz, 1440 x 1600 pixels per eye resolution, 110 degrees, hi-res audio) mounted to a Windows 10 Pro installed PC station (Intel® Core™ i5-9400F @ 2.9 GHz, 16 GB RAM, 256 GB Intel SSD + 2TB HDD, NVIDIA GeForce GTX 1660Ti) with a second HDMI connected monitor (LG DM2352 LED IPS, 23", Full HD) have been used.

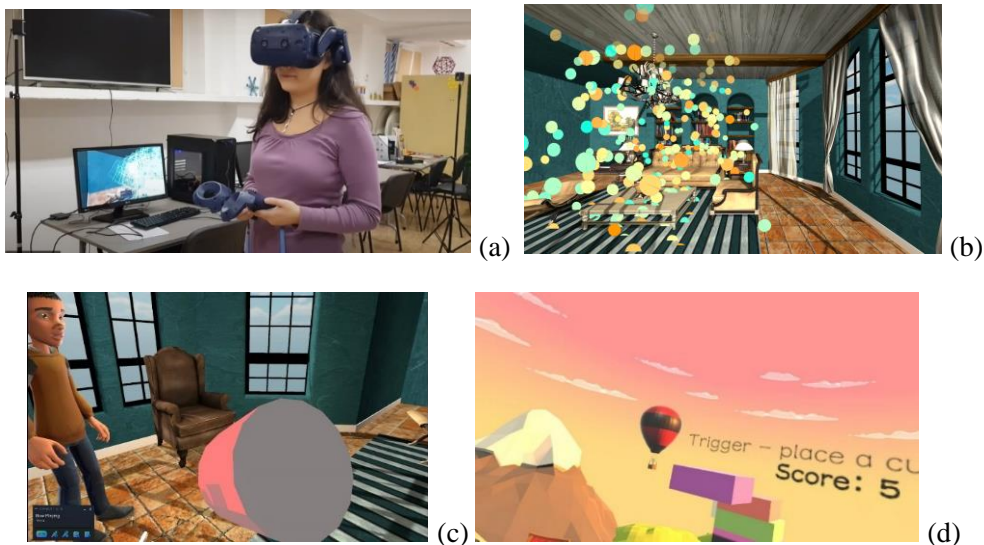


Fig. 2. Virtual Reality cabinet general representation (a) with multiple screenshots, concerning Vessya (b), (c) & Blumber+ (d) environments.

The implemented software environments have been created in Unity and allow three basic active learning functionalities exploration: (i) controllable observation of a set of 3D geometric shapes in a virtual room with audio background, (ii) manipulation and observation of a set of 3D geometric shapes in a virtual room, with a virtual assistant interactive support and audio background, (iii) dynamic building of cubic towers, according to the overlaying size with results counting, visual feedback and audio background. Here it should be noted that both (i) & (ii) have been implemented in Vessya, whilst (iii) in Blumber+ (see Figure 2).

4. Multicriteria Assessment Approach

Successfully understanding the cognitive effects from the digital training both in 2D & 3D environments is generally quite complex task. So, presently only a selected battery of 12 characteristics (“Disorientation”, “Dizziness”, “Dizziness”, “Inspiration”, “Reality Mixing”, “Overexcitement”, “Interaction Confusion”, “Improved Memorizing”, “Environment Addiction”, “Abstract Thinking”, “Motivation for Success”, “Competitive Behavior”, “Entertaining”) has been studied. A preliminary training of 3.5 min of the experimental subjects is performed, watching a skillful, trained player activity on a 2D monitor. Further, feedback collection on the selected battery of characteristics is obtained with a brief interview. The training sessions have been organized in 2 epochs (3.5 min each, similar to [19] on the three-functionality explorations, see Figure 2) with 10 min break between the epochs. This arrangement was implemented due to prior expectations of some disorientation and dizziness, known as cybersickness in the 3D environment [18]. Ten healthy subjects (4 female & 6 male) have been explored, separated in three groups, following their generation affiliation: Y-generation (4 male & 2 female), Z-generation (2 female), Alpha-generation (2 male). The younger generations (Z- & Alpha-) were on direct observation of their parents during the experiments. All activities in the virtual reality were recorded by using Flash Back Pro 5 software, whilst in the physical environment – with mobile smart phone camera.

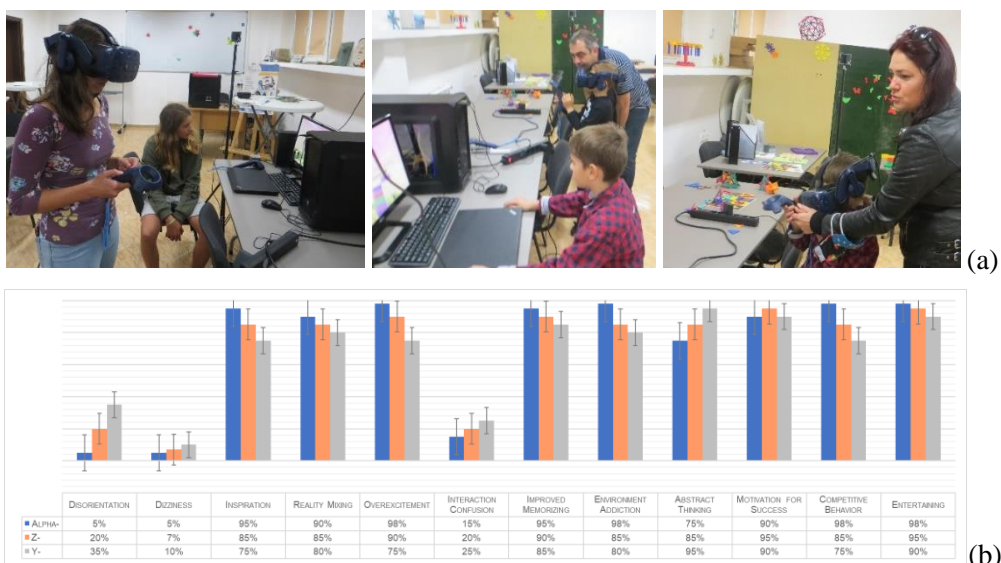


Fig. 3. Selected moments from the 2D/3D training experiments (a) and generalized results on the multicriteria assessment battery for Y-, Z-, and Alpha- generations (b).

The presented results from the training experiments, clearly demonstrate technological motivation marked with inspiration (75 – 95 %) and overexcitement (75 – 98 %) for the all three studied generation groups, that will hopefully positively stimulate the education and training process in the future. Apart of this, the improved memorizing capabilities (85 – 95 %), competitive behaviour (75 – 98 %) and entertaining (90 – 98 %) are definitely giving a positive glance to the advanced digital learning and edutainment. The overall variations for disorientation (5 – 35%), interaction confusion (15 – 25 %) and dizziness (5 – 10 %) are somewhat negligible, but these aspects should also be studied for longer training sessions, though the idea of the present approach is mostly related to abstract thinking (75 – 95 %), inspiration & motivation (90-95 %) stimulation. The environment addiction (80 – 98 %) and reality mixing (80 – 90 %) together with the rest of the aforementioned assessment criteria are giving slight variation (10 – 20%) within the age variation. Finally, it should be also noted that Z- & Alpha- generation participants have demonstrated clear preference for group work in the 3D environment in respect to the mixed 2D/3D ones.

5. Discussion

Properly handling the digital transformation effects on future training need to address human, biotope and technological mixing for achieving a resilient new society. The mixed 2D/3D interfacing presently is to some extent still artificial but in the near future is going to be significantly improved. At the same time, the constant acceleration of technological effects is from one hand motivating their users, providing new lifestyle with advanced capabilities of learning, memorizing and knowledge accumulation due to new digital skills and cognitive capacity establishment. From another – providing a quite exhaustive hyperreality that is a generator of new cyber risks for the human factor due to the entertaining and fascinating motivation of the constantly evolving machine intelligence. Thus, achieving both technological progress in the future, fostered with multiple distractors is generation dependable and in parallel – quite immersive from the sensors, gadgets and connectivity ultraintegration and social behaviour transformation, adding more closely smart machines with future humans, establishing new transhuman with digitally augmented skills and cognitive capabilities that however are getting technologically more dependable then presently.

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Software Architectural Solutions in Network-oriented for Security and Defense Operations

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Abstract. Conceptually, network centric operations are based on a distributed digital communication system with discrete information flows. The text examines the characteristics of popular architectural styles of desktop and web-based software solutions. A comparative analysis is carried out and a modern software solution is proposed, based on the provision of network resources with state control.

Key words. Network centric operations, Web programming, Software architectures.

1. Introduction

In the conceptual context of network centric warfare, popular tactical data links can not meet the increased demands for high quality real time network data transmission and sharing between multi-nodes [5], as well as providing end-users with complete real-time battlefield information.

Taking into account the concept of action in a network centric operations environment [3], two types of information flows can be identified, namely, horizontal and vertical links. Horizontal links serve a two-way flow of information between the devices which are nodes in the information network and are located on the same level in the command hierarchy. Vertical links represent the two-way vertical information flow, namely the possibility of information exchange between arbitrary command levels. At the same time, the ability to operate on a local communication level is preserved, which implies a two-way exchange of information up to several levels up or down the information network.

From an abstract perspective, such an information process is considered to have fulfilled its purpose when the results are brought to the attention of the relevant command-line staff. This is the finalizing visualization phase of the information process, and from a contemporary perspective, guidelines for improving the visualization subsystem are to be sought by means of an upgrade to advanced web-based software solutions.

2. Architectural pattern Model-View-Controller

One of the first architectural software development patterns which has gained popularity among developers was named Model-View-Controller (MVC) by its developer [2]. The components of the MVC (Figure 1) are briefly defined as:

Model - the main part of the application, highly dependent on the subject area and the specific purpose of the software being developed. These are the data we work with.

View - the part of the application intended for visualization of data and any results achieved by their processing. The design of the view is largely dependent on the software development environment used.

Controller - designed to retrieve data from the model, process the data by using certain methods and transmit them to the view.

The following features of the architectural pattern under consideration can be highlighted as important:

- Independence of the model from the controller and the view;
- The model can be designed and built independently from the other components;
- Different views can present the same model;
- The controller and the view can be reprogrammed without affecting the model.

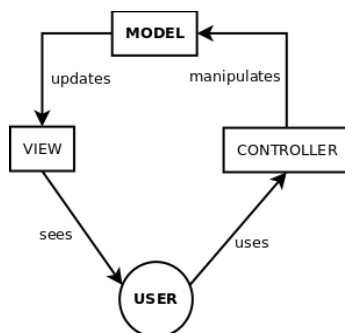


Fig. 1. Architectural pattern Model-View-Controller

3. REST architectural style

REST (Representational State Transfer) [1] architectural style has been developed exclusively to meet the challenges of network programming. The approximate translation of REST as "provision of resource with controlling the state" presents its essence most briefly, namely - a client-server query and supported transferring of a resource "image". Here, the term "resource" is used as a generic term and may include document, data and information structure in an appropriate format.

The REST style requires that the following conditions are met:

- **Client and server separation:** Data storage is provided entirely on the server. The server is not related to the user interface.
- **No session state (stateless):** Customer session states are not saved on the server. Each customer query contains the necessary information for its execution. Session state is therefore kept entirely on the client's side.
- **Caching:** The client can cache (save) information received in response from the server and use it again for subsequent queries. It should be clearly stated if caching shall be used in a specific case so as to avoid data misinterpretation in subsequent queries;
- **Multilayer system:** It requires the usage of server mediators for improved efficiency and increased query processing capacity, provision of shared caches.
- **Code on demand:** This is an optional condition but it allows functionality expansion. In response to a query, a server-generated code is sent for execution on the client's side.
- **Uniform interface:** It allows each of the architectural software components to be designed and developed independently.

Any network application meeting the above requirements may be considered RESTful. In summary, while preserving the positive features of the MVC programming pattern, REST architectural style provides means for development of complete applications designed to work in a web environment.

4. Software solutions for development of RESTful applications

Undoubtedly, JavaScript is one of the most popular scripting languages today. This programming language is compliant with the ECMAScript Language Specification, and is built into all modern web browsers. With regard to the required RESTful features of a web application, the JavaScript scripting language is provided with the embedded object class XMLHttpRequest [4]. This approach to building modern web applications is also known as Asynchronous JavaScript And XML (AJAX).

From client's perspective, in a practical AJAX implementation, it is convenient to implement the jQuery multi-platform library developed after 2006. The internal organization of jQuery enables the addition of advanced functionality based on the development and publishing of plug-ins by a broad community of software specialists. The latter, in turn, contributes to achieving an even higher level of web development standard, with the application of software frameworks similar to the RAD software tools which are well-known in desktop programming.

Generally, the server support for the web application is in configuration with the following components: web server (Apache), Database management system (MySQL) and program module for query processing and provision of resources (PHP).

5. Components, interactions and interface

Figure 2 represents a diagram of the interacting components of the system, with a line for online data as an entry point.

We assume that the client module is installed and running on an automated workstation, mobile computer or another smart device under the supervision of officers from the command-line staff. In the context of the above analysis of software development architecture, the client's workstation must be equipped with a web browser. The graphical user interface is designed by means of HTML (Hyper Text Markup Language) and CSS (Cascade Sheet Style). The RESTful characteristic of the application required in compliance with the analysis above presupposes the intense usage of JavaScript and AJAX for running asynchronous queries to the server. The latter requirement, along with the desirable, but not unimportant at all, demand for a user-friendly graphical interface implies the implementation of an effective software framework, such as the jQuery based product jqWidgets being proposed in this case [6].

The block diagram in Fig. 3 represents a solution to the development of a subsystem for visualization of results in the interest of the command-line staff.

As far as the MVC architectural pattern is concerned, the figure highlights its three components, complemented by the RESTful features, which are important for the development of a stable web application.

The data model given here is presented through a dataSource whose structure defines the expected data fields returned from the server after a query. The dataSource component also activates (implicitly for the user) the AJAX communication with the server part of the system.

The properties of an application **controller** are acquired by the component denoted as dataAdapter in the figure. The activation of a loadComplete event is a signal that the loading of a portion of data from the server has been completed and if necessary, the data can be converted so as to become appropriate for other screen components.

The view, as a final result of the application operation, is taken up by specially developed classes (GUI components) for displaying data on screen. It is proposed that jqxGrid and jqxDropDownList are used in the specific application. The tabular representation is provided by jqxGrid.

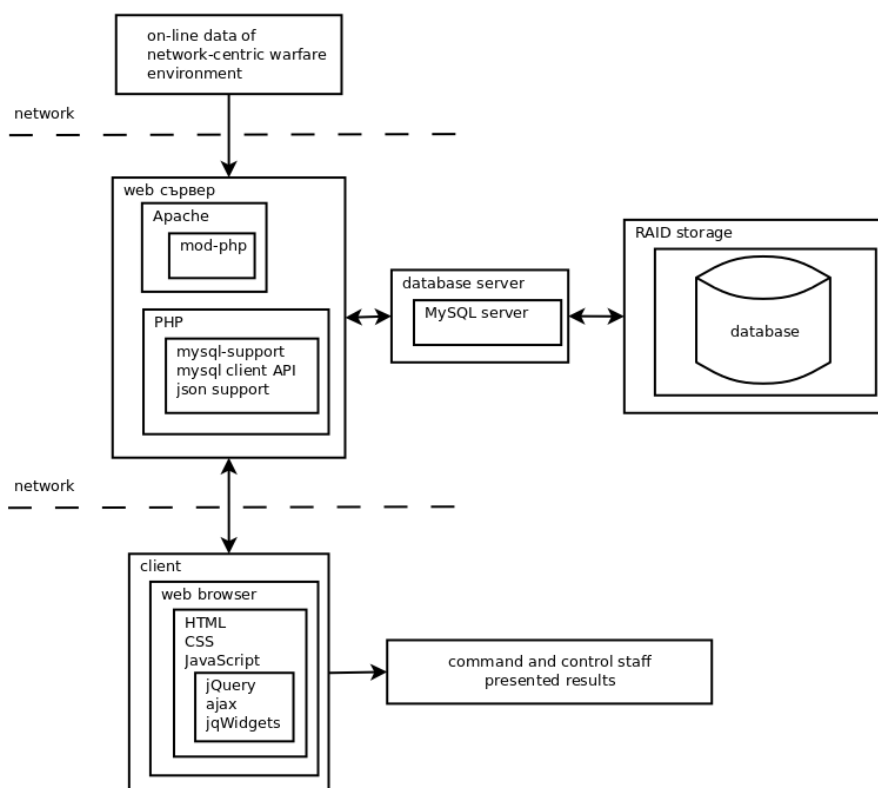


Fig.2. Components and interactions in the system

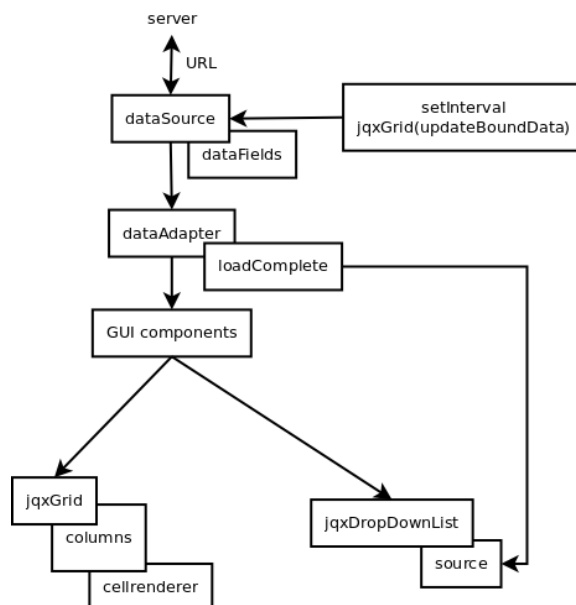


Fig. 3. GUI in the interest of the command-line staff

A set of information fields is defined in the information structure and these fields usually coincide in meaning with the dataFields structure. The cellrenderer method can be enabled for each data field and can change the view. While jqxGrid can directly use the dataAdapter structure, the onscreen component jqxDropDownList requires data in a different format. The preparation of data for jqxDropDownList is convenient to be executed with the loadComplete component of dataAdapter. The setInterval mechanism provides a periodic update of the results under observation.

6. Conclusion

Through visualization of the RESTful type, we design a graphical user layer of an information system in the interests of the command-line staff in the field of security and defense. The members of the command-line staff are supposed to be timely informed on the occurrence of certain events. This information shall serve as a basis for assistance in making informed decisions.

By adopting the modern architectural software development pattern, we make use of the indisputable advantages of multiuser access, a multi-platform client component, fewer requirements to the client's workstation hardware, possibility to use virtually all known mobile devices with network connectivity and an operating web browser. By being in perfect compliance with the today's vision of network centric operations, multi-user access and increased mobility options are particularly relevant in the case of developing a special application.

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Methodological Approach for Studying the Functioning of the Homeland Security System of the Republic of Bulgaria

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Abstract. The paper presents a theoretical and methodological study to determine a methodological approach to the study of the homeland security system of the Republic of Bulgaria. The structure of the homeland security system and the connection between its functioning and the security environment are described, as well as the possibility to study similar systems, reformed according to the modern conditions. A review of the relevant theory for the study of systems and objects by the Public administration is made. A methodology and the respective methods for research of the homeland security system of the Republic of Bulgaria are proposed, they can be applied after the described adjustment.

Keywords. Methodology, Research methods, Homeland security, Security environment, Research of good practices.

1. Introduction

The National security concept of the Republic of Bulgaria does not give a definition of homeland security, but defines the law enforcement and judicial authorities of the country as authorities for protection of its homeland security. Their role is to address security risks and threats, as well as the efficiency and fairness of justice. The emphasis in the field of homeland security is on the effectiveness of the judiciary in the fight against crime and corruption [1].

A National Security Strategy is in force, which was updated in early 2018. It offers an updated view of the parameters of homeland security, building on what is stated in the Concept. The Strategy reflects the new elements of homeland security, which make it increasingly difficult to distinguish between external and homeland security as a scope. The reason for the latter is the influence of external processes on the homeland security of Bulgaria. Cross-border and transcontinental structures, projects and processes are mentioned, the role and commitment of our country as an external border of the EU, as well as in the fight against cross-border crime and terrorism are reflected [2].

The cited strategic documents outline schematically the scope of homeland security, ie. indicate the diversity of environmental factors and their various spheres of influence. Next, they give guidelines in general terms of what would be needed to ensure it - effective work of law enforcement and judicial authorities of the country.

2. The homeland security system of the Republic of Bulgaria.

The homeland security system of the country includes the institutions and organizations whose legal commitments are aimed at the protection of homeland security or in other words these are the institutions and organizations from the national security system of the country (according to art. 3, para. 1 of ZUFSSZNS [3]), whose legal commitments are relevant to the protection of its homeland security.

The elements of the system can be classified into three groups: for strategic management of the homeland security system, specialized structures for protection of homeland security, non-specialized structures and others. The classification is made on the basis of the activities assigned to these elements by the legislator and is summarized in Fig. 1.

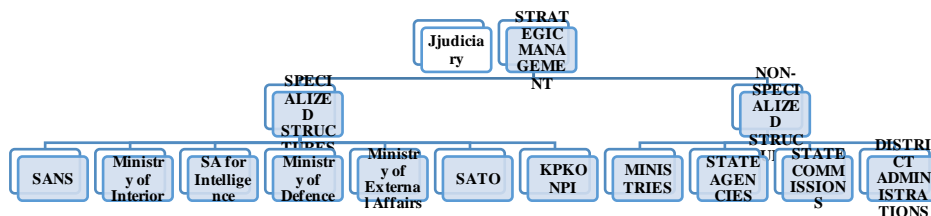


Fig. 1. Elements of the homeland security system of the Republic of Bulgaria [4].

The need to study the functioning of the homeland security system of the Republic of Bulgaria is determined by the dynamics of changes in the security environment. Current crises and conflicts do not fall within our familiar framework and require a new approach. Consequently, it is necessary to establish the current state of the homeland security system in relation to the new challenges. Whether the way the system is built and functioning allows it to reflect the current risks and threats facing homeland security.

The origin of its imperfections can be found in the strategic framework governing the structure and operation of the various structures, as well as in the legal framework governing the functioning and powers of the elements of the security system. Another reason could be the interdepartmental arrangements governing the interaction and coordination between the various structures or the absence of such arrangements. Such imperfections would reflect on the adaptability of the system as a whole and its elements in particular to the security environment. This in turn would reduce the expected synergistic effect of their activities.

Therefore, when studying the functioning of the homeland security system in analytical terms, the following will be sought:

- derivation and analysis of the current factors of the security environment;
- summarizing the structure, functioning and organizational parameters of the homeland security system (at strategic and organizational level);
- research of good practices and experience.

3. Theoretical bases of methodology for the research of the homeland security system

The approach to studying the functioning of the country's homeland security system must take into account the specifics of the system, which make it difficult to assess. The restrictions are related to the handling of state and official secrets in the activity of the security structures, as well as to the basic idea that the activity should be implicit in some of its segments, in view of its efficiency. The stated limitations, as well as the outlined main points related to the activity of the homeland security system, allow to determine the main parameters according to which it should be assessed - on the one hand in the security environment, and on other hand compared to its counterparts in other countries.

In view of the outlined specifics of the homeland security system of the Republic of Bulgaria and the indicated limitations in the development of a methodology for its research, the following must be taken into account:

- The object of the study is a system;
- The homeland security system is a specific part of the Public administration.

3.1. Research methodology

Regarding a systematic approach to problem solving, Flood and Carson graded the research approach from the general to the private, offering the following definitions:

1. Philosophy - broad, vague guidelines for action.
2. Methodology - does not have the precision of the technique, but more precisely directs the actions of philosophy.
3. Method - a precise and specific program of action that will give an accurate result [5].

Research methodology is the science and philosophy behind any research. It allows to understand the different ways in which knowledge can be created, and the ultimate goal of research is to expand and deepen knowledge about the world. The researcher's critical approach to how relevant knowledge is or is being created suggests that it is possible to add value to it [6].

The Dutch author Van Thiel has focused her work on research methods used in Public Administration and Public Management. It shows the gradation in the research approach from the general - research strategy, to the practical stages of application of a specific method or technique in the research process.

The four main types of strategy are experiment, survey, case study and desk research, the characteristics of which are shown in Table 1.

Table 1. Characteristics of the four main research strategies [7].

Strategy	Research problem	Number of units	Number of variables
Experiment	Explain, test, evaluate	Small	Small
Survey	Describe, test, diagnose	Large	Large
Case study	Explore, describe, diagnose, design, evaluate	Small	Large
Desk research	All	Varies	Varies

This presentation will look in more detail at case study and desk research strategies, due to their direct relevance to homeland security research.

The case study is a research strategy, following which one or more cases from the object of research are studied in everyday, real conditions. A case can be almost anything: a group, an organization, a country, a city or a neighborhood, an event, a connection, a project or a process, it can even be a law or a decision. The cases are a typical research strategy for research in Public Administration and Public Management. The frequent use of case studies in these studies is due to the fact that they are applicable mainly to everyday events, and the objects of study are unique or rare. The third reason for the frequent use of case studies is their applied nature. In the applied study, the researcher tries to contribute by solving a specific social problem, which in principle means that there is no need to consider other cases.

The typical case study uses a holistic approach, ie. a large amount of predominantly qualitative data relevant to the case has been accumulated. Usually different methods are used, which are combined with each other.

Desk research is another type of research strategy. Unlike research methods, in which researchers collect data themselves through observation or interviews, for example, desk research uses data already collected or created by someone else. Existing data sources have been created for a purpose other than the study, but could be used for this purpose as well. Such data are annual reports, legal documents, articles. Desk research is an efficient and cost-effective strategy [8].

3.2. Systems research - definitions and properties.

The fundamental contribution to the study of systems was made by the Austrian biologist Carl Ludwig von Bertalanffy (1901-1972) for the development of the so-called General Systems Theory (GST). It provides new foundations and capabilities as a generalized systems theory with applications in many research areas, including biology, information theory and cybernetics. According to Bertalanffy, the concept of GST is also applicable to the social sciences. Currently, Bertalanffy's GST is a liaison for interdisciplinary systems research in the social sciences [9].

The development of GST can be found in many current scientific developments. For example, Dr. Ezza summarizes that Systems Theory is an interdisciplinary study of systems in general that aims to discover patterns and clarify principles that can be derived from and applied to all types of systems at all levels and in all branches of science.

The GST provides a holistic approach to studying any organization or phenomenon. The interdependence and interaction between the system elements is considered to be the main source of transformation of the state of the system as a whole. The theory takes a holistic approach, focusing on the organization of the elements in the system. It assumes that the overall behavior of the system is more than the sum of the behavior of its parts [10].

The proposed definition of a system is linked to the everyday use of the word in different contexts such as "computer system", "health system", "education system". Therefore, "system" is a common name used in all branches of science. Systems can be defined as ordinary interactions between independent elements that act as a whole and in a specific pattern or order.

The author points out that the changes in the environment of the system are reflected by the system itself, which makes the appropriate settings to keep its state stable. For the environment of the system we can define everything outside its boundaries, i.e. this is the world around the system. The characteristics of the environment depend on the definition of the system. In summary, it can be said that the system interacts with the environment and feedback cycles are available [11].

For the purposes of this paper, the definitions of complicated systems and complex systems are proposed, according to the cited book "Theory of Systems". The type of the studied system predetermines the interrelations and interactions between the elements of the system, as well as its macro behavior as a result. In complicated systems, the components of the system have a degree of independence from each other, therefore the macro existence of the system will not be disrupted by removing its element in order to reduce its complexity. Conversely, removing an element from the complex system will destroy the existence of the system.

Complex adaptive systems are composed of approximately similar elements, which may differ in their goals, attributes and / or beliefs. They change their state in response to a change in the environment, goals or a change in resources. The changes are made in stages in the process of operation of the system as it goes through different states and dynamics, while maintaining its overall performance, within the changing environment. Adaptation is common and common in many social systems because its internal components and relationships are

able, ready, and necessary to change in order for the system to withstand change or improve. [12].

Another classification for systems - closed and open is offered by the authors of "Qualitative Methods for Practice Research". In the definition of a closed system, they argue that it is an experimental field or environment in which factors or variables are entirely under the control of researchers or practitioners. Unlike a closed system, in an open system the events are not predetermined and therefore depend on all the conditions, visible and invisible, that a given environment or context creates [13].

Gibson, Gibson and Scherer define the term "system", believing that the system is a collection of elements related to help achieve a certain goal. There are three dispositives to this short definition. First - the existence of a set of elements. This is a group of objects with the same or similar characteristics. Second - the objects must be interconnected or interact (influence). And third, the interconnected elements must be created to achieve a certain goal. A random set of people, things or something, even if they are very close and influence each other in some way, this is not a reason for them to form a functioning system and be accepted as such [14].

3.3. Research process in Public Administration and Public Management

In addition to requiring an interdisciplinary approach, the Public Administration has three other distinguishing features. They all reflect on the conduct of the study.

The first distinguishing feature is the object of study, namely the public sector. As a result of the broad understanding of the scope of the public sector, the research field of Public Administration and Public Management is also expanding - from the construction of a railway line, through the restrictions on trade in HB, to international security policy and voter rights.

Another characteristic of the Public Administration is that many of the objects of study are unique - a central bank, an electoral system, a president and a prime minister. On the one hand, this facilitates the research, because it is clear which are the objects that will be included in the research. On the other hand, it would be difficult to draw definite conclusions as there is no basis for comparison. Therefore, the applicability of methods such as case studies in Public Administration and Public Management is emphasized above. Last but not least, the limited number of cases does not always mean a small amount of information to process. This means that the research process in decision-making is often associated with a large amount of information concerning the various actors who interact for a long period of time to reach a common final decision.

The second distinguishing feature of the research work in the Public Administration concerns its applied nature. It is a young science and research is usually focused on finding solutions in the public sector. The third distinguishing feature of the Public Administration can also be deduced here. Due to the fact that it is a young science, it deals with the theories of other basic scientific disciplines.

Taken together, the distinctive features of the Public Administration lead to the predominant use of methods that are suitable for the study of a small number of cases and that allow direct application of the results in everyday practice. This does not automatically preclude historical research or the application of statistical methods [15].

In their book "Management Research Methodology", the authors consider management as synonymous with decision-making, taking into account the activities related to human resources, technology, supply chain, production, marketing, accounting and finance, PR, policies and strategies of the organization. And decision-making, in turn, is defined as choosing one of several options for solving a problem, according to a set of criteria [16].

The authors of the "Research Methods for Graduate Business and Social Science Students" describe the most appropriate approaches in business and social research. Attention is paid to the possibility for researchers to use one type of study or a combination of two types. It is up to the researcher to select the types and combinations of methods that best serve the objectives of the study [17].

4. Methodology and methods for studying the functioning of the homeland security system of the Republic of Bulgaria

4.1. Methodology

The methodology for conducting a study of the homeland security system is built in accordance with the objectives of the study. In this case, it is a study of the mechanism of functioning of the homeland security system of the Republic of Bulgaria with a view to discovering the dysfunctional elements and respectively revealing opportunities and mechanisms for improving the functioning of the system.

First of all, an assessment of the adaptability of the homeland security system to respond to the current security risks and threats at the time of the study should be sought. This task is a combination of two subtasks - the first is to study the security environment, and the second - to study the state of the system in view of the dynamics of the security environment in which it operates. The first subtask requires an analysis of environmental factors and their impact on society. The second subtask can be solved by studying the existing regulations to establish the current state of organizational structures in the field of homeland security and study their systemic integration.

Secondly, a detailed study of a part of the structure of the system for homeland security, referring to the path of information flows related to the protection of homeland security of the country, is needed. For the realization of this part it is necessary to study the legally set rights and obligations of the different structures and the existence of connections and dependencies between them.

The third element of the study of the homeland security system is to study similar systems of other countries, which will allow to refine the assessment of the state of the system in Bulgaria and to provide opportunities for finding specific guidelines for its improvement.

The methodology of the study of the homeland security system of the Republic of Bulgaria is a set of theoretical-cognitive principles, generalizations and conclusions, based on theoretical knowledge and practical research. The study of the strategic approach in the organization of the protection of homeland security presupposes the use of general scientific and private methods of scientific knowledge. When choosing the different methods, the need is taken into account the need for each of them to ensure the reflection of essential features and patterns of the studied phenomenon, as well as to be consistent with the specifics of the cognitive process.

4.2. Methods for studying the functioning of the internal security system of the Republic of Bulgaria.

According to the established methodology for studying the functioning of the homeland security system of the Republic of Bulgaria with a view to discovering the dysfunctional elements and respectively revealing opportunities and mechanisms for improving the functioning of the system with the selection of research methods to be used. The properties and characteristics of the system as a research object are taken into account. According to the presented theoretical models, the object of research is an open system and is part of the public

sector in the country. In open systems for the analysis of their activity, as well as for the design of such systems, the influence of the environmental factors as well as the interconnections and interdependencies between the elements in the system must be taken into account. This in turn will give an idea of the functioning of the system and its overall performance. Differentiating the strengths and weaknesses of the system, its capabilities and the threats it faces, will make it possible to outline future steps for its improvement.

A. Systematic research method. The basis of the systematic method of research is the observance of the basic principles and regularities of the dialectic and the theory of knowledge, integrity and comprehensiveness of knowledge, interconnection and interdependence of the phenomena. The application of a systematic approach in the study of the application of strategic management in the field of protection of homeland security means that its elements are considered as interconnected and purposefully organized to achieve a certain goal, as a whole complex. On the other hand, it is necessary to study not only the complex activity of the system, but also its constituent parts, each of which is an element of a more complex phenomenon - on the one hand, the specific role it plays as an element of public policy. and on the other hand as an object of influence by environmental factors.

The systematic approach allows the activity of the structures of the internal security system to be considered as a function of a complex system, including goals and tasks, organizational structure, forms of the activity for protection of the homeland security of the country, specific methods and means used, as well as to study the connections between them.

A systematic approach can reveal the structure and organization of forces and means in the homeland security system of leading countries in the field to identify the main points related to the adaptability of individual structures and the whole system to modern requirements of the security environment.

B. Documentary analysis, including analysis of the regulatory framework. The method can be applied to documents concerning interdepartmental coordination. The analysis of these documents clarifies the interdepartmental agreements, and hence the path of information flows related to the homeland security of the country. The method is basic for the establishment and assessment of the legal regulation of the activities for protection of the homeland security in the Republic of Bulgaria and other countries, allowing to reveal the powers of the different structures for achieving the goals of the system. Next, the documentary analysis allows to assess the legislation in the field by revealing its positives and negatives and, accordingly, conclusions can be drawn for its improvement. It is necessary to make an analysis of the relevant strategic documents governing security issues - the National Security Strategy, the National Security Concept and others.

C. Functional analysis. The purpose of the functional analysis is through it to study, analyze and evaluate the performance of the administrative structures. The basic goal is to seek improvement in the implementation of the activity, outlining the areas for improvement and the result of the analysis to serve for the preparation of a coherent action plan.

Functional analysis, depending on its type, can be prepared at inter-institutional and institutional level and cover one or more administrative structures. The scope of functional analysis depends on the specific goals set [18].

D. PESTEL-analysis. PESTEL-analysis is a tool used to analyze and monitor the macro-factors of the environment (external environment), which could have a significant impact on the performance of the organization. This tool is especially useful when starting a new business or entering a foreign market. The results of the application of the method allow to identify the threats and weaknesses of the organization, which in turn are used in the SWOT-analysis. For this reason, it is often used in conjunction with other business analytics tools such

as SWOT-analysis and Porter's Five Forces analysis to clarify the environment and related internal and external factors. PESTEL is an acronym for P - Political; E - Economic; S - Social; T - Technological; E - Environmental; L - Legal. However, over the years, people have expanded the framework with factors such as demographic, intercultural, ethical and environmental, leading to options such as STEEPLED, DESTEP and SLEPIT. In FIG. 2 shows graphically the PESTEL analysis.

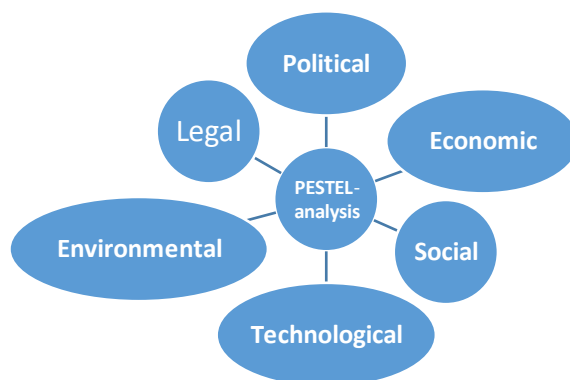


Fig. 2. PESTEL-analysis

The PESTEL-analysis presented in this way covers only a small part of the general external factors that companies should take into account. There are many more factors that could affect a business. In addition, the importance of the individual factors would vary depending on the business and the population [19].

As far as homeland security is concerned, these basic factors would be applicable after some adaptation of their content, because different economic and social factors, for example, would have a significant impact on business compared to those that are essential for homeland security. Next, the PESTEL-analysis can be further expanded by environmental factors related to security in particular - transnational organized crime, conventional crime, international terrorism and others. However, the inclusion of such additional factors requires that their selection be motivated in order for the result of the analysis to be realistic.

E. SWOT-analysis. SWOT-analysis is a tool of strategic planning and includes the choice of strategic actions to balance the internal strengths and weaknesses of the organization with external opportunities and threats. The grouping of information about the strengths, weaknesses, opportunities and threats to the organization has two purposes - it provides an illustrative presentation of the strengths, weaknesses, opportunities and threats to the organization for the analysis that managers must do and offers a standardized four-quadrant format to compile situational information about the organization [20]. This format is presented in Table 2.

The method requires adaptation of the research objectives due to the specifics of the security field, but its applicability is indisputable. As the analysis is strategic, it should be applied to the homeland security system as a whole, and not to its individual elements. In support of the same it can be said that the purpose of the study is to look for a synergistic effect of the functioning of the elements in a system.

Table 2. Matrix of SWOT-analysis with examples of strengths, weaknesses, opportunities and threats to the organization [21].

<p>Potential strengths</p> <ul style="list-style-type: none"> - Market leadership - Strong research and development - High quality products - Cost advantages - Patents 	<p>Potential weaknesses</p> <ul style="list-style-type: none"> - Large stocks - Capacity exceeding the market - Change of management - Bad market image - Insufficient management capacity
<p>Potential opportunities</p> <ul style="list-style-type: none"> - New foreign markets - Falling trade barriers - Elimination of competitors - Diversification - Economic prosperity 	<p>Potential threats</p> <ul style="list-style-type: none"> - Market saturation - Threat of ingestion - Foreign competition with low product cost - Low market growth - Growing government intervention

F. Benchmarking. Benchmarking is a method of measuring and improving an organization's performance by comparing it to the best [22].

Benchmarking consists of two aspects. The first is to compare the levels of organizations to identify the differences between the best and the organization that needs to be improved. Here the goal is to assess whose experience would be most useful. The second aspect is the study of the practices of the best. An important emphasis is on looking for those good practices and experiences that make these organizations the most successful, and then these practices are adapted and applied. In short, with the help of benchmarking:

1. Defines a project or area of business to be improved.
2. Find an organization that does what is wanted, better than the organization that will develop.
3. Identify the practices used by the better organization that make it so.
4. These practices shall be adapted and applied to the organization in need of development [23].

It can be summarized that benchmarking supports the selection and prioritization of projects, helps in finding appropriate solutions and in identifying goals.

Each of these contributions to the application of the Benchmarking method is part of the objectives of the Homeland Security System study. Guidelines for improving the functioning of the homeland security system of the Republic of Bulgaria should be sought in the organizational decisions of leading countries in the field of security. Moreover, at the time of the study, these countries should have reformed their security systems in line with the changes in the security environment caused by current influences. The research process will give a clear idea of the degree of modernization of the security system in the country, compared to the considered analogues. Next, the applicability of the respective models within the Republic of Bulgaria will be clarified.

4. Conclusion

When building the methodology for studying the functioning of the system for protection of homeland security, the specifics of the system and the goals and scope of the research are taken into account. It is taken into account that the object of study is a system; the affiliation of the security system to the public sector is taken into account, taking into account the resulting properties and characteristics of the system. The selected methods are in line with

the tasks set before the study, namely the study of the security environment, the functioning of the homeland security system within this environment, the study of the experience of other countries. The methods to be applied are described and their choice is supported by the relevant justification.

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Methodology for Improving Cyber Awareness Competencies of Employees in Public Administration

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Abstract. In this report, the authors present a methodology for enhancing the capacity of users in public organizations to work in pandemic conditions, which aims to improve their cyber awareness and secure a safe working environment. Pandemic has shown data exposure is a real issue for public sector. The coronavirus crisis accelerated the need for information and management systems that would support remote and virtual working. Most users do not have enterprise standard IT in their own homes, meaning the fallback for short term remote working in a crisis, as we have seen, is the use of laptops and mobile devices in 'home' environment which imposes high cyber security risks. Smart workforce collaboration requires a high level of cyber awareness, which is crucial for sustainable work operations. As a practical implementation of the proposed methodology, the authors present a developed by them Cyber Awareness portal. Its main purpose is to provide national and international information and resources on cybersecurity and information security, and to be the main point of knowledge access. The portal also provides opportunities to test your cyber knowledge, participate in public survey related to cyber topics, share and exchange information, opinions and useful practices on cyber incidents and cyber knowledge.

Keywords. Public Sector, Cybersecurity, Cyber Awareness, Cyber Security, Information Security, Methodology, Portal, Website.

1. Introduction

In this report, the authors present a methodology for enhancing the knowledge of public sector organizations' personnel to work in a secure environment and to refine and improve their cyber awareness skills.

The methodology has two aspects - informative and research. The main goal is to secure a safe working environment in cyberspace, considering extreme conditions, such as those imposed by the COVID-19 pandemics. This is achieved by refining and improving the cyber awareness and competencies of users who work in public sector organizations. From information aspect, the methodology aims to:

- expand knowledge in the field of cyber hygiene and cybersecurity;
- helps users take preventive action to reduce the risk of information security incidents;
- provides access to online applications for testing and validation of information resources;
- provides information and contacts of relevant national and international organizations for information and cyber security;
- provides access to information resources on news, events, specialized publications and scientific publications on cyber awareness and security;

- provides immediate support by providing information on resolving cyber incidents that have already occurred;
- provides an opportunity for users to report potential cyber incidents, to share and exchange knowledge.

From a research aspect, the methodology intends to:

- Explore various aspects of the online behavior of employees when accessing remote access services, as well as the of work from home (WFH - Work from Home) mode during the pandemic COVID-19;
- Examine the vulnerability of employees and the possible potential risks of identity theft;
- Investigate the level of competencies related to cyber hygiene and cyberethics through the possibility of solving relevant tests;
- Provide functionality for conducting specialized surveys among professionals on information infrastructure, etc.

The methodology is implemented using state-of-the-art information technologies and content management systems CMS (Content Management System), where a web-based application has been developed - portal “Cyber Awareness”. It is designed and developed initially as an information website. The target audience for it can be a wide range of users from the public sector, who differ in terms of their competencies and skills in the field of information, computer and cybersecurity. The group of potential users includes both specialists - professionals with a high level of qualification, such as information security officers, system, network and other administrators, cybersecurity specialists, as well as non-specialist employees. They can achieve a safe stay in cyberspace through the services of the portal. The site could also be useful to information security and cybersecurity managers and employees – i.e., Chief Information Security Officer (CISO) in connection with the inspection and improvement of cyber hygiene and user competencies in the field of security of computer systems and networks, as well as risks and threats in cyberspace.

The main purpose of the Cyber Awareness portal is to increase the cyber awareness capabilities and competencies of employees in public sector organizations to work in cyberspace. It provides information resources from national and international organizations on cybersecurity and information security. The portal provides opportunities for testing users' cybersecurity competencies. In addition, the environment gives the possibility for users to participate in a survey, which examines various indicators and serves as a basis for subsequent analysis. The portal provides further implications related to cyber topics, sharing and exchanging information, opinions and best practices on cyber incidents.

2. Methodology for developing the project portal “Cyber Awareness”

The project for the portal design and development has followed a waterfall approach, where a breakdown of project activities is done into linear sequential phases. The main phases through which the project underwent are as follows:

- The portal initial concept and architecture,
- The portal visual design and theme choice,
- The portal implementation and development,
- The portal security implementation and assurance and finally
- The content creation and management.

2.1. Portal concept and architecture

In the initial phase of portal planning, the goals, idea, concept and architecture of the topic and activity of the initial website are specified, as well as the information structure. They determine what to expect and get as a result after its completion, in terms of structure, functionality.

For this purpose, as a useful practice, it is proposed to develop a site map describing menus, pages and brief content using Excel.

Specifying the content and collecting information.

It is necessary to prepare texts, documents, URLs and other materials. Development of the platform kicked-off with setting up the initial structure in the form of website.

The name of the initial site is also chosen, ie **choosing a name and domain**. Choosing a domain for the site is an important condition in the process of creating a website. It is especially important that the domain of the site contains, if possible, an important keyword for it and for the activity of the organization, which will potentially help for better indexing of the site by search engines. The choice of a domain name is closely related to the concept and future user orientation of the site. There are several approaches for choosing a domain name keyword:

- Important keyword for the activity. It is recommended when the emphasis is more on the activity and function that is performed by the site (or organization),
- Organization name for domain name - It is recommended when the emphasis is on the representation of the organization in the web space,
- A combination of a keyword about the activity and the name of the organization, which can be merged or hyphenated between them. It is recommended when both are of equal importance. In this case, it is necessary to consider the length of the domain name. It should not be too large, as this would lead to difficulty remembering and the possibility of an error when typing manually in the address field of the browser or speaking on the phone.

Choosing a domain is also about checking that the selected name is free. In many cases, it turns out that it is already occupied or free, but not with the extension with which the initial choice was made. Therefore, it is advisable to devote time and attention to choosing a suitable domain, as it will not be able to change later.

For the purposes of the proposed methodology and the implemented project for choosing a domain name keyword, the first approach was chosen. The chosen keyword – “cyberhelp” relates to the activity.

As mentioned above, in the initial phase - the website concept and architecture development - the main goal is the creation of the website structure and a mechanism through which the content of the website will be created and managed. After considering the project requirements, namely such that fulfil the project’s purpose for provision of relevant and useful information on cybersecurity, the next step is choosing the portal for site development.

Choosing a portal for site development

WordPress as a content management system (CMS) is chosen for the development of the site. There are a couple of main reasons underlying this decision.

Firstly, WordPress is a free open-source content management system. Being open source, the system has a complete set of documentation that allowed the team to develop the website as the project’s needs and be flexible in the development.

Secondly, wide application's popularity and gained national and international usage of this portal has been taken into consideration. As of May 2021, according to the stats of W3Techs [1] WordPress has 40% market share of all public facing websites on the Internet. This large market share is due mainly to the ease of use of the system for back-end users (users with administrative rights), as well as a number of useful features such as integrated content management.

Thirdly, the degree of privacy that the portal provides. WordPress has a five-star privacy rating from the Electronic Frontier Foundation [2]. In addition, the degree of security that the system provides is suitable for the requirements that team set before the development of the project.

2.2. Selecting and developing a site design

The next phase of the project is the selection and development of the visual design of the website and the choice of WordPress theme. This includes defining: User interface; Site structure; Navigation and Design.

In WordPress, themes are a set of templates that visualize the content for public users. In WordPress there is a wide variety of themes, which are a set of templates that visualize for users the content of the site with a certain graphic design, color scheme, as well as the appropriate arrangement of objects on web pages. When considering what visuals should be used, the team decided on using latest design trends concerning User Experience (UX) and User Interface (UI). Solemn, but modern and avoiding clichés color scheme was chosen to reflect the nature of the website as Cybersecurity is a very serious topic. Modern UX trends are reflected as micro-animations are used to enhance public users' experience when browsing the website.

Moreover, the de-facto standard industry approach for "mobile-first" design means it is easily accessible from any device, including mobile and tablet devices, as well as the traditional laptop and desktop devices. The frontend of the website is also compatible with the latest three versions of all major browsers.

Regarding the visualization of browsers on mobile devices [3], it is necessary to apply the following good practice: the pages and links on the site should be located in separate sections of the site main menu only in the "drop-down" menus. If there were "cascading" menus and submenus, this would make it difficult to navigate the pages through a browser on a mobile device or tablet.

2.3. WordPress deployment - environment and the website installation and setup

The next phase of the project was the actual WordPress deployment, installation of the chosen WordPress, implementation of various functionalities specified as per the project's requirements and any additional development activities. Overall, this phase process included:

- Initial setup of the WordPress;
- Subsequent implementation of modules (plugins) for various functionalities that were set in the initial plan for the website (e.g. modules for contact forms, visual content management and editing, security management, backup management, multilingual version creation);
- Implementation of a WordPress theme for visualization. The theme name is Ivory. It is a theme that was purchased under license for the use of the website. In order to customize the theme to accommodate the project needs and requirements best industry practices were applied;
- Content input and layout.

2.4. Security implementation and assurance

The next phase of the project focuses on the implementation of security measures to ensure the required level of website protection. A set of actions were undertaken in order to assure that the website is secured for a variety of threats. It includes, but is not limited to, the following key measures:

- Implementation of a specialized WordPress module (plugin) for security.
- Server setup for prevention of commonly known attacks against WordPress based systems, as per the Open Web Application Security Project (OWASP) Top 10 list [4] (The OWASP Top 10 is a standard awareness document for developers and web application security that represents a broad consensus about the most critical security risks to web applications, <https://owasp.org/www-project-top-ten/>). Some potential threats include Cross-Site Scripting XSS, Clickjacking and others.
- Implementation of server Security Content Policy to restrict the types of files and content served to end users.
- Implementation of Let's Encrypt SSL certificates to ensure secure connection between the website's server and end users. Let's Encrypt is a free, automated, and open certificate authority brought by the nonprofit Internet Security Research Group (ISRG) [5].
- Implementation and configuration of Cloudflare Web Application Firewall (WAF) to ensure proper mitigation of potential DDoS attacks and filtering of malicious traffic.

2.5. Content creation, input to the WordPress panel and management

The final phase of the project was the content creation, input to the WordPress panel and management. The website content is bilingual – English and Bulgarian. It provides potential users information in their language. Content is broken down to different sections, relevant to different aspects of Cybersecurity.

Publishing to a web server

The content of the website is entered into the selected server and is published on the Internet.

A file transfer protocol (ftp) is commonly used to transfer files to the Internet. There are a number of free ftp clients on the Internet that can be installed. The website is located at the following URL – <https://cyberhelp.digital> and is hosted Bulgaria.

3. Practical implementation of the Cyber Awareness portal

As can be seen from the pre-developed concept and site map, its structure contains a horizontal menu with five drop-down menus with relevant sections. The five drop-down menus are respectively: Home, About us, Useful information, Cyber-check and Contacts. The **Home** page is set as the home page. Each section is accessible via the menu, which is displayed top and at the bottom of the browser screen - Fig. 1, Fig. 2.

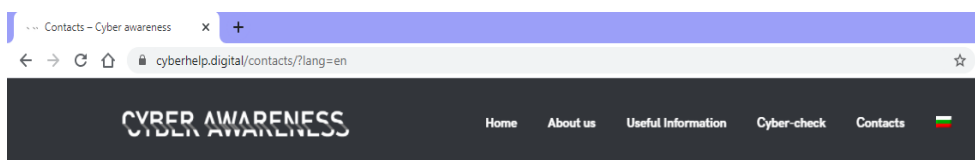


Fig. 1 Web-site main menu

The Menu Tabs Useful information, Cyber-check and Contacts follow the same structure: - Title, Body and Link. They are designed in the same simple and clean design, which does not intrude and does not prevent the user to focus on the content. It in turn can be classified as static (these are the logo, title, text and other elements containing unchanging information) and dynamic - these are links and elements that require action by the user (test form, survey, and other).

The **Home page**, Fig. 2, presents information about the purpose and mission of the site.

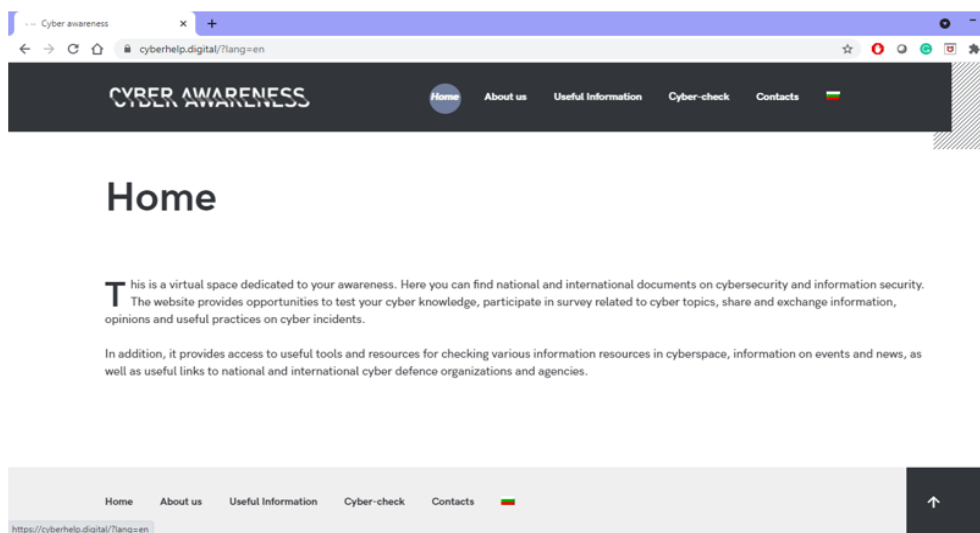


Fig. 2 Home page screen

In the menu “**Useful Information**” (Fig. 3), users can find links to Bulgarian as well as international **documents** on cybersecurity and information protection, Bulgarian and international **organizations** for cyber defense, as well as links to specialized **publications** in the field. There is an appropriate animation - an effect to hide part of the menu when reading the content of the page. This makes it easy to read, which is especially great when accessing the site from a mobile device.

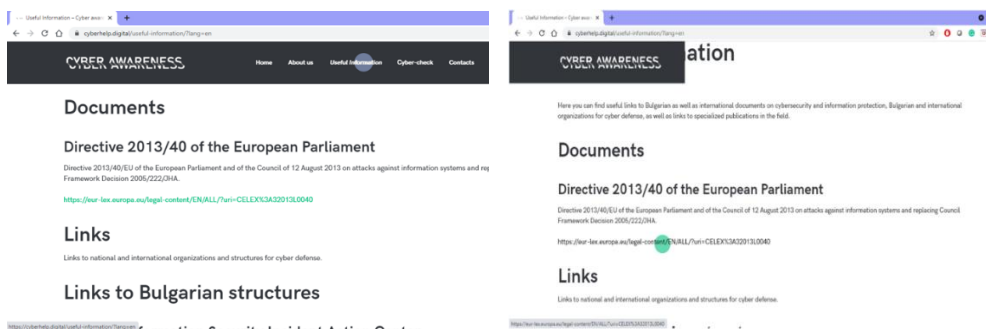


Fig. 3 Animation effect for shrinking the menu when reading the content

In the “**Cyber-check**” menu (Fig. 4) the users can find variety of useful cybersecurity online tools for checking different aspects of the security of web resources and sites. Such tools are extension to alert for existing threats, tools for obtaining additional information on a domain; tool for checking received attachments before using them; tool for checking graphic images in the web space, in order to analyze their authenticity. In addition, in this menu are added opportunities for employees to participate in surveys and cyber awareness competency testing. Such studies are particularly important when working from home in the context of the global COVID-19 pandemic. The issues of raising the culture of cybersecurity, which is related to cyber awareness of users, is widely used in many fields of research [6, 7].

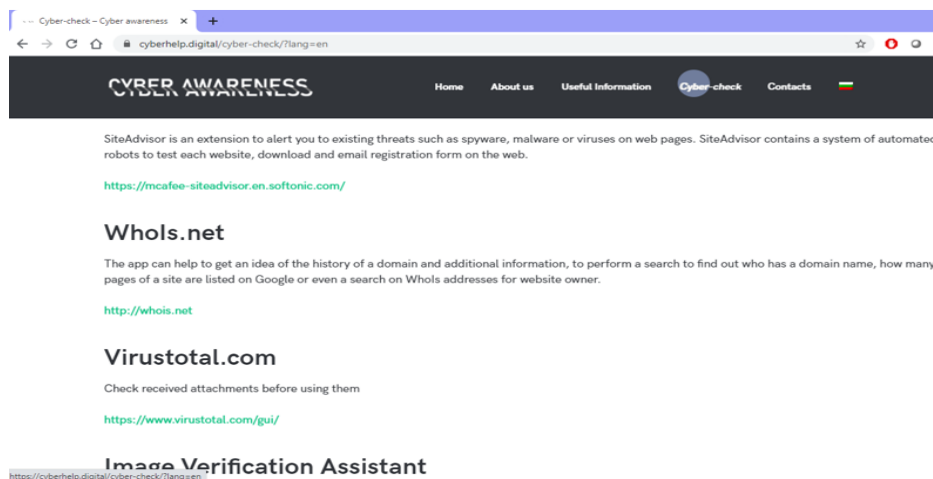


Fig. 4 “Cyber-check” Menu

In the “**Contacts**” menu, (Fig. 5) users can find useful links to national and international institutions when a cybersecurity problem arises. Such is, for example, the connection to the National Information Security Incident Action Center, where there is a form, CERT Bulgaria Information Security Incident Reporting Form for reporting a cyber incident.

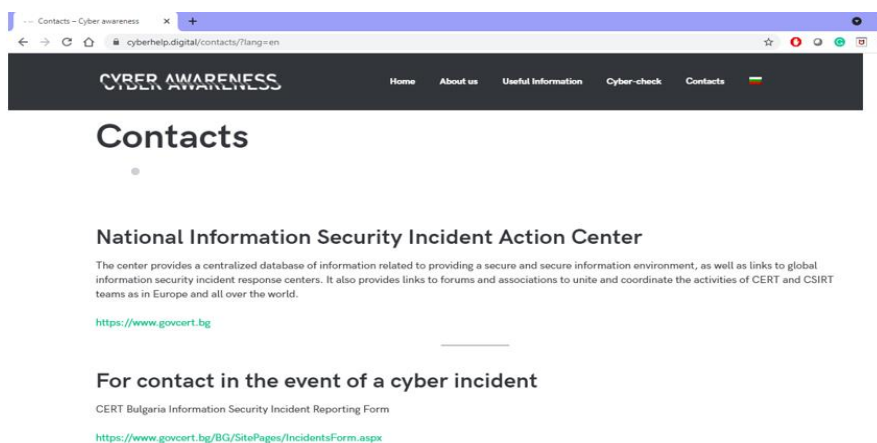


Fig. 5 “Contacts” menu

4. Conclusion

It can be summarized that the developed portal can be further improved in a collaborative platform that enables regular editing and enrichment of the content with additional up-to-date information, setting up a forum and discussion structure, as well as adding additional tools for site checking and analyzing such as statistical site traffic, number of documents downloaded from it, links of other organizations to it and others. The proposed methodology for improving cyber awareness of public sector employees has an interdisciplinary effect, as it could be successfully applied in other cyberdomains and areas of cyberspace.

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Investment Decisions Using Simulation Modelling and Probability of Reversal Approach

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Abstract. This paper proposes an approach to choosing an investment alternative that combines the probability of reversal method and the simulation modeling. This approach is applicable in cases where investment alternatives are compared in terms of risk and return and there is no dominating alternative. It is then recommended to calculate the probability of reversal between the two alternatives using a simulation model. The model calculates the net present value (NPV) and standard deviation of NPV for both alternatives. For this purpose, an algorithm is proposed, which includes: development of a deterministic model for calculation of NPV indicators, identification of the random variables that affect them, determination of the probabilistic characteristics of these random variables, development and recalculation of a simulation model, statistical analysis of the results, probability of reversal calculation, choice of an alternative.

Keywords. Monte Carlo simulation modeling, Investment decisions, Probability of reversal, Risk, Return.

1. Introduction

The application of contemporary analytical tools and software is intensively used in the business practice. On the other hand, the need for rational reasoning of investment decisions becomes increasingly important, especially when it comes to investing significant financial resources. The practice of investment decision-making is very rich, but nevertheless it is appropriate to offer new approaches and methods which allow for rational choices that consider the attitude of the decision maker to risk. When making their decisions, investors continuously comply with several criteria, but it is always recommended to take into account at least two of them: the expected return and the level of risk for each investment alternative. Monte Carlo simulation models are also gaining ground in the practice. They can successfully overcome the weaknesses of other methods used to assess investment risk.

2. Problem identification

The successful development of a business requires continuous innovations – new products, technologies, entering a new business or new markets. Nowadays, favorable conditions exist and at the same time the business is expected to regularly conduct investment projects. An important element of investment management is the ability to make rational investment decisions.

No matter in which direction one invests, it is always necessary to choose between investment alternatives. Different alternatives can be based on different possible directions for investment, different production volumes, different technologies used, different products, different territorial location of the new production units and many others. Therefore, during the investment process it is necessary to evaluate the alternatives and to choose the most

suitable one or ones. The evaluation of alternatives must always be multi-criterial. It is usual for an investment project to pursue multiple goals and provide different effects.

Usually, when it comes to business investment decisions, the main goal is to increase the well-being of owners. Therefore, in most cases, the main criterion for choosing an alternative is the assessment of return, measured by various indicators – *NPV*, *IRR*, *PBP* and others.

At the same time, investing inevitably requires a certain risk. The risk may be higher or lower. The theory and practice of investment management show that the assessment of investment risk is a mandatory and vital element of the decision-making process, in parallel with the assessment of return. Of course, it should not be forgotten that the evaluation of alternatives must be focused on other aspects as well, for example: the degree of achievement of strategic business goals, environmental protection, social effects, corporate social responsibility, corporate security, and others. This means that the evaluation must be multi-criteria and therefore follow the logic of multiple criteria decision-making. This paper focuses on methods for decision-making by simultaneously assessing return and investment risk. Thus, the choice is based on evaluation and selection of an alternative according to these two criteria.

From the point of view of the decision theory, it is possible that different situations arise when evaluating alternatives on two criteria. In the first situation, one of the alternatives dominates. The dominating alternative has better values in terms of both return and risk. If, for example, the return estimate is based on the net present value (*NPV*) and the risk estimate is based on the *NPV* standard deviation (σ_{NPV}), then the situation can be depicted as follows (Fig. 1). Project B dominates over project A because $NPV_B > NPV_A$ and at the same time $\sigma_{NPV A} < \sigma_{NPV B}$. In such a situation, the rational investor will prefer the choice of project B because it provides both higher returns and lower project risk. than project A. Dominance also exists in the next two situations (Figs. 2 and 3). In the situation shown in Fig. 2 $NPV_B > NPV_A$ but $\sigma_{NPV A} = \sigma_{NPV B}$, i.e., the level of risk in both projects is the same. In the situation shown in Fig. 3 $NPV_B = NPV_A$ but $\sigma_{NPV A} > \sigma_{NPV B}$, i.e. the return of both projects is the same, but the risk in project A is higher. In the second and third situations, the rational investor will again prefer the choice of project B. The situation depicted in Fig. 4 is completely different. It lacks a dominating alternative, because project B provides a higher return, but at the same time hides a higher risk.

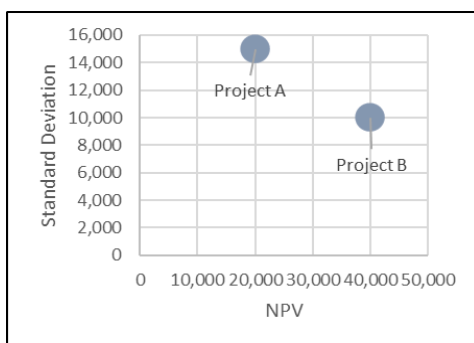


Fig. 1. Project B dominates over project A, because $NPV_B > NPV_A$ and $\sigma_{NPV B} < \sigma_{NPV A}$

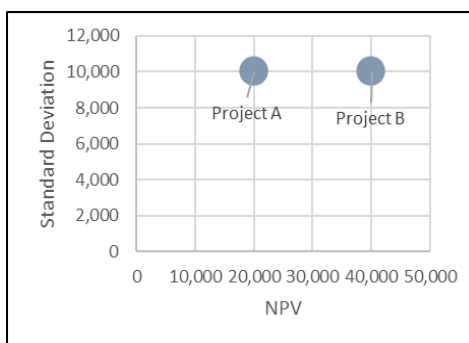


Fig. 2. Project B dominates over project A, nevertheless, $\sigma_{NPV A} = \sigma_{NPV B}$

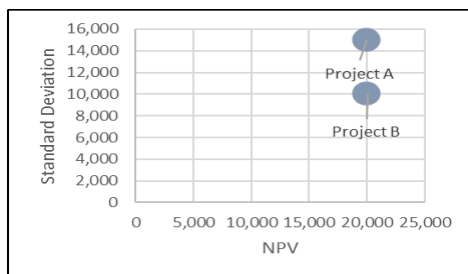


Fig. 3. Project B dominates over Project A, because $NPV_B = NPV_A$ but $\sigma_{NPV A} > \sigma_{NPV B}$

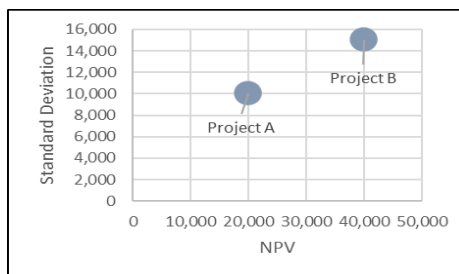


Fig. 4. There is no dominating alternative

From the point of view of Decision Theory, decision-making in the absence of a dominating alternative requires the application of complex mathematical algorithms, determining the relative priority of the two criteria. There are many approaches to such a choice.

The main idea explored in this paper is to use the probability of reversal indicator in such a situation. This indicator determines how likely project B is to provide a lower *NPV* value than project A. Such a situation is possible because the *NPV* of both projects can vary in both positive and negative directions. It is proposed that the probability of reversal calculation be performed using a simulation model.

3. Literature review

The capital budgeting issues are the subject of in-depth research in many literature sources. In this report, I do not intend to present a complete literature review, but only some selected areas that are directly related to the problem of this research.

In their remarkable work, Dayananda, Irons, Harrison, Herbohn, and Rowland (Dayananda, Irons, Harrison, Herbohn, & Rowland, 2002) present in detail the process of capital budgeting. They believe that capital budgeting is aimed at achieving the main goal of the company – to maximize shareholder wealth or value of the firm and it is oriented towards decision-making for long-term investments (Dayananda, Irons, Harrison, Herbohn, & Rowland, 2002, p. 2). The capital budgeting process includes: corporate goal, strategic planning, investment opportunities, preliminary screening, financial appraisal, quantitative analysis, project evaluation or project analysis, qualitative factors, judgements and gut feelings, accept/reject decisions on the projects, implementation, facilitation, monitoring, control and review, continue, expand or abandon project, and post-implementation audit (Dayananda, Irons, Harrison, Herbohn, & Rowland, 2002, p. 5).

Sandeep Goel provides an in-depth overview of the investment decision-making process within the capital budgeting process. According to him, capital budgeting is a continuous process and is carried out by different functional areas of management such as production, marketing, engineering, financial management, and so on. (Goel, 2015, p. 12). In his book the author presents in detail the logic and process of feasibility study of investment projects. He believes that „A feasibility study is an analysis of the viability of an idea. It helps to answer the question of “should we proceed with the proposed project?” (Goel, 2015, p. 19). In other words, the author draws attention to the decision-making process of choosing or rejecting an investment idea. The process of feasibility study is performed in the following steps: identify the business drivers, determine the alternative solutions, conduct the feasibility, selection of the most suitable choice, implement the project and can be performed in the

following areas: market assessment, technical feasibility, financial / economic feasibility, organizational / managerial feasibility (Goel, 2015, pp. 20-26).

Oshodi and Lam systematize capital budgeting evaluation techniques, known and widely used in the world practice – formal financial evaluation, risk analysis, best/worst estimates, searching and screening of alternatives before accepting projects (Lam & Oshodi, 2015, pp. 589-590). The same authors present a comparative analysis of the use of various known techniques for evaluating investment projects, such as payback period (PBP), average accounting rate of return (AARR), internal rate of return (IRR) and net present value (NPV) techniques. (Lam & Oshodi, 2015, pp. 590-591).

William R. Folks, Jr. focuses on the basic assumptions that are usually made when evaluating foreign investment projects (Folks, 1981, pp. 138-152). Benallou and Aboulaich emphasize on the constraints faced by analysts who use the classical deterministic capital budgeting framework and offer opportunities to improve capital budgeting by using probabilistic approaches (Benallou & Aboulaich, 2017).

Another important research area is the application of multi-criteria decision methods in capital budgeting. Many authors can be mentioned here, among which are the following. Gotze, Northcott and Schuster discuss several popular methods for multi-criteria decision-making – utility value analysis, analytic hierarchy process (AHP), multi-attribute utility theory and preference ranking organization method for enrichment evaluations (PROMETHEE) (Goze, Northcott, & Schuster, 2015, pp. 163-203). Crum and Derkinderen analyze a number of important aspects of the application of multicriteria approaches to decision modeling in the field of capital budgeting, including, for example, the logic of identifying criteria and setting appropriate aspiration levels, as well as selecting appropriate criteria (Crum & Derkinderen, 1981).

Many authors also work in the field of developing and application of simulation models. Dayananda, Irons, Harrison, Herbohn, and Rowland define a series of advantages and disadvantages of simulation compared with other techniques in capital budgeting (Dayananda, Irons, Harrison, Herbohn, & Rowland, 2002, pp. 179-180). Arnold and North present a series of risk simulation concepts and methods that can be directly used when choosing an investment solution (Arnold & North, 2011). Benallou and Aboulaich offer a three-step procedure for applying probabilistic approaches to capital budgeting – namely: selecting the input variables to be modeled with probabilistic distributions, identifying the probability distribution to be used for those variables, running the simulations, and interpreting the results (Benallou & Aboulaich, 2017, p. 7). Chandra also proposes a procedure for applying the simulation analysis when taking investment decisions, focusing in more detail on an important methodological issue – the logic of obtaining probability distributions of basic variables, as well as some commonly used distributions – uniform, triangular, step rectangular, normal (Chandra, 2019, pp. 397-403). In his book, Georgiev presents an algorithm for selecting the best version of the project, considering the values of the *NPV* (for return assessment) and the standard deviation of the *NPV* (for project risk assessment). In cases where none of the two compared alternatives dominates the other, the so-called “probability of reversal” indicator is used (Beenhakker, 1975, p. 146, Cited in Georgiev, 2013, p. 282) This is the probability the difference between the *NPV* of the variant with a higher *NPV* value and the variant with a lower *NPV* value to be less than zero (Georgiev, 2013, p. 283).

4. Methodology

This paper proposes to use a combination of the probability of reversal method and Monte Carlo simulations when comparing two investment alternatives in which neither is dominating. For this purpose, an algorithm is proposed, which includes the following steps:

1. Development of a deterministic Excel model for calculation of *NPV* values for the two compared alternatives based on given input variables. The model calculates the *NPV* values for each of the alternatives, as well as the difference between the *NPV*s of the two alternatives.
2. Determining those input variables that will be considered random. These are variables for which it can be expertly determined that the changes in their values pose the highest risk for the projects.
3. Expert determination of the type of probability distribution of these random variables.
4. Expert or based on analysis of statistical data from previous projects (if any) determination of the probabilistic characteristics of the random variables, according to their probability distributions.
5. Determining the required number of recalculations with different random values of the input random variables.
6. Development of a simulation model using the @Risk software (Palisade Corporation) and application of the model.
7. Statistical analysis of the obtained results for the *NPV* values for each of the alternatives and of the difference between the *NPV* of the two alternatives. Calculation of mean and standard deviation of *NPV* of both alternatives.
8. Check for the existence of a dominating alternative, i.e., alternative for which a higher value of mean of *NPV* and a lower value of standard deviation of *NPV* have been calculated. If there is – then the dominating alternative must be chosen. If there is no dominance, proceed to the next steps.
9. Calculation using the @Risk software of probability of reversal between the two alternatives. The decisionmaker must decide whether this probability is high or low. If the probability is high, the option with a lower *NPV* value is selected and vice versa. If the decisionmaker decides that the probability of reversal is low, the alternative with a higher *NPV* must be chosen.

5. Development and application of the simulation model

For the purposes of this paper, two hypothetical alternatives of an investment project (project A and project B) have been developed. Based on this, a deterministic model was developed to calculate their *NPV* values as well as the difference between them. Certain trends in the dynamics of the fixed costs and sales variables for the entire period of the production phase are envisaged. The input variables are defined, which are perceived as random. These are: investment costs, fixed costs for the first production year, sales for the first production year, and variable costs. For each of the random variables, the following are expertly determined: the type of probability distribution as well as their probability characteristics. The output variables are: *NPV* of each of the alternatives (*NPV_A* and *NPV_B*, respectively) and the difference between them.

It is estimated to perform 1 000 iterations using the simulation model. Based on these data, a simulation model was developed using the @Risk software. This number of iterations is considered to be sufficient for the purposes of this paper, and the capabilities of the hardware and software used allow for a sufficiently fast simulation. The following results were obtained after simulation (Fig. 5 and 6). The statistical processing performed by the software provided the following results (Table 1).

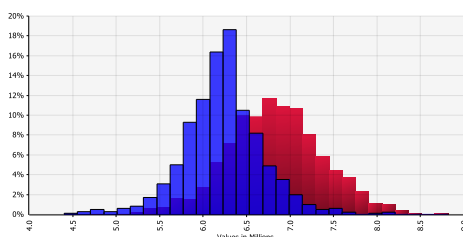


Fig. 5. Relative frequency of NPV_A (in red) and NPV_B (in blue)

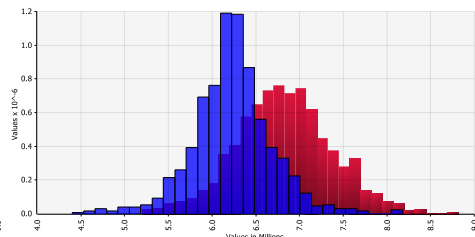


Fig. 6. Probability Density of NPV_A (in red) and NPV_B (in blue)

Table 1. Statistical results from the recalculations of the simulation model

Parameter	NPV_A , Lv.	NPV_B , Lv.
Minimum	5,206,955.25	4,400,318.86
Maximum	8,820,395.80	8,177,932.93
Mean	6,830,087.15	6,231,104.09
Mode	6,925,309.36	6,210,396.48
Median	6,819,957.02	6,230,278.12
Standard Deviation	544,565.48	455,503.59

The mean of NPV_A is higher than the mean of NPV_B and at the same time the standard deviation of NPV_A is higher than the mean of NPV_B . It is evident that in this case there is no dominant alternative (see fig. 7). Therefore, it is necessary to calculate the probability of reversal indicator.

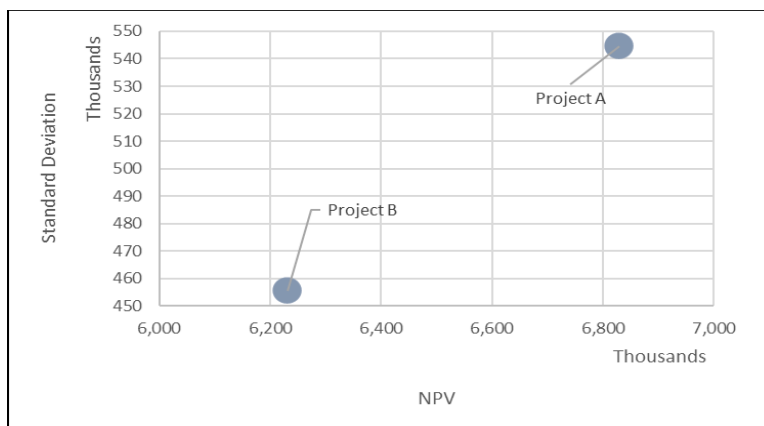


Fig. 7. Comparison between NPV and standard deviation of projects A and B. No dominating alternative

For this purpose, each time the model was recalculated, the difference between NPV of the two alternatives – $NPV_A - NPV_B$ was calculated. The following results were obtained (Fig. 8 and 9).

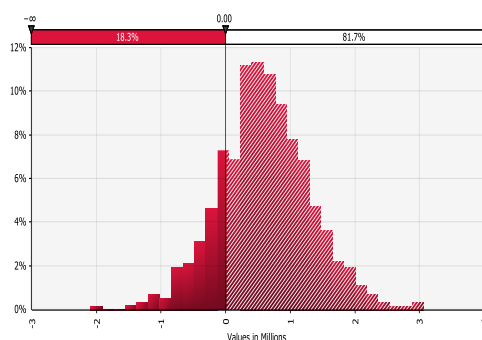


Fig. 8. Relative frequency of NPV_A –

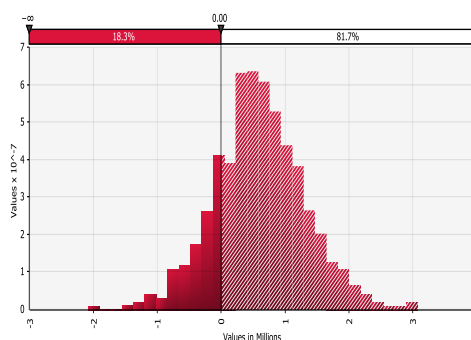


Fig. 9. Probability Density of NPV_A –

From the result it can also be seen that the probability of $NPV_A - NPV_B < 0$, i.e., to appear a reversal is 18.3%. In other words, the project with a higher value of NPV to be of lower value due to the possibility of varying the indicators in a positive or negative direction is 18.3%. The decision maker must analyze this result. Based on his specific attitude to risk, he must assess whether the probability of reversal is high or not. If the person considers this to be a high percentage, it will mean that project A is highly likely to have an NPV lower than project B. In this situation, the recommendation will be to choose project B. In this situation, the recommendation to the person will be him to choose project B. If the person considers that this is a low percentage, the recommendation to the person will be to choose project A, because it provides a higher value of NPV and this fact is unlikely to change.

6. Comments and conclusions

One of the possible approaches for choosing an investment alternative in terms of return and risk is the application of probability of reversal, using Monte Carlo simulations. To this end, it is necessary for the investment decision-maker to be aware of his own attitude to risk – how willing he is to make risky investment decisions and to be able to clearly express his attitude. The approach is appropriate in cases when investment alternatives are approximately equal in scale (amount of investment costs, production volume, expected value of NPV). In cases where the alternatives differ significantly in scale, the standard deviation of NPV indicator will not be suitable for measuring investment risk. In such cases, it is more appropriate to use the coefficient of variation indicator (see for example Chandra, 2019).

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The Customized Software – a Tool for Planning, Analysis and Control of the Key Value Indicators and Levels of Real Estate Companies

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Abstract. The paper discusses the options for customized software using by real estate companies to analyse, plan and control their sales revenue, total expenses, financial results from sales as well as their total income and expenses, final financial result, proceeds, payments and liquidity. Real estate companies report six key value indicators corresponding to three value levels as mentioned above. The application of customized software could significantly facilitate the financial experts of such companies in relation to these key value indicators and levels but it cannot be comprehensively covered by a single piece of paper. This paper presents the general options to use such software when dealing with the said value indicators and levels focusing on the application of customized software by real estate companies providing services and special purpose vehicles and specialized companies incorporated by such vehicles that make real estates available for use under rental, tenancy, lease and management agreements. It does not cover the use of such software as to the value indicators and levels of construction companies producing and selling material finished products as they have a number of specific characteristics. The full-value use of customized software requires thorough knowledge of the key value indicators and levels by the financial experts of real estate companies.

Keywords. Customized software, Real estate companies, Income, Expenses, Financial results, Proceeds, Payments, Liquidity

1. Introduction

Real estate companies are companies that have real estate activities as their scope of operations, i. e. real estates form the key source of their revenues. These companies include real estate agencies, special purpose vehicles securitizing real estates, service companies, specialized companies, construction companies, facilities and property management companies and appraisal companies. Detailed information about the activities performed by these companies can be found on the Internet.

Material finished products are created by construction companies and service companies where assigned by special purpose vehicles under applicable agreements (these companies maintain the real estates owned by special purpose vehicles). Respectively, these companies generate revenues from sales of finished products.

In its capacity of a real estate sale and rental transaction intermediary, a real estate agency generates revenues from sales of services. Facilities management companies (they maintain the shared parts of real estates), property management companies (they search for and find lessees of and service residential and commercial properties) and appraisal companies generate revenues from sales of services as well.

A service company also generates revenues from sales of services as it receives remunerations by the respective special purpose vehicle securitizing real estates for the maintenance of its real estates. As to special purpose vehicles securitizing real estates, they generate rental income, income from tenancy payments, income from lease payments and income from payments under rental, agricultural tenancy, lease and management agreements. A special purpose vehicle may also generate revenues from sales of real estates.

Specialized companies are incorporated by special purpose vehicles securitizing real estates in accordance with the Law on Special Purpose Vehicles. Similar to special purpose vehicles securitizing real estates, specialized companies acquire real estates and make them available for use and generate rental income, income from tenancy payments, etc. The shares of specialized companies can be held by special purpose vehicles securitizing real estates only. A specialized company may acquire real estates in the territory of Bulgaria or another member state, while a special purpose vehicle may acquire real estates in the territory of Bulgaria only. Another member state may be any of the EU member states, Iceland, Liechtenstein or Norway. The said Law provides for more information about specialized companies that represent a new economic entity in Bulgaria.

This paper aims to demonstrate that the application of customized software allows a comparatively quick identification of certain trends relating to the key value indicators and levels of and expedient reactions by real estate companies, if needed. Additionally, such software may be useful in the process of identification of options to optimize these indicators and levels.

This paper is in line with the Bulgarian legal framework regulating the reporting of financial relations of real estate companies and such practical reporting by these companies.

2. Key value indicators and levels of real estate companies

Real estate companies report six key value indicators (sales revenue, total expenses, corporate income and expenses, proceeds and payments) that correspond to three key value levels – financial result from sales, corporate financial result and liquidity. The total expenses relating to the sales of services over a particular period include the cost of services sold, the administrative expenses and the direct expenses related to sales for the same period. The total expenses related to the realization of rental income, income from tenancy payments and other income by special purpose vehicles (and by specialized companies securitizing real estates incorporated by special purpose vehicles) are all expenses directly related to making properties available under lease, tenancy and other agreements, including remunerations of service companies and illumination, heating and other costs related to the properties made available for use. It should be clarified that this paper does not cover the issues related to the revenues from sales of finished products and the expenses generated and incurred by construction companies and service companies (that may build sites as assigned by special purpose vehicles) as they have some specific characteristics.

The financial result from sales may be positive (profit), negative (loss) or zero. It is about the financial result from sales of services that is the difference between the revenues from sales of services and the total expenses employed in the creation and sale of services and the financial result from making real estates owned by special purpose vehicles available under rental, tenancy, lease and management agreements that is the difference between the revenues generated and the total expenses incurred by special purpose vehicles in relation to these real estates.

The financial result of a real estate company represents the difference between its total income and its total expenses. It may be profit, loss or zero. In this case, profit represents income in favour of company owners distributed in a certain manner by the latter. Profit is a

source of dividends allocated to owners. In other words, profit is a form of collective income, while dividends are a form of individual income.

Liquidity is the ability of a company to settle its current liabilities in a timely manner (the time period for their settlement is 12 months as from 31 December of the current year). In terms of the balance sheet as at 31 December, such ability is the static liquidity measured using indicators calculated on the basis of specific data stated in the balance sheet. Dynamic liquidity is the ability to settle current liabilities. It is measured on the basis of the corporate financial plan taking into consideration the cash available to a company as at the maturity date of a payable and the amount of such payable. Logically, the available cash as at such date should equal or exceed the payable amount.

The key value indicators and levels of real estate companies and the customized software that may be used when dealing with such indicators and levels based on the data reported for the respective periods of a calendar year (monthly, quarterly, half-yearly and annual data) may be illustrated in Fig 1.

In general, the sales revenue, total expenses, corporate income (including other sales revenue and income types) and corporate expenses (including total expenses and other expense types) generated and incurred over a given calendar year (1 January – 31 December) are reported in the income statement (prepared by the companies applying the National Accounting Standards) and in the statement of profit or loss and other comprehensive income for the period (prepared by the companies applying the International Accounting Standards), which are elements of the annual financial statements. All proceeds and payments realized over a given calendar year are disclosed in the statement of cash flows for the period, which is a component of the annual financial statements prepared by the companies applying both the National Accounting Standards and the International Accounting Standards.

3. Time points of income and expenses arising. Time points of realization of proceeds and execution of payments. Customized software role

When realizing sales revenue, a company may receive cash that represents a pecuniary form of such revenue, i. e. the time point of income arising may coincide with the time point of proceeds realization. It is possible that the time point of income arising occurs before the time point of proceeds realization. Example: a company realizes a sale transaction in October of the current year but it will receive the particular payment in April of the next year in accordance with the applicable sale agreement. In this case, the income arises in October and the item of proceeds is realized later (in April of the next year) – in October, the company reports the income and a receivable equalling such income and the receivable is transformed into an item of proceeds in April. The time point of income realization may occur after the time point of proceeds realization. Example: a company receives cash and reports the amount received and deferred income relating to following periods, i. e. it does not represent current income. Over the following period(s), such deferred income is transformed into current income. In other words, the time point of current income arising occurs after the time point of proceeds realization. Over the following period(s), such current income affects the corporate financial result.

A company also generates a number of other types of income and proceeds to which the said general time points apply.

The time points of expenses arising and payments execution are similar as explained further in this paper.

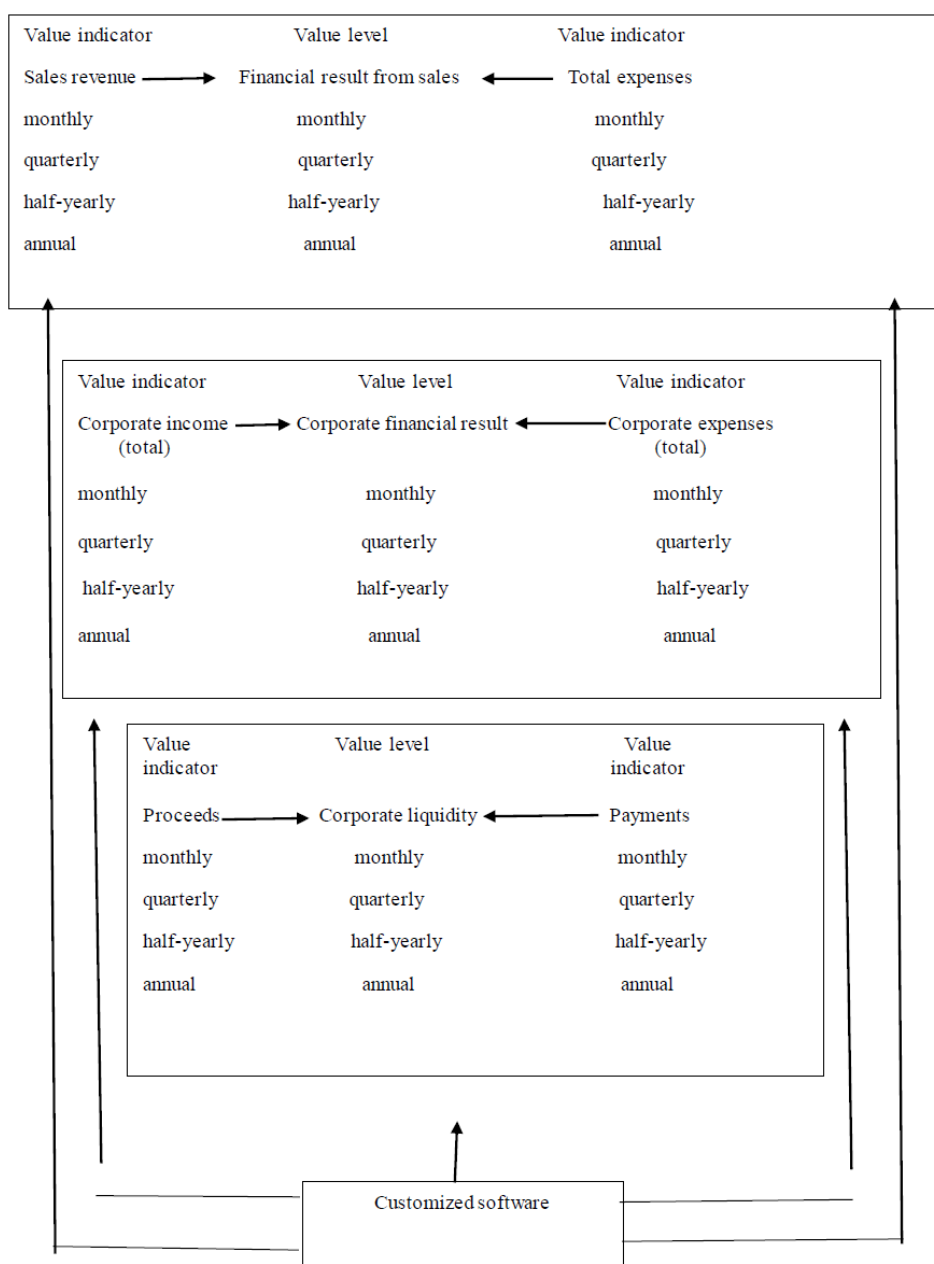


Fig. 1. Key value indicators and levels of real estate companies and their procession using customized software

The time point of expense arising may coincide with the time point of execution of the payment that represents a type of expense. Example: a company receives materials and uses them in its primary activity (for example: facility activity) on the same date. On such date, the

company also executes the payment due to the particular supplier. In this case, the time point of expense arising coincides with the time point of payment execution. The time point of expense realization may occur before the time point of payment execution. Example: a company receives materials and uses them in its primary activity on the same date but the payment is to be executed in six months under the applicable agreement. In this case, the expense is realized before the payment due. The time point of expense realization may occur after the time point of payment execution. Example: a company executes a due payment over the current period but reports a deferred expense, i. e. the time point of current expense realization occurs after the time point of payment execution.

The stated above is illustrated in the schemes below.

The first scheme presents the three possible variants characteristic to the time points of income arising and proceeds realization (Fig. 2).

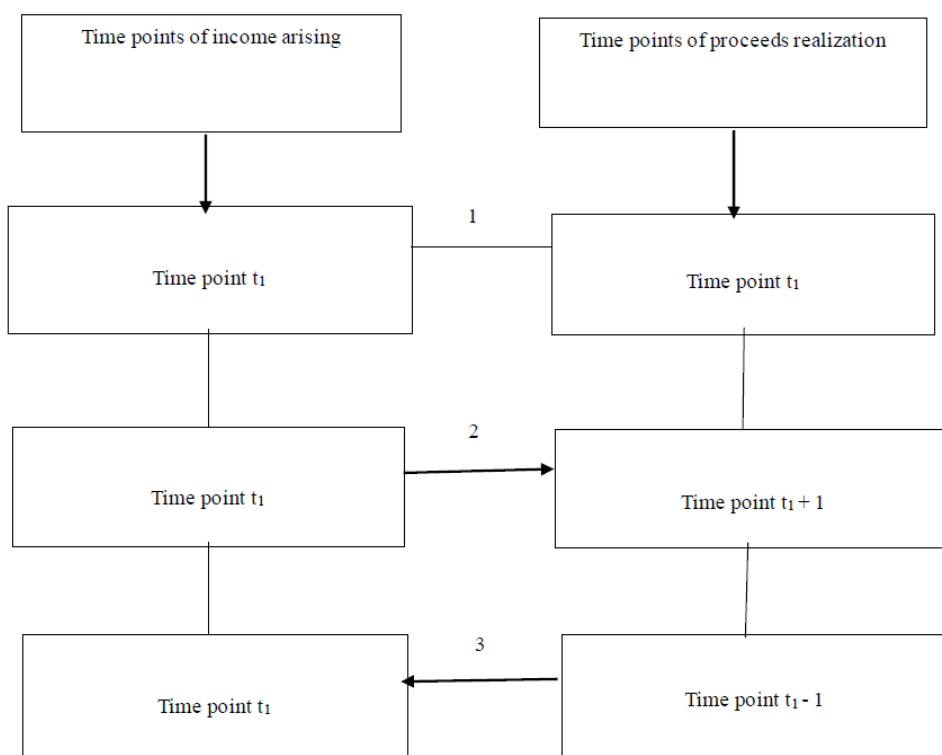


Fig. 2. Time points of income arising and proceeds realization

Note:

Time point t_1 : the present time point

Time point $t_1 + 1$: a time point after time point t_1

Time point $t_1 - 1$: a time point before time point t_1

1 – the time point of income arising coincides with the time point of proceeds realization

2 – the time point of income arising occurs before the time point of proceeds realization

3 – the time point of income arising occurs after the time point of proceeds realization

The second scheme presents the three possible variants characteristic to the time points of expense arising and payment execution (Fig.3).

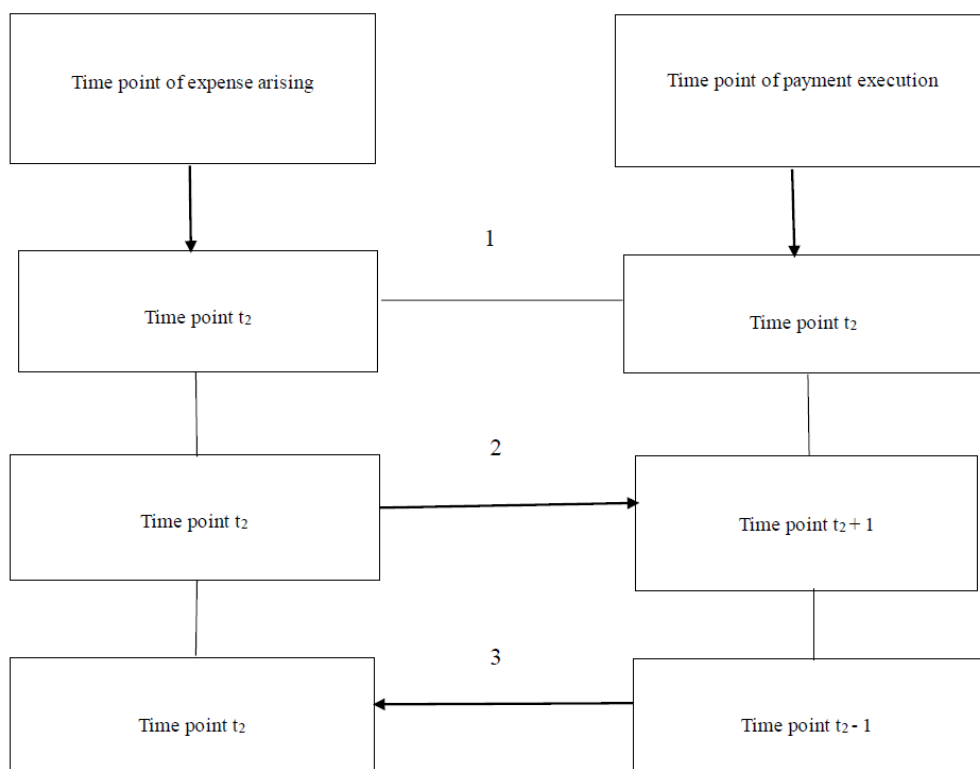


Fig. 3. Time points of expenses arising and payments execution

Note:

Time point t_2 : the present time point

Time point $t_2 + 1$: a time point after time point t_2

Time point $t_2 - 1$: a time point before time point t_2

1 – the time point of expense arising coincides with the time point of payment execution

2 – the time point of expense arising occurs before the time point of payment execution

3 – the time point of expense arising occurs after the time point of payment execution

Real estate companies should consider the possible variants explained and illustrated in Schemes 2 and 3 above when ordering software to ensure more precise planning, analysis and control of income, proceeds, expenses and payments. Customized software allows monitoring of items such as monthly revenues from sales of services and related total expenses. This can be also performed by real estate companies creating and selling services such as real estate agencies, facilities management companies, etc. So, it is possible to compare the actual revenues from sales of services and total expenses and the planned revenues from sales and total expenses for the respective month as well as the current figures and the figures reported for the same month of preceding years and to draw certain conclusions in order to make adequate management decisions. This may be also applied as to the quarterly, half-yearly and annual figures and the financial results from sales of service.

Customized software may be used to monitor the generated rental income, income from tenancy payments, income from lease payments and income from payments under rental, agricultural tenancy, lease and management agreements by month, quarter, half-year and calendar year – such income is typical to special purpose vehicles securitizing real estates and to specialized companies incorporated by special purpose vehicles (as provided for by the Law on Special Purpose Vehicles). It is possible to compare the actually generated rental and other income and the planned rental and other income as well as the actually generated rental and other income and such income reported for preceding periods. The same applies to the total expenses and financial results related to making real estates owned by special purpose vehicles and specialized companies available for use. Based on such comparisons, certain conclusions can be drawn in order to make adequate management decisions.

In general, the corporate total income, total expenses and final financial result and the corporate proceeds, payments and liquidity are treated in the same manner.

We have already discussed the total revenues from sales, total expenses and total financial result from sales realized by a real estate company as to all sites as applicable to a given period (month, quarter, etc.). However, customized software plays a key role when analysing the revenues from sales, total expenses and financial results from sales relating to individual sites that generate revenues in favour of real estate companies. It enables comparatively quick calculation and comparison by a real estate agency, for example – calculation and comparison of the actual income from rental services and the income from services related to sale transactions by residential quarter and the same figures planned for the particular period and reported for preceding periods. The same logic applies in case of calculating and comparing the total expenses and the financial results from sales realized by an agency in relation to rental services by quarter and the planned figures. The current figures and the same figures reported for preceding periods are also compared. The revenues from sales, total expenses and financial results related to sale transactions by residential quarter are treated in a similar manner. All that allows drawing conclusions that may be used as basis when making decisions on optimization of the economic activities of real estate agencies.

Customized software has a material importance to special purpose vehicles securitizing real estates and to specialized companies incorporated by special purpose vehicles. Its application by these companies enables comparatively quick calculation and comparison of the income under rental, tenancy and other agreements, the total expenses related to individual sites and the financial results realized over a given period with the figures planned for the same period and comparison of the current figures and those reported for preceding periods.

Customized software plays a key role in the course of operations of real estate companies when monitoring cash inflows and outflows related to real estates as it allows comparatively quick calculation and comparison of such flows as to individual sites. For example: a special purpose vehicle may quickly calculate the individual cash inflows and outflows related to its real estates. Such software may be also used when calculating the cash required to settle all payables over a following period.

4. Conclusion

Customized software significantly facilitates the work of the company experts dealing with the key value indicators and levels and shortens the time required to process all related data. To a great extent, it ensures avoiding technical errors that may be made by the competent experts. Real estate companies should acquire customized software designated for application when dealing with the key value indicators and levels as it saves time and resources and this is crucial in the conditions of competition among economic entities. The application of

customized software as to the key value indicators and levels is beneficial to real estate companies as it is a prerequisite for optimization of their economic operations.

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Main Methodologies for Digital Business Models Development

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Abstract. The aim of this paper is to review the main Digital Business Model development methodologies for organizational transformation in the digital economy. The digital business model concept has been introduced and related components discussed. Comparison among three methodologies for digital business model development is presented and the main factors for successful digital business models' development are outlined. The description of the factors is structured in three aspects - Strategy and management aspect, Business aspect and Technology aspect.

Keywords. Business models, Digital business models, Digital transformation, Digital economy.

1. Introduction

In the modern economic and technological environment, companies are forced to use digital technologies and to transform their business models into digital to become more competitive and even to survive. In that process, companies need to introduce a design approach that incorporates business and technological aspects of digital business modeling. Most of available methodologies focus mainly on the business aspect, and do not consider the significance of technologies in the design and implementation of a business model.

The purpose of the paper is to review the most popular methodologies for digital business model design and implementation. The term "digital business model" and its components are introduced. Three popular methodologies for digital business model development are presented and compared - *St. Gallen Business Model Navigator*, *Business model canvas*, and *SAP® Business Model Design and Innovation Methodology*. Key factors that influence the successful digital business model design and implementation are outlined.

The results presented in the paper are based on a broad literature review accomplished in the fields of digital transformation and business models.

2. Digital Business Model

In academia, the term "business model" has been used since the late 1950s. In the late '90s of the last century, the term became very popular because of the rapid development of information technologies and the Internet. Existing companies face the challenge to offer new products and services, to seek new channels of communication and distribution, to access new customers, and to transform the business models. Furthermore, new companies have emerged with innovative business ideas based on using information technologies and Internet.

At present, the "business model" concept is closely related to corporate performance management that "an umbrella term that describes the methodologies, metrics, processes, and systems used to monitor and manage the business performance of an enterprise" [1].

Generally, the business model is defined as an abstract illustration of how an organization works to achieve its strategic objectives.

The main components for designing a business model are as follows [2,3]:

1. ***Target customers***

A business model is designed around a good understanding of the specific needs of the customer. Target customers are those customers who are addressed by the value proposition, segmented according to their needs, behavior, and profile.

2. ***Value proposition***

Value proposition includes offered products and services to the target customers. Some of the products and services may be innovative, while others may be with added features and functionalities. The offered products and services must create value for the customer segment through a different combination of elements that meet the needs of the customers.

3. ***Value creation chain***

Value creation chain consists of all activities and processes necessary to achieve efficiency in implementing the business model, i.e., activities related to design, manufacturing, and delivery of a product in significant quantities and/or high quality; activities related to the development of new solutions to individual customer problems; activities related to the development of platforms or networks such as e-commerce platforms and others.

4. ***Communication, distribution, and sales channels***

Channels are the means through which the offered products and services are delivered to the customers. The channels connect with customers and deliver necessary products and services.

5. ***Customer relationships***

Customer relationships are activities that a company establishes with specific customer segments. Relationships can be driven by the needs for attracting new clients, retaining existing customers, and increasing sales.

6. ***Key resources***

Resources are needed to create and offer quality products and services, reach markets, maintain customer relationships, and build strong competitive advantages. Key resources can be owned/leased by the organization or acquired by key partners. Organizations often enter strategic partnerships with other companies or invest in start-ups to gain access to key resources needed to fulfill the business model.

7. ***Key partnerships***

Companies create partnerships to optimize their business models, reduce risks, or acquire resources. A network of suppliers and partners supports the implementation of a business model.

8. ***Revenue model***

The revenue model covers the financial aspects of a business model describing the structure and sources of the revenue. New mechanisms for revenue sources can be implemented by using digital technologies. Defining revenue streams depends on the question of what price the customer is willing to pay. Different pricing mechanisms can be applied for each stream, such as fixed prices, licensing negotiation, etc.

9. ***Cost model***

The cost model describes all costs incurred for the implementation of the business model.

In digital businesses, digital technology affects the components of a business model in two ways according to Cigaina and Riss (2016) [4]:

- Digital technologies play a significant role in the supply of products and services (on the service portfolio, customer experience, or both), affecting almost all components of a business model. In this case, the model is called the "**digital business model**".
- "**Business model based on digital technology**", which refers to any business model in which at least one of the components is significantly based on digital technologies.

Digital business model design includes a description of **nine components** of the business model from **five perspectives** including technological aspects related to the application of digital technologies.

The technological aspects of a digital business model are [4]:

- **People and communities** - digitally connected individuals and communities that use digital opportunities through different types of devices to create connections and interactions with each other and generate data.
- **Business network** - digitally connected companies that combine their digital capabilities to create new solutions.
- **Things** - digitally connected objects or smart things that exchange data and can be connected in networks (sensors, robots, autonomous vehicles, drones, IoT networks, etc.).
- **Data** - complete, detailed, consistent, transparent, accessible, and real-time data used for analysis, planning, and forecasting through complex analytical methods that process small or large amounts of data (big data).
- **Cloud** - a shared environment in which people, businesses, and objects connect to share and accumulate data using digital services, available when needed, and from anywhere.

In the process of designing a digital business model, both business and technology aspects should be analyzed and integrated into the model. This process requires an adaptive approach focused on application of technologies that ensure changes in the corporate strategy and compliance between the strategic objectives of the digital business model and the company's corporate strategy. From a strategic and managerial point of view, many methodologies are developed by research and business organizations to guide companies through the process of business modeling, but few of them are focused on the transformation of the business model based on digital technologies.

3. Main methodologies for Digital Business Model Development

The main methodologies that are designed to help businesses in the process of creation or improvement of their business models are:

- St. Gallen Business Model Navigator
- Business model canvas
- SAP® Business Model Design and Innovation Methodology

There are other methodologies for business model design (like Lean startup canvas [9] and Blitzscaling business model innovation canvas [10]), but most of them are in a form of adaptation of Business Model Canvas and/or are focused mainly on the business and financial aspect of the business model design and not on opportunities for transformation of the model using digital technologies.

In 2010 the Institute of Technology Management at the University of St. Gallen developed **St. Gallen Business Model Navigator**. It is a research-based methodology offering a structured approach for business model design and development. According to its authors, it

aims to facilitate a better understanding of the key drivers of business model success and to encourage innovation in business models [2].

The Business Model Navigator methodology includes four stages (Fig. 1):

1. *Initiation*: Analyzing the company's ecosystem
2. *Ideation*: Adaptation of models
3. *Integration*: Shaping the business model
4. *Implementation*: Implementation of the business model

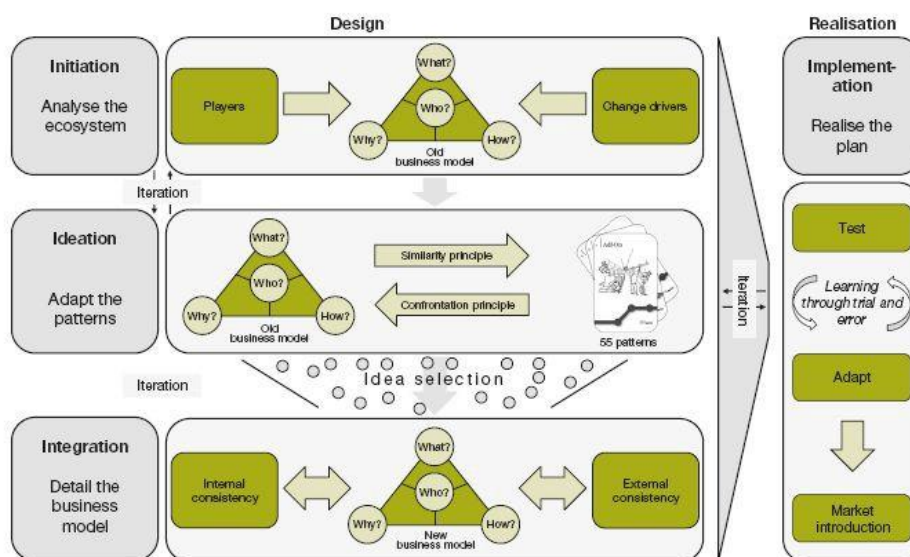


Fig. 1. Business Model Navigator design methodology (Gassmann et al, 2013)

The first stage *Initiation* includes analysis and description of the existing business model through four elements – **customers (who), value proposition (what), value chain (how), and revenue model (why)**. The stage aims to understand the existing business model, various factors influencing the model, and all participants in the ecosystem - the partner network, customers, and competitors. External stakeholders like customers, suppliers, distributors, solution providers, researchers, consultants can inspire new ideas and help to realize new concepts. Competitors and their business models can also initiate new ideas. The most important drivers of change need to be analyzed and find the way they can transform and impact the business model. The two main influencing factors are technology and new current trends in technology development.

The analysis of the ecosystem and business model reveals opportunities for innovation in the business model used for the stage of *Ideation*. 55 business models (part of the methodology) are developed as a tool for assisting the process of generating new ideas. These 55 business models are presented as cards. Each card describes a business model: title, general description of the main idea of the model, description of a real-life company that uses the model, and examples of other companies that use it. The adaptation of the model is the result of finding a balance between new ideas from outside environment and creativity in thinking of the organization.

As a result of Ideation, many ideas for a potential new business model are generated. During the *Integration* stage, new ideas must be shaped into a business model that meets the organization's internal requirements and to be consistent with the external environment. The business model is described in detail with four elements to ensure the internal consistency of the business model. The external consistency of the model is related to the correspondence between the business model and the ecosystem. A consistent business model provides competitive advantage that cannot be easily imitated by competitors.

In the *Implementation* stage, the idea needs to be transformed into a prototype to reveal the strengths and weaknesses of the idea using rapid prototyping concept for quick and inexpensive testing. Feedback on the prototype testing is important to get from stakeholders both inside and outside the company to gather as much information as possible about the prototype. This information will lead to better and more advanced prototyping or rejection of the prototype. The implementation cycle is an iterative process that must be elaborated several times before the business model is ready for the market.

Business model canvas is another methodology for development of new or description of existing business models, initially proposed in 2005 by Alexander Osterwalder and further developed in 2010 [4]. The methodology is focused on strategic management of business models development.

The Business Model Canvas methodology includes five phases (Fig. 2):

1. *Mobilization*
2. *Understanding*
3. *Design*
4. *Implementation*
5. *Management*

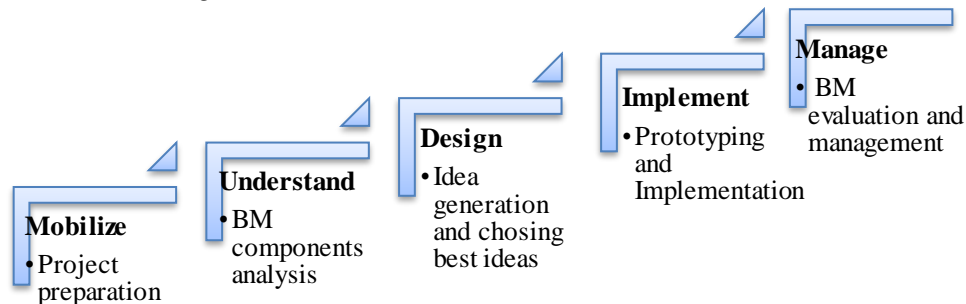


Fig. 2. Business Model Canvas design methodology

Within the *Mobilization* phase, the project objectives, project planning, and team formation are performed.

During the *Understanding* phase, the business model components are analyzed through a combination of activities such as market research, interviewing experts in the field of the domain, and outlining competitive business models.

Within the *Design* phase, innovative ideas are generated, potential business models are tested with external experts or potential clients to receive feedback that can lead to model modification and successful model refinement.

After the final design, the business model is implemented by organizing legal structures, preparing a detailed plan and roadmap of the project implementation, etc. During the *Implementation* phase, a business plan is prepared, project management and risk

management plans and mechanisms for adaptation of the business model after receiving feedback on the market are developed.

The *Management* phase involves continuous assessment of the model and scanning of the environment to understand what external factors may affect the model in the long term.

SAP® Business Model Design and Innovation Methodology, BMDI (2014) is a methodology for designing digital business models, developed by Marco Cigaina and Uwe Riss (SAP experts). It is based on the Business model canvas. The methodology is focused on overcoming the shortcomings of the Business model canvas adapting it to the needs of digital business models by linking the nine elements of Business model canvas with five more elements to describe digital business models [4].

The SAP® Business Model Design and Innovation methodology includes five phases (Fig. 3):

1. *Analyze and improve*
2. *Challenge and change*
3. *Test and verify*
4. *Evaluate and decide*

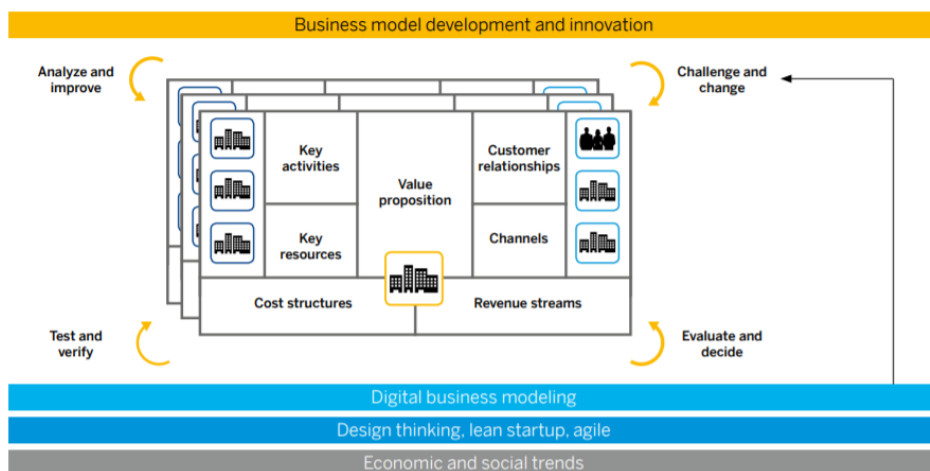


Fig. 3. SAP® Business Model Design and Innovation Methodology (Cigaina and Riss, 2016)

During the *first* phase the current situation, the business environment, and in particular market trends are analyzed. The main purpose is to analyze the existing business model of the organization, to identify new opportunities, and to consider the key digital elements in the model - for example if existing services can be replaced by digital services.

Within the *second* phase, the analysis focuses on digital challenges and opportunities. It includes an overview of the relevant market segments, including competitors' digital business initiatives and customer expectations. As a result of the analysis, a digital business model is designed including changes resulting from the outline of digital opportunities.

The *testing and verification* phase aims at consolidating the developed business model projects. Prototypes need to be tested and validated at an early stage. As a result of testing, prototypes may be dropped, and alternatives developed.

During the *evaluation and decision* phase, the designed models are evaluated and the most promising of them are selected for further evaluation in terms of quality and quantity.

Such an assessment is usually based on two factors: *impact* against *easy* development. The impact factor describes the potential impacts that implementation of the digital business model could bring, while the easy development factor indicates the possible barriers (related costs, internal resistance) could be met.

The key challenge in the design of digital business models is to keep the focus on opportunities related to digital technologies by using five key components (people and communities, business networks, things, data, and cloud) of the business model that are related to the digital value. These components are used as building blocks for the design of the digital business model.

The successful implementation of a digital business model requires development of digital strategy in accordance with strategic goals, adapted to the context in which the analysis and design of the business model are performed.

This methodology offers tools and instruments for definition and description of the strategic goals of digital business model, indicating relevant components of the business model that are affected. The strategic goals identified are as follows:

- *Replacing tangible products with virtual products* or creating intelligent digital services. It affects all components of the digital business model.
- *Increasing customer satisfaction by solution simplification* achieved by extracting the necessary data from public networks (communities, user profiles, devices, and other sources) or by using analytical services, provided through cooperation with companies that provide analytical services or data. It affects the products and services offered and the level of customer satisfaction.
- *Achieving global coverage* mainly through global network access and/or through cooperation with various partners. It affects customers and channel components.
- *Offering customized solutions* by identifying and profiling individual customers and their specific needs using digital technology. It affects customers and channel components.
- *Improved attraction of new and retention of existing customers* is achieved by social networks that provide new access to potential customers. It affects the customer relationships component.
- *Use of business ecosystems* that leads to the integration of companies and more appropriate distribution of tasks in the partnership, creating opportunities for increased outsourcing and cooperation. It affects the key partnerships component.
- *Exploitation of new resources* including digital content, digital technologies, digital services, etc. as a source of value in the business model and as a mean for expanding that leads to a significantly larger amount of data that can be used for new or improved solutions or can be sold to partners for direct use. It affects the resources component.

Presented methodologies are compared based on the business model *components* that describe the model design, the internal and external *ecosystem* that is influencing the model, the *design phases* of the methodology, and *offered tools and instruments*.

The comparison is summarized in table 1.

Table 1. Comparison of the three methodologies

	Business Model Navigator	Business model canvas	SAP® Business Model Design and Innovation
Components Model	1. Customers 2. Offered products/services 3. Value chain activities 4. Revenue Model	1. Customers 2. Offered products/services 3. Value chain activities 4. Revenue model 5. Communication channels 6. Customer relationship 7. Key resources 8. Key partners 9. Cost model	9 components of the Business model canvas plus 10. People and communities 11. Business network 12. Things 13. Data 14. Cloud
Environment	Customers Partners and competitors Technologies Trends and regulations	Market forces Trends Macroeconomic forces	People and Communities Partners and competitors Smart devices and IoT Data and cloud
Design Phases	1. Initiation 2. Ideation 3. Integration 4. Implementation	1. Mobilization 2. Understanding 3. Design 4. Implementation 5. Management	1. Analysis & Improvement 2. Challenge & Change 3. Testing & Validation 4. Evaluation & Decision
Tools & Instruments	Four components to design 55 BM cards Case studies Interactive software for BM design Online courses Workshops	Nine components to design Idea generation methods Visual thinking techniques Prototyping Storytelling 5 BM templates Case studies	Matrix for the description of digital BM BM templates Strategy objectives and focus on digital transformation

The three methodologies are developed to guide business model innovation and suggest components model for the description of the business model.

St. Gallen Business Model Navigator proposes four components, Business model canvas improves the description by five additional components related to communication channels, customer relationships, key resources and partners, and costs. SAP® Business Model Design and Innovation Methodology further develops the concept by including components related to the particular use of digital technologies in the business modeling, thus

focusing on the specific role of digital technologies in the design of digital business models.

Concerning the environment, St. Gallen Business Model Navigator considers the external partners and technologies as key drivers for business model innovation, thus supporting the design of business models based on digital technology. The main concept of the Business model canvas is to deliver value to the customers. It is focused on the organization, what a company delivers, how it will be delivered, and what is necessary to do. This is the reason why some authors [5,6,7] point out some limitations of the methodology: it's static, lack of clear and close connection with the external environment, missing competitive strategy to cope with the competition. BMDI Methodology is designed around the use of technologies and recognizes the technology as the main drivers that influence the business model innovation and digital transformation.

The presented methodologies offer a structural approach to the process of business model design including analysis of the existing business model and environment, generation of new ideas for improvement, prototyping, testing, and implementation phase. In St. Gallen Business Model Navigator, the generation of new ideas for innovation is a core phase of the design process. The process in the Business model canvas is more project management-oriented while the BMDI methodology is inspired by agile methods for development and management.

The methodologies include tools, instruments, and techniques from different approaches and merge them in a toolbox that can be used by companies.

4. Factors for successful digital business model development

Successful digital business model design and implementation depend on strategy and management, business, and technology aspects:

- **Strategy and management aspect**

Digitalization forces all companies to rethink and digitalize their business models in means of market success, which ensures the future viability of the company. Organizations that want to explore the opportunities offered by digital technology to design or redesign their business models face different directions that can be taken. The choice of the right direction is determined by its business strategy and management decisions. Many innovative business models failed because of inadequate business strategy or bad management decisions. Therefore, the design of a digital business model is strongly influenced by the factors:

- Identified strategic goals and objectives that describe a well-defined direction of future development.
- Development of a digital strategy compliant with strategic objectives adapted to the context in which the analysis and design of the business model are performed.
- Strong leadership and support from executive management.

- **Business aspect**

In 2017, an empirical study of 40 companies that have launched new business models in a variety of industries is performed to identify the key factors for success of digital business models that have a potential to transform industries. Company models with a higher number of the following six features were correlated with a higher chance of transformation. The study shows that companies that have been successful in practice are those that have digitally implemented at least three of the six success factors. The factors identified are [8]:

- *Personalized products/services* tailored to customers' individual needs.
- *A closed-loop process* by recycling used products to reduce overall resource costs.
- *Resource sharing* for reducing costs.

- *Usage-based pricing* that charges customers when they use the product rather than purchasing the product.
- *A more collaborative ecosystem* with supply chain partners to allocate business risks and facilitate cost savings.
- *An agile and adaptive organization* that takes real-time decisions based on changes in market needs.
- **Technology aspect**

The technologies that drive the successful implementation of the digital business model are:

- *Sensors and IoT*: Sensor data can be collected continuously from multiple sources and at multiple points in the system, huge amounts of data can be accumulated over the time. Data is generated by sensors and various applications related to the Internet of Things. More and more devices are connected to the Internet and automatically send information to be stored in clouds.
- *Big data, artificial intelligence, and machine learning*: The use of big data is a challenge for businesses because the volume, diversity, and speed with which data is generated and processed have set new requirements for ICT technologies for storage, management, processing, and analysis of big data. Big data enables companies to convert large amounts of data into rules, decisions, and knowledge.
- *Connected devices and cloud technology*: Cloud services are mainly used for storage, archiving, and synchronization of devices. To enterprise systems, clouds offer huge advantages by providing a flexible computing infrastructure, in terms of scalability, location, and capabilities for processing and analyzing data over the Internet. Although data integrity and security are risks when using cloud services, the cloud offers a place where huge amounts of data can be analyzed.

5. Conclusion

New business models are resulting from digitalization and digital transformation processes, that create new ways for developing products, finding new clients, creating and delivering value and generating higher profits. Companies need guidelines to go through the process of transforming their businesses into digital ones and create business model innovations.

Advanced technologies and disruptive innovations catalyze the inclusion of new components within the business models which reflect on developed methodologies for business model design.

In the presented paper the components of a business model are outlined and popular methodologies that propose definitions, guidelines, methods, techniques, tools and instruments for business model design are presented. Based on the literature review, the main factors for successful design and implementation of a digital business model are discussed.

Acknowledgements

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Digital Ecosystem Design Approaches

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Abstract. Digital ecosystems emerge challenged by the digital transformation trends and become an innovative approach for connecting different stakeholders to collaborate and deliver products and services to customers. Digital ecosystems encourage deep changes in markets and alliances - from hierarchically managed supply chains-based markets to non-hierarchically managed interactions between organizations, enabled by openness, modularity, and quality. The paper aims to review the characteristics of digital ecosystems and to introduce an analysis of design approaches, developed by businesses and experts in the field of digitalization and digital transformation. Based on the analysis of the presented approaches, an outline of the main stages and activities in the digital ecosystem design are derived to be followed within the of digital transformation processes in the organizations.

Keywords. Digital ecosystem, Digital platforms, Digital transformation, Digital economy

1. Introduction

Internet is a digital infrastructure that connects users, digital assets, and physical objects and causes changes in business and individual relationships. Internet has become a new environment for introducing new digital products usable worldwide, while reducing communication and transaction costs. Digital products can store and transmit various forms of information, which expand the potential for data sharing between individuals, companies, organizations, and governments, wherever are located. The data can be captured, encrypted, transformed, and stored at different places worldwide. Digitized information can be quickly transported over long distances which allows cross-border marketability of services and reduces the need for physical colocation. Algorithms for accurate prediction of people preferences based on past behavior, patterns, and choices offer new opportunities for people, communities, and regions to connect with the global community and to create new economic opportunities. The ability to connect with anyone anywhere over the Internet is enhanced by technologically complex platforms that reduce barriers to creating communities and networks that are not related to geographical location or jurisdiction.[1]

The digital platform is a digital service that facilitates the interaction between two or more different but interdependent sets of users who interact through the service via Internet. At the beginning digital platforms connected buyers and sellers through transactions. Currently, digital platforms are evolving into complex platforms that bring together consumers, service providers and other stakeholders to facilitate the economic value exchange. Participants in digital ecosystems not only contribute and benefit from the platform, but also generate greater value and innovations for all parties in the ecosystem.

Complex platforms lead to the creation of digital ecosystems that consist of interconnected multisided business platforms with excessive market power. Therefore, various

issues such as competition, regulations, business strategy, innovation and intellectual property are important to be considered.

Nowadays the companies are forced to be digitally transformed and they face the challenges in design and implementation of digital platform and ecosystems processes.

The paper aims at presenting the main characteristics of digital ecosystems to select and summarize the most of available approaches for their design. The result achieved is a developed roadmap with the main stages and activities in the digital ecosystem design within the organizations' digital transformation process. The paper's outcome achieved are based on the performed literature review in the field of digital ecosystems and digital transformation.

2. Digital ecosystems

Digital ecosystems are complex integration of applications, operating systems and platforms that interact in a specific way to enhance the user experience [2]. All activities in the digital ecosystems are designed to ensure the interaction between participants, to create and deliver value for all in the digital ecosystem.

The characteristics of digital platforms are summarized in two aspects [2,3]:

- **Economic and social aspects**

Digital ecosystem consists of a set of ecosystem management mechanisms provided by independent users that complement the value proposition of the platform by co-creating its value. Through mediation in the interactions between users, the platforms become multilateral markets, which are a key part of the modern economy. Digital ecosystems are characterized with:

- **Strong network effects** – The value of a platform per participant increases with the increase of the number of participants. For example, in e-commerce platforms such as Amazon, the value of the platform for the seller increases when there are more buyers and vice versa.
- **Ability of technology to generate new solutions** driven by diverse users. For example, crowdsourcing platforms provide the opportunity to produce new solutions to challenging problems based on the diversity of participants.
- **Reduction of costs** (for distribution, search, negotiation, and monitoring). For example, TripAdvisor collect and combine travel information from multiple sources into one platform, thus reducing the cost of searching for information and using the services of intermediaries.

- **Technological and management aspects**

Technological architecture and organization, and coordination of the technological development of additional products is ensured by principle of modularity and appropriate management structures.

The digital ecosystem comprises of the following elements outlined by Kapoor (2018) [5]:

- **Participants** - interdependent organizations that are digitally connected and not managed by a hierarchical structure. Participants in the digital ecosystems are contributors and users. **Contributors** who autonomously decide to join an ecosystem and provide additional products or services to contribute to the value proposition of the platform. Depending on self-autonomy, contributors can be weakly linked to the digital platform and contribute to the variety of value proposition and strongly linked to a digital platform and form strategic partnerships that strengthen the ecosystem. **Users** who are beneficiaries of

services, who in turn contribute to the value proposition in the platform by providing information on how and which services are used.

- **Value creation** - activities aiming at creating and supporting network effects and market expectations in ecosystem users. Ecosystem leaders and participants should create value in a form of transactions and innovations for end users and in turn generate revenue for all involved in the ecosystem.
- **Digital platform** - a digital service that facilitates the interaction between two or more different but interdependent users via the Internet. Its architecture determines the technological interactions that organize the exchange between supply and demand in the ecosystem. This is a key building block of the ecosystem on which ecosystem partners can build their products or services.

The digital platform architecture is based on the principles of *openness*, *modularity*, and *quality* [6]. Openness means that the platform allows access to the resources of the platform (for example through API), which allows participants in the ecosystem to develop their own solutions. Modularity means providing services and tools for building additional products or services on the platform by different organizations. Quality means to design features that allow high availability, reliability and security of the platform highly valued by ecosystem participants and attracting other participants in the ecosystem.

The ownership of the platform is an essential factor for the design and management of ecosystems. It covers issues like legal management entity, level of ecosystem management centralization and relations between partners in the ecosystem. Centralized digital ecosystems are controlled by a single owner. In such cases, the centralized power of the platform owner becomes enormous and leads to domination of digital platforms in their markets. Digital ecosystems managed by consortia in which a group of participants owns the digital platform. Decentralized digital ecosystems are managed by partner communities. They enable participants directly to influence the future direction of the ecosystem.

3. Digital ecosystem design approaches

In 2016 PricewaterhouseCoopers (PwC) is conducting a study called Global Industry 4.0, with more than 2,000 participants from nine major industrial sectors and 26 countries. The study explores the benefits of digitalization and building innovative digital products and services. As a result of the study, the authors develop an approach for digital business transformation. The creation or inclusion in digital business ecosystems is pointed out a key step in digital business transformation process approach [7].

According to PwC, digital business transformation comprises of six phases:

5. Creation of Industry 4.0 strategy

The phase includes three steps:

- a. Analysis and assessment of the current state in terms of business processes and technologies to identify strengths and weaknesses that can be upgraded, and which processes may need to be integrated into future solutions.
- b. Analysis and evaluation of the partner network to identify new partners for cooperation - customers, suppliers, technology partners and competitors. The strategy needs to consider future changes in customer behavior and how relationships will change.
- c. Establishment of a team, project management and clear leadership needed for building new opportunities, adapting processes and technologies, and driving the necessary cultural change.

6. *Creation of initial pilot projects*

Initial pilot projects can be related with new digital business models, digital engineering, smart maintenance, and service, digital working place, digital marketing etc.

7. *Definition of the needed capabilities*

The definition of needed capabilities is performed within four strategic dimensions: *organization, people, processes, and technologies*.

- New **organizational structures** such as: incubators, centers of excellence and laboratories, where self-organized teams without a formal hierarchy to solve problems or develop ideas in an interdisciplinary way and which provide inspiring, creative atmosphere where a culture of self-learning is encouraged.
- Development of a strategy for attracting **people** with the right digital skills and knowledge.
- Ensuring the security of information and trust in an environment of cooperation and management of risks and threats. The changes cover new models of collaboration, data preparation processes, security approaches, access rights, standards for control and management of sensitive customer data.
- A flexible **IT architecture** for continuous improvement of products and services.

8. *Creation of a strategy for use of data and analytics*

Creating a strategy for data use and analytics focuses on predictive and prescriptive analytics and forecasting, making management decisions based on analytics and automated feedback to the organization.

9. *Transformation into digital enterprise*

Transformation into digital enterprise includes activities like continuous improvement of digital skills related to the design of digital strategy, technological architecture and design of user experience and opportunities for rapid prototyping and talent retention strategy.

10. *Planning an ecosystem approach*

Companies can develop and market products, and services in digital ecosystem, which means that with interfaces to suppliers, partners and customers, the product is embedded in an ecosystem for joint development and new value creation.

In 2017 Deloitte presents the **Strategic Alliance Model**. The challenges of forming a strategic partnership in digital ecosystems are the focus of this model. The stages in the model for formation of strategic partnerships in the digital ecosystem are 3 (Fig. 1)[8]:

1. *Research and analysis of digital ecosystems*
2. *Design of a digital ecosystem model*
3. *Implementation of the digital ecosystem model*

During the first phase, research and analysis of digital ecosystems is including:

- Research and analysis of strengths and weaknesses of the business model and identification of shortcomings in the effectiveness of business models.
- Research and analysis of existing digital ecosystems.
- Identification of key digital ecosystems that can overcome performance gaps in business models and improve the business model.

The second phase is Design of a model for digital ecosystem and consists of the following steps:

- Formulation of ecosystem goals, identification of opportunities and risks
- Selection of digital ecosystem model: expansion of an existing ecosystem or creating a new ecosystem.

A practical approach

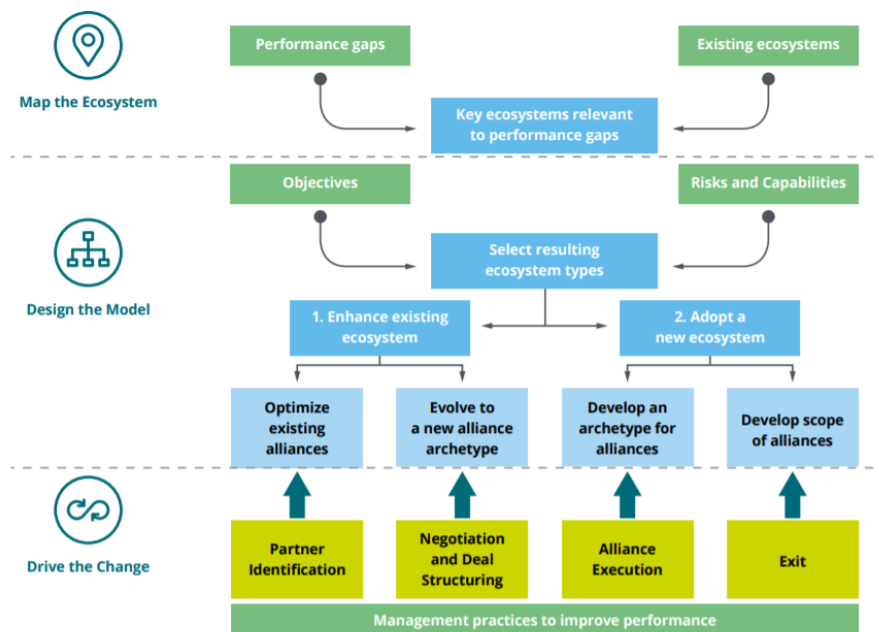


Fig. 1. Strategic Alliance Model of Deloitte (2017)

- Selection of organizational structure of the ecosystem among different options:
 - Centralized: A clear ecosystem organizer who manages the interactions needed to achieve the goal. Participants usually interact only with the organizer.
 - Consecutive: Traditional supply chain or distribution system with a high-level organizer. Participants can interact with other participants up or down the chain.
 - Assisted: Mainly driven by participants with multiple, complex patterns of interaction. The organizer determines only protocols for management and interaction.
 - Self-organized: Powered by participants. There is no organizer and usually includes systems without certain standards or barriers to entry.

During the last phase, the digital ecosystem model is implemented, covering the activities:

- In case of expansion of an existing ecosystem: identification of partners and signing contracts.
- In case of creating a new ecosystem:
 - Formation of the ecosystem organizational structure: different models of partnership - from centralized to self-organized structure.
 - Depending on the organizational structure, investments can be hard (financial or in assets) and soft (in people, methods, processes).
 - Definition of the scope of products and services - joint product roadmap, pricing, marketing, and branding.
 - Determining the degree of exclusivity and rules of engagement (geographies, customers, products).

- Identification of key performance indicators - shared key performance indicators, financial indicators, operational SLAs, and incentives.

In 2019 Valdez-de-Leon in the article "How to Develop a Digital Ecosystem: a Practical Framework", presents the main aspects of the digital ecosystem that need to be encompassed in the digital ecosystem design process (Fig. 2) [6]:

1. *Digital platform*
2. *Network effects*
3. *Market expectations*

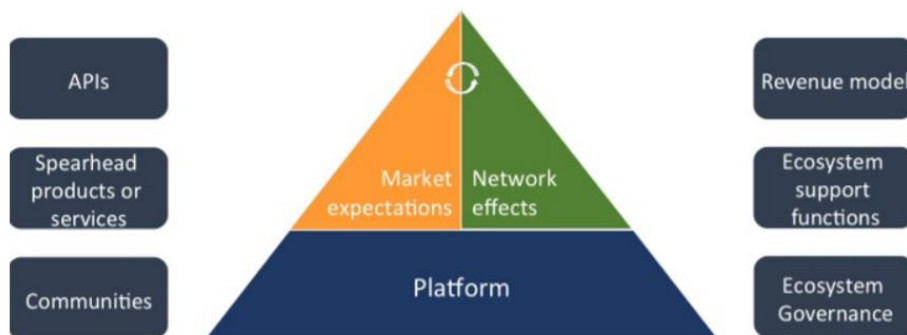


Fig. 2. Digital ecosystem model of Valdez-de-Leon (2019)

Platform: a key building block of the ecosystem, which enables ecosystem partners to build their products or services. In the process of designing the platform, important aspects are openness, modularity, and quality. The platform in turn supports the other two elements.

Network effects: the second element concerns the self-improving cycle of participation in the ecosystem. More participants and products or services in the platform lead to more end users attracted by it. At the same time, attracting more end users to the platform leads to more participants with their products and services. Ecosystem leaders and actors should create value for end users, which in turn generates revenue for all those involved in the ecosystem. The ecosystem strategy must be based on fair revenue sharing and incentives to participate, such as access to market channels, as well as the sharing of marketing resources and technical support. The ecosystem must be designed to allow for rapid expansion.

Market expectations: market expectations are related to how future consumers perceive an ecosystem in terms of its potential expanding. To shape market expectations, organizations that develop the digital ecosystem can launch specific products to boost engagement and launch the ecosystem. Establishing an initial set of partnerships to support the ecosystem is essential for further growth of market expectations.

Valdez-de-Leon's proposed framework for creating digital ecosystems is based on the key components with a focus on the application of the six factors – APIs, Communities, Innovative Products/Services, Revenue Model, Ecosystem Management and Supporting Functions to the creation of digital platforms. The six factors can be used in different ways, depending on the context, the maturity of the ecosystem and the strategy pursued.

The presented three approaches for designing digital ecosystems - PwC (2016), Deloitte (2017) and Valdez-de-Leon (2019) are developed as a result of research made by businesses and experts in the field of digitalization and digital transformation. These frameworks outline

the stages in the design of digital ecosystems, including a set of steps, which are realized by different methods and tools.

Table 1 presents a comparison between three presented approaches based on their scope, focus and design phases.

Table 1. Comparison of the three approaches

Approach	Scope	Focus	Design Phases
PwC (2016)	Digital transformation	Business organizations	<ol style="list-style-type: none"> 1. Creation of Industry 4.0 strategy 2. Creation of initial pilot projects 3. Definition of the needed capabilities 4. Creation of strategy for use of data and analytics 5. Transformation into digital enterprise 6. Planning an ecosystem approach
Deloitte (2017)	Strategic Alliances	Digital ecosystems	<ol style="list-style-type: none"> 1. Research and analysis of digital ecosystems 2. Design of a digital ecosystem model 3. Implementation of the digital ecosystem model
Valdez-de-Leon (2019)	Digital ecosystems elements	Digital ecosystems	<ol style="list-style-type: none"> 1. Development of digital platform (APIs, management, and maintenance) 2. Design of network effects (Revenue model, Communities, Products/services) 3. Formation and support of market expectations (Communities and Products/services)

PwC (2016) is focused on the digital transformation of the business organizations and the design of digital ecosystems is the last step of the approach that shapes the transformation of business organizations. Deloitte (2017) and Valdez-de-Leon (2019) target the design of a digital ecosystem.

Based on the analysis of the three approaches, main stages for design and development of a digital ecosystem are outlined and presented in table 2.

Table 2 Design of digital ecosystem

Stages	Phases	Activities	Results
1. Analysis	State-of-art in the organization	Analysis of: <ul style="list-style-type: none"> • Business processes • Offered products and services • Technologies used • Elements of the business model • Partnership network • Internal and external environment 	<p>Identified strengths and weaknesses</p> <p>Identified opportunities for change</p> <p>Ideas of a business model innovation</p>
	Existing digital ecosystems	Analysis of the existing ecosystems based on their characteristics and elements	<p>Identified key digital ecosystems and opportunities and a strategy for:</p> <ul style="list-style-type: none"> • Expanding an existing ecosystem <p>Or</p> <ul style="list-style-type: none"> • Creating a new ecosystem
2. Design	Business model	Available methodologies and tools for business model design	Designed improved or new business model
	Digital platform architecture	<ul style="list-style-type: none"> • Selection of ownership model of the platform • Design of value creation mechanisms and participation in the platform (community) • Creating APIs • Data sharing mechanisms 	Digital platform architecture
	Digital ecosystem model	<ul style="list-style-type: none"> • Formulation of ecosystem goals, identification of opportunities and risks • Selection of a digital ecosystem model and organizational structure • Definition of Ecosystem management model • Planning of market expectations and network effects • Revenue model 	Digital ecosystem model and architecture

3. Implementation and evaluation	Digital business model	<ul style="list-style-type: none"> • Prototyping business model • Test and evaluation • Implementation 	Digital business model applied
	Digital platform	<ul style="list-style-type: none"> • Prototyping digital platform • Test and evaluation 	Implemented digital platform
	Digital ecosystem	<ul style="list-style-type: none"> • Formation of the organizational structure of the ecosystem • Determining investments depending on the organizational structure • Determining the degree of exclusivity and rules of engagement • Identification of shared key performance indicators, financial indicators, operational SLAs and incentives • Evaluation 	Digital ecosystem

The **Analysis** stage starts with activities related to analysis of the current situation in the organization aiming to identify the strengths and weaknesses, and the level of digitalization of the business. The analysis is focused on business processes, offered products and services, technologies used, elements of the existing business model, partnerships, and internal, and external environment. As a result, new opportunities for development are formulated with the aim to improve or create a new business model. During this stage, a research and analysis of existing digital ecosystems is performed to identify if available digital ecosystems can overcome shortcomings in the efficiency of the business model and improve it. Based on the performed analysis, a strategy for the development of the digital ecosystem is elaborated based on decisions to expand or join an existing ecosystem, or to create a new ecosystem.

The **Design** stage covers activities for designing an *improved or new business model*, *digital platform architecture* and *digital ecosystem model*. Available methodologies and tools for designing business models are used. The business model is described and ready for prototyping. During the process of design, the digital platform architecture, activities considered are selection of ownership model of the platform, design of value creation mechanisms and participation in the platform, APIs, and data sharing mechanisms. The design of the digital ecosystem model starts with formulation of ecosystem goals, identification of opportunities and risks, selection of a digital ecosystem model, definition of organizational structure and management model, planning the market expectations, network effects and the revenue model.

The last stage of **Implementation and evaluation** of the designed business model concerns implementation of s digital platform and an ecosystem. The business model and digital platform go through the cycle of prototyping, testing and evaluation before their implementation. In the implementation of the digital ecosystem, the activities differ depending

on the formulated strategy in the Analysis stage - to expand or join an existing ecosystem, or to create a new ecosystem. In case of expanding or joining an existing ecosystem, the activities include finding partners, negotiating, and contacting them. In case of creating a new ecosystem, the organizational structure and investments are established, a joint roadmap for pricing, marketing, and branding, and degree of exclusivity and rules of engagement (geographies, customers, products) are determined. It is also very important to identify key performance indicators valued for the ecosystem, financial indicators, operational SLAs, and incentives, as well.

4. Conclusion

Design and implementation of a digital ecosystem are critical challenges for companies in the process of digital transformation.

In the paper, characteristics of digital ecosystems and available approaches for their design were presented. Based on the literature review, main stages in the digital ecosystem design of companies approaching digital transformation are outlined.

Approaches for design of digital ecosystems determine the main aspects that should be considered, but still there is a need for elaboration of a complete methodology to cover definitions, methods and tools to ensure the successful ecosystem's implementation and development.

Acknowledgements

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Integrated Software Environment Based on Spark for Predictive Analytics with Using DuPont Model

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Abstract. Building an integrated software environment for predictive analytics based on Spark, involves loading the Spark software package, along with all the accompanying programs needed to perform predictive analysis and visualize the results. Predictive Analytics helps an organization detect and predict trends, anticipate business changes, and stimulate empirical strategic decision-making using a set of methods and software tools. The example in this document is focused on the predictive analysis of ROE.

Keywords. Predictive analytics, Analytical systems, Processing, ROE

1. Integrated software environment for Predictive Analytics with Spark

Building an integrated software environment for predictive analytics involves loading a copy of the Spark software package, along with all the accompanying programs needed to perform predictive analysis and visualize the results [1].

To install a local version of Spark, must select the surrounding software products because they must be installed with it. As the Spark package itself does not have the means to algorithmize the Predictive Analytics and visualization of the processing, this activity will be performed via Python. In general, the architecture of the installed system will be as follows in Fig 1.

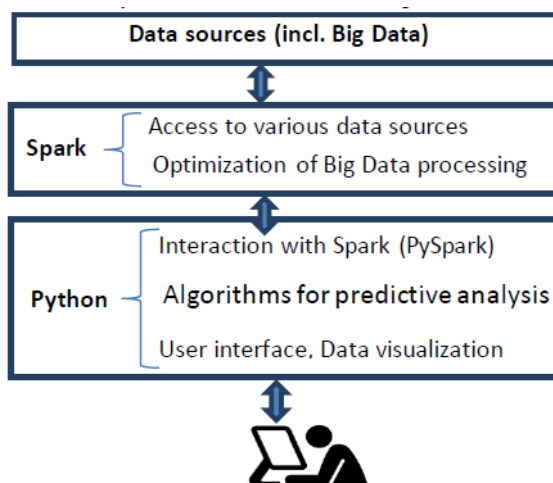


Fig. 1. Architecture of the installed system

Spark SQL allows SQL queries to be executed on structured data. Spark streaming uses micro batch processing to provide near real-time data processing. However, when a person needs real real-time processing, such as automated stock trading, he needs Apache Storm. MLib provides a library of algorithms and machine learning utilities. GraphX provides algorithms for applications that structure data as graphs so that the user can, for example, identify potential friends or social media connections. SparkR is a distributed framework with an interface that supports operations for selection, filtering, aggregation of big data.

PySpark is the integration, the connection of Apache Spark and Python. Apache Spark is an open source cluster framework, and Python is a universal, high-level programming language. This language is needed for further calculations. Python is an algorithmic and analytical language, the installation steps of which we will specify, with which to further algorithmize the processes, perform analyzes and make graphs.

2. Predictive Analytics

Predictive Analytics helps an organization detect and predict trends, anticipate business changes, and stimulate empirical strategic decision-making using a set of methods and software tools for forecasting analysis.

Predictive Analytics combines statistics, machine learning, data acquisition, and modeling to analyze content and historical facts in order to make predictions for future events. Forecast analysis enables people to better predict the future based on data from the past. Based on indicators created by him, which come from patterns of behavior and activities of the past, actions can be taken by companies to influence future purchasing decisions of consumers.

The Predictive Analytics in the field of accounting should reflect the planned financial condition of the organization as of a certain date, in terms of assets, liabilities and capital. Predictive Analytics is usually related to the business strategy of the organization. The Predictive Analytics ends with the provision of a predictive balance.

The predictive balance sheet may reflect the financial condition of the organization as a whole or of any of its divisions. In some cases, during its formation, indicators are taken into account that are able to give the company's management the opportunity to assess the degree of satisfaction of the customer and the counterparty from its activities as one of the factors for demand for products or services.

The methods of the predictive balance used in the formation of its structure in relation to the business model of an enterprise may be different. Thus, the competent specialists of the company can adapt it to reflect the estimates of revenues and expenses specifically for the sale of products, if the relevant source is the main one in terms of the formation of the company's revenues. The balance sheet compiled in this structure may include indicators classified as those relating to the accrual method or cash, if necessary to improve the quality of forecasting business indicators.

It is possible to make a predictive balance of the enterprise with an emphasis on the difference between the cash flows generated by revenues and those created as a result of investing in business by owners, partners, creditors. This document may also include data on costs related to investment income or capitalization.

The compilation of a predictive balance includes:

- Analysis of the current financial indicators within the activity of the company.
- The study of the financial results for the different reporting periods, as well as the identification of factors that may affect them. This includes all historical periods for which the organization has data.
- Determining the changes in the assets, liabilities of the company, its revenues and expenses, in accordance with different reporting periods.

- Formation of predictive indicators and their subsequent documentation.

In order to form the relevant predictive indicators, it is necessary to build an integrated software environment for predictive analysis.

3. Methods for Predictive Analytics

Predictive Analytics uses mostly quantitative statistical and mathematical methods. These methods focus on the use of known data, which includes input data properties and a target model to build a model on which to make predictions for the future.

When compiling Predictive Analytics, several KPIs are used.

We choose as an example two of the most commonly used - return on equity (ROE) and Return on Assets (ROA).

Return on Equity (ROE)

“ROE represents the financial performance of the company, or the money that the company makes on the basis of the individual’s total ownership stake. One can calculate it by dividing net income by shareholder’s equity. The formula for calculating shareholders equity is Asset of the company – Debt.

The purpose of calculating ROE is to find out how effectively the company is utilizing the assets to earn profits. Net income, in this case, is the total income, net of expense and taxes for a given period.

ROE could be positive or negative, but it being good or bad depends on the industry standards. If a company is outperforming peers, then we can say that the company is performing better than others. However, investors mostly take S&P500 as a benchmark and compare the return of their investment against the same.” [2]

Return on Assets (ROA)

*“A common formula for determining ROA is **operating income** divided by total average assets. Operating income refers to the amount of income your business receives from its activities. Total average assets usually refers to the average of assets at the beginning and end of a period, typically a year.” [3]*

In order to be able to forecast the return on equity (ROE) we will use the DuPont model [4].

4. Using the DuPont model

The DuPont model is one of the most popular models for analyzing the return on assets (of the capital invested in the business). The main goal of the DuPont model is to identify the factors that can determine the effectiveness of the business in order to assess the degree of influence of these factors on trends in terms of their changes and significance. This model forecasts the return on equity (ROE), and the task is to identify the factors that affect the value of ROE through the model.

In the DuPont model, the return on equity (ROE) is presented as the product of three factors:

- Net profit margin = (Net Income / Sales value)
- Total asset turnover = (Sales value / Total Assets)
- Financial leverage = (Total Assets/ Equity)



Fig.2. DuPont model formula

To calculate the estimated return on equity (ROE) it is necessary to determine the four components involved in the formula. The size of three of the components can be regulated through company management decisions.

- Planned amount of own assets
- Planned amount of total capital - by increasing or decreasing the attracted capital.
- Planned return on sales - by increasing or decreasing prices relative to cost.

The subject of probabilistic forecasting is the volume of sales.

In this document we will use one of the popular methods for forecasting time sequences with seasonal changes SARIMA (Seasonal Autoregressive Integrated Moving Average). The method is available in the Python statsmodels library. The example will be built using Python.

To check the validity of the model, we divide the data into: data for training of the model -2017-2019 and data for test -2020. After training the model, we compare the forecast data for 2020 with the test data - the real data for 2020.

It is necessary to train the model to check whether it gives sufficiently accurate data for a previous period.

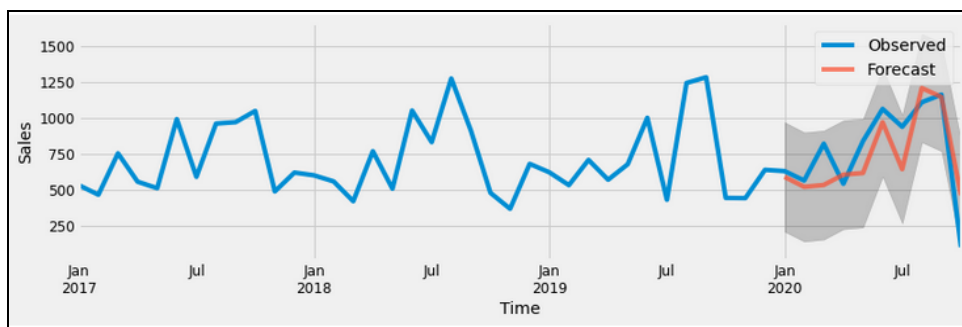


Fig. 3. Data obtained from model training

The predicted data are close to the real ones. For statistical evaluation, indicators such as: Mean Squared Error, which takes into account the root mean square difference between the predicted values and the actual value, and Root Mean Squared Error, used as a measure of the differences between the values predicted by the model, are used. and the observed values.

About the model:

- Mean Squared Error is 595.97
- Root Mean Squared Error is 24.41.

Application of the sales forecast model for 2021 and 2022

Once we have made sure that the forecast data are close to the real ones, we can apply the model to forecast sales for 2021 and 2022.

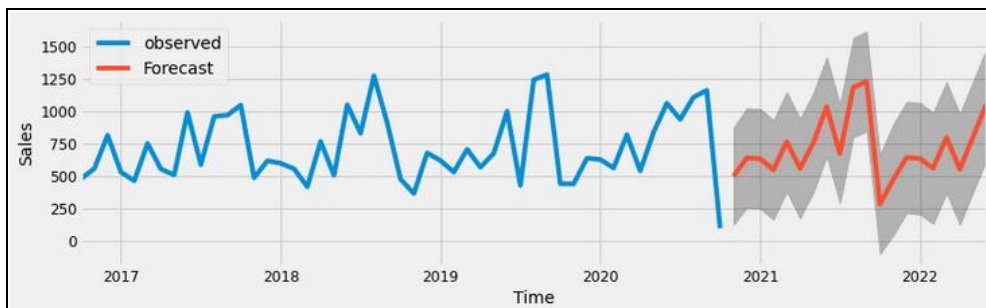


Fig. 4. Data obtained from the application of the forecasting model

Once we have obtained the estimated value of sales, we can calculate the estimated value of ROE for 2021. We could use for example What-If analysis, reproducing the model with different values of the parameters managed by the business organization of the other three quantities - equity, total capital, and return on sales ratio. In order to obtain data for the research, the aggregated data from the specialized companies can be used.

5. Conclusion

Based on the considered example, we found that we can build an Integrated software environment based on Spark for Predictive Analytics with using DuPont model. The example focused on the predictive analysis of ROE. In order to obtain data for the research, the data aggregated by the specialized companies can be used. Data are taken from financial statements by industry, which are provided against payment. A certain amount have to be paid to the companies for receiving such data.

Acknowledgements

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Storing Big Data in NoSQL Databases Compared to SQL – Advantages and Problems

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Abstract. The present paper gives a definition for Big Data, explains the different types of data that can be collected and gives the main characteristics of Big Data. In the paper are included examples of the 3 types of data that can be collected – structured, semi-structured and unstructured. A definition of NoSQL databases is presented. The study presents advantages and problems for storing Big Data in NoSQL databases compared to SQL.

Keywords. Big Data, NoSQL, Structured data, Semi-structured data, Unstructured data

1. Introduction

Nowadays technologies are developing in such fast pace from simple telephones, through sensors that are used almost everywhere in our daily life to computers, robotics, Artificial Intelligence, and Internet of Things. Everything from above generates different types of data – structured, semi-structured and unstructured. Not only the technologies are developing but more and more people are using different types of devices that generate even more data.

Generating and gathering data gives us one of the biggest challenges – where and how we will store and process data that is gathered. Here comes the term Big Data and NoSQL that we will examine in detail in the following paper.

2. What is Big Data?

Big Data is the term that describes the data, which is so large and complex that it is difficult or in some cases impossible to process using traditional methods [1]. Gathering such vast amounts of data, it is useful for making better and broader analyzes of given problems, which are important for the companies.

The sources of the data are becoming more and more complex, and are gathered from different sources as Artificial Intelligence, mobile devices, social medias, etc. As we mentioned before the different types of data are gathered from different types of sensors, the web, social medias, which are generated in real-time in very big quantities.

This leads us to the next important point in this paper – the different types of data that can be collected – structured, semi-structured and unstructured data.

3. Types of data

Depending on the sources from which the data is collected, there are 3 types of data – structured, semi-structured and unstructured. The structure of the data is important not only

for how you are going to work with it, but what conclusions can be drawn and what solutions of given problems of companies can be made.



Fig. 1. Types of Data

Structured data is all the information that can be stored and processed in fixed format [2, 4]. Structured data is usually stored in relational database. In this type of databases, the tables are created beforehand and the types of data that will be stored inside are defined and cannot be changed later. As we already said the structured data has predefined structure. It can be stored not only in relational databases, but in Excel also. Some examples of structured data are financial and accounting transactions, addresses, customer information, locations, etc.

Semi-structured data is data that cannot be organized in relational database because it does not have strict structure but still has some [2, 4]. Semi-structured data has characteristics from structured and unstructured data. One example of semi-structured data is an email. The email message has some structure, as it has the email of the sender, the recipient, subject, etc. The message sent by itself is unstructured, but the rest of the email has some beforehand defined fields.

Unstructured data is type of data that does not have any form of structure, it cannot be stored in relational databases [3]. For this type of data is quite difficult to be processed and analyzed because it comes in different formats. Nowadays, the unstructured data, is the type of data that is mostly generated, so we need to make sure that we can store and analyze it correctly. Examples of unstructured data are photos, videos, text files, websites, social media content, PDF files, etc.

4. Main characteristic of Big Data

Big Data is large amount of data that cannot be processed by traditional methods. It has some characteristics that are important for understanding how to work with this type of data and they are called V's. In the following paragraphs we will give definitions of the 5 most important V's of Big Data – Volume, Veracity, Variety, Value and Velocity [5,6].

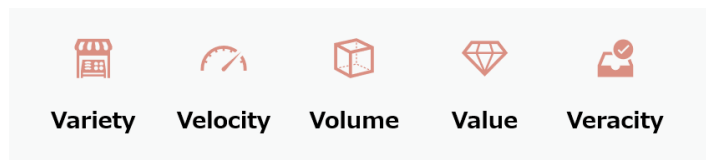


Fig. 2. Characteristics of Big Data

The first characteristic that we will look at is the Variety. This characteristic refers to the diversity of data and sources it is coming from. Nowadays, the sources of data can be emails, images, PDF files, audio files, video clips, etc. or said in other way the data can be structured, semi-structured and unstructured depending on the source from which is coming from.

The next characteristic that we will look at is the Volume. The data comes in immense amounts, because of all the systems, devices, social medias, processes that generate data not daily, not hourly, but they generate huge volumes of data every second. The greatest example of Volume in Big Data are the different social medias with many registered accounts, because there every second a person is making some interactions as liking posts, following people, sharing news, etc. The next V in the line is the Velocity. We have great variety of data that is generated in great volumes every minute with huge Velocity. This characteristic defines the speed with which the data is generated in real time and the speed with which is processed.

The next characteristic of Big Data is Value. This V is quite important because we may gather big quantities of data, with great velocity and volume, but the data must be valuable or said in other words – for the data to be gathered, stored, processed, and analyzed in a proper way, and then to be useful for the business.

Finally, we will look at the Veracity. This characteristic means that the data should be accurate and reliable. This could be proved with the source of the data.

These are the 5 most important V characteristics, but Big Data continues to grow and develop because of all of the technologies that are developing and the data that is gathered, stored, and analyzed, and for that reason many more V characteristics appeared with time.

5. Definition of NoSQL

NoSQL database is a non-relational database, which stores and uses key-value for data access and retrieval. NoSQL databases do not have fixed schemas [23]. These types of databases are used for large data volumes and when flexible data model is needed, which is quite important for the applications nowadays. NoSQL database do not use rows and columns in tables as relational databases do. NoSQL stores every element into the database with unique key and in addition to that this type of database does not need a prefixed schema. It has a lot of advantages for storing Big Data, but that will be the subject of the following points.

Operations in NoSQL are faster than these in the relational databases and the data structures which are used are more flexible. Operations in non-relational databases are faster, because the data is spread across the nodes and it is processed faster. Some of the NoSQL databases do not follow the ACID principle (Atomicity, Consistency, Isolation, Durability), but others do follow it partially. The difference comes from that the non-relational databases are created to have high availability and that can damage either the consistency or the durability.

There are 4 types of NoSQL databases, which can resolve different problems based on the needs of the company. The types are Key-value pair, Column-oriented graph, graph based and document oriented. The NoSQL database has some important principles about consistency, availability, and partition tolerance. The data should be consistent after an execution of an operation in the database, the database always should be responsive, and the partition tolerance principle says that the database should continue functioning even when the communication is not stable [24].

Key-value database is a database that uses key-value method to store data, which means that data is stored as collection and connects value with key, as the key is a unique identifier [18,19]. The key-value database is useful for efficient finding of values by their key. This type of database is partitionable and supports horizontal scaling. The key can be anything, the only thing is that needs to be unique and if the database by itself has some restrictions. The key-value database is very fast in reading and writing operations, also flexible, which is very important with all the emerging technologies nowadays. Examples of key-value databases are Oracle NoSQL, Redis, Riak.

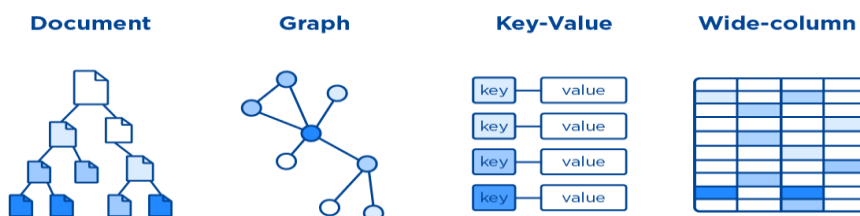


Fig. 3. Types of NoSQL databases

Document-oriented database is a database that stores data as documents in JSON format [20]. These types of databases are flexible and semi-structured, which allows them to evolve with the need of the application and the needs of the business. Document-oriented databases work well with user profiles and content management systems which develop with time. The schema of this type of database is flexible, which means that it doesn't need to be predefined. One of the most famous examples of document-oriented database is MongoDB.

Graph-based database is a non-relational database that stores and navigates relationships [21]. Graph database use nodes and edges. Nodes store data entities and the edges store the relationships in between them. This type of non-relational database is very useful if used for social networking, fraud detections or recommendation apps. Graph databases are flexible and scalable, so no prefixed schema is needed. The way of expanding this type of non-relational database is by adding new nodes and edges. Examples of the graph-database are Cassandra, IBM Graph, Azure Cosmos DB.

Column-based database is a non-relational database that stores data in tables by columns and not by row [22]. This type of database is convenient for fast retrieval of data, which is very useful for analytical applications. Examples of column-based databases are MariaDB, Apache HBase, Apache Kudu.

6. Definition of Relational Database

A Relational Database is a database in which the data is stored in predefined tables [8, 9]. Relational databases are based on relational model. The table consists of columns and rows, as in the columns is the type of data and the fields consists of the actual value that is stored. In relational databases there are primary keys, which ensure that the record entered is unique and their foreign keys, which form the relationships with the rest of the tables in the database.



Fig.4. Relational Database

7. Advantages and problems for storing Big Data in NoSQL databases compared to relational databases

Relational and non-relational databases have different approaches when it comes to data. In the previous points we looked at the main characteristics of both databases and now we will look at the advantages and problems for storing Big Data in NoSQL databases compared to the relational databases.



Fig. 5. SQL vs. NoSQL

Relational databases consist of tables which are connected in between each other with relations and each table has a primary key and a foreign key. In the next few paragraphs, we will examine some of the biggest advantages and disadvantages of the Relational databases and if it is possible to store Big Data.

This type of databases has the following advantages:

- Data Accuracy

Data accuracy means that there is no possibility of duplication of data thanks to the relations of the database and the primary and foreign key.

- Data integrity

Data integrity confirms that the data in the database is accurate, complete and there is consistency in it.

- Normalization

Normalization is a technique that makes sure that there are not any differences in the structure of the database [10]. Normalization divides bigger tables into smaller ones, which are connected with relationships with the help of primary and foreign key.

- Easy use

Relational databases consist of tables, which consist of rows and columns, and are very easy to understand and use.

- Possibility of Future Improvements

The relational databases store everything in different tables, which are divided by categories and are connected to one another, which means that if improvements are needed by the business it will not be a difficult task to make changes when needed.

There are quite few disadvantages about the Relational databases.

- Architecture

The biggest disadvantage of the relational databases is that the architecture needs to be developed beforehand. Some companies and business cannot give an exact structure of what they want from their system and because of that it is quite difficult to develop everything from the beginning and eventually it may need changes.

- Structural limits

When creating relational database, the datatypes should be defined beforehand and there are cases in which the system will need more characters for some fields, but the database do not support it, which directly leads to data loss.

- Amount of data

Some relational databases become more complex when the data grows, which complicates the relations between the data.

- Speed

With the increasing amount of the data the relational database becomes slower.

NoSQL databases developed more and more in the last years because of the emerging technologies that generate a lot of data and need more storage. Let us look at some of the most important advantages and disadvantages.

NoSQL advantages:

- Flexible data model

NoSQL databases can store and combine different types of data – structured and unstructured.

- Possible changes

NoSQL databases does not mean that we do not have schemas when we say that unstructured data can be stored, but the schema can be updated and can change with the different requirements that appear from the business.

- Scalability

NoSQL databases scale linearly, because of the servers that are used, not like the relational databases where the databases are scaled as we add more memory, processors, and additional storage.

- Efficiency

In the non-relational databases, the data is stored and processed faster because of the scalability and the use of data partitioning. Data partitioning means that data is spread and is spread across the nodes.

NoSQL disadvantages:

- Data Consistency

As mentioned earlier the non-relational databases do not follow the ACID principles, which is the technique that makes sure that the entire data in the database is consistent. For that reason, this is one of the main disadvantages of the NoSQL databases.

- Security

The terms of security in the non-relational databases are still developing and that is one of the disadvantages. Security may be quite difficult because of the unstructured data that is stored and the distributed servers.

- Standardization

The design of the different NoSQL databases and the query language may vary from non-relational database to non-relational database.

We mentioned that as the technologies develop the volume of the data that is generated escalates quickly, and because of that we will need a lot of storage, so here comes the question: Which is better for Big Data – relational or non-relational database? The two types of the databases have their own characteristics, also advantages and disadvantages in different scenarios.

The benefit if a relational database is used for storing Big Data is that ACID principle, as the integrity and data consistency is very important not only for the database, but for the system created on this base after. Also, relational database is the perfect option for storing and handling structured data, except if the volume of the data is becoming more and more.

Table 1. SQL vs NoSQL

	SQL	NoSQL
Structure	Needs predefined tables with the data types that will be stored.	Does not need predefined schema.
Flexibility	The predefined structure cannot be changed	Original structure can be changed
Scalability	Vertical scaling	Horizontal scaling
Efficiency	The data is stored and processed in one place, which means that for the next data to be processed the previous one should have finished.	The data is stored and processed faster because of data partitioning and spreading across nodes.
Principle	Follows ACID principle	Follows CAP principle

The NoSQL database comes as the best option for storing large volumes of semi-structured and unstructured data of different types, because the data type can be changed and even there is no need to define it in advance. Other positive things of the non-relational database are the cloud-based storage and the fast development. When working with Big Data the ability to handle different data types is quite important and the option to change the original structure, which gives great flexibility of the NoSQL databases. Relational databases have difficulties in this part of working with semi-structured and structured data.

8. Conclusion

As a conclusion, we cannot say with certainty if the relational database or the non-relational database is better for storing Big Data, because this depends on the business, the company, the ideas, the types of data that need to be handled, if this data will increase immensely fast. NoSQL databases are more flexible, scalable, faster, changes can be made in the structure, but relational databases are easier to use, the data integrity and data accuracy are better, so everything depends on the case.

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Key Aspects of Leadership in Business Organizations under the Conditions of the Covid-19 Pandemic

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Abstract. The paper reviews emerging aspects of leadership in business organizations under the conditions of the Covid-19 pandemic as identified two levels of its realization – on an organizational one and individual one, cultural approach to leadership, pursuing leadership through human resources and appropriate communications, considering the opinions and experience of outstanding individuals in the business world.

Keywords. Corporate culture, Crisis management, Personnel management, Natural Disasters and Their Management

1. Introduction

The times of crises are traditionally considered as promising opportunities of renegotiating and reaching new consensus among constituencies of target companies, pursuing irreversible acceleration in their organizational and market performance through social innovations, new business models, better employee engagement and implementation of new technologies. The ongoing Covid-19 pandemic has already disclosed some interrelated nuances as health, economic and financial ones. On one hand, the occurrence of all these contradictory phenomena in the business world is tightly related with timely planning and conducting of change management initiatives by senior executives.

On the other hand, change management is interwoven with performing of leadership efforts in companies, simultaneously striving for sustainable increase in profitability and organizational growth. *That is why the purpose of this report is set to review the emergence of key aspects of leadership in business organizations under the conditions of the Covid-19 pandemic.* Literature review, content analysis and critical analysis represent the applied research methods in this paper.

2. Diverse aspects of undertaken leadership initiatives

The solving (resolving or absolving) of pending business related issues, originating from the development of the current Covid-19 pandemic, provoke leaders to pursue survival and new competitive advantages for their companies by means of discussing, planning and implementing necessary cultural changes in their organizations [1, 2]. Furthermore, the importance of undertaking deliberate leadership interventions, continuously shaping the image of the aspired organizational culture during the entire realization of the employee life-cycle in the company, is also emphasized. Thus, relying on good practices of succeeding companies during the current crisis, O'Boyle and Hickman [1] apply the process approach by introducing a set of three steps in order to create an organizational culture with potential to inspire personnel members (Table 1).

Table 1. Creation of aspired organizational culture by managers

<i>Steps</i>	<i>Description</i>
1. Capture	Managers are expected to take mental snapshots of the ongoing work-related situations in the companies in a timely manner by applying cultural analysis (What happened? How it felt to be a part of the respective event? What worked and what didn't work? How to proceed in a similar situation in the future?).
2. Codify	Based on the advantages and disadvantages of the observed cultural manifestations, managers are expected: (a) to create the appropriate language, intended to support important aspirational cultural attributes, (b) to identify target cultural forms subject to unlearning by the personnel members and undertake concrete actions to discontinue their existence, (c) to find unique answers of what brings organizational success under normal work conditions or during the occurrence of key marker events, and (d) to analyze the realized ideation (invention) process in the company ("Who originated the idea? How did the idea get evaluated? Who was part of the decision-making process? What was the approval process?").
3. Communicate	Managers are expected to share meaningful stories of success, supporting their employees' hope in the future and clearly relating their meanings with key aspects of the aspirational organizational culture.
Source: [1].	

Deliberate change interventions in organizational cultures are recommended not only to the specific case of this crisis, but also to any key marker events in the future with potentially great devastating impact on the respective business (i.e. disruptions) whose negative short-term effects and long-term consequences for the company may be mitigated or even inverted by the proactive actions of the managers, monitoring the business environment, detecting early warning signals and adopting a strategic approach to build or strengthen organizational resilience [2]. Reshaping organizational culture to one, characterized as strong, preserving only a small set of core values, providing opportunities for leaders and their followers to transpose company mission in each work-related decision and activity even in situations when shifts in priorities are unavoidable. A structured, consultant-led discussion for the creation of supporting organizational culture is proposed, based on several questions (see Table 2).

Forrester, Hillman and McDevitt [3] who reflect on the results of a global leadership survey [4], limit the span of their analysis to outline some emerging changes in organizational culture only in the short run, because of the high unpredictability in the (business) environment that hampers the prognostication in the mid- and long-run. Managers' intentions of restarting organizational growth and driving positive cultural change for this purpose are not questioned, simply the possible initial culturally congruent strategic positions of companies (i.e. "distinct cultural pathways") at the threshold of this crisis are mapped and succinctly described, classified by their potential of ensuring faster recovery – "strengthened and enhanced", "adaptive and recalibrating" and "arrived and deprived". Thus, several characteristics of aspired organizational culture are formulated (i.e. strong, managed and constructive). Furthermore, two basic nuances in the relationship "pandemic-related changes - dominating organizational culture", pertaining to the successful performance of organizational leaders, are outlined:

- The need of understanding cultural changes in context

- The precision in measuring of the employee opinions in relation to establishing a new, negotiated, workplace social contract that may balance the interests of constituencies under the new conditions.

Table 2. A list of specific questions, intended for discussing the creation of “thriving work culture”

<i>The questions...</i>
1. What opportunities exist to strengthen and reinforce the organization's purpose, mission and vision?
2. What opportunities exist to capitalize on positive brand sentiments gained from demonstrating organizational values with employees and customers?
3. What organizational values need to be institutionalized to further localize effective decision-making?
4. How can innovation and speed to market accelerate?
5. What key leadership messages need to be amplified?
6. What cultural values in action need to be in the spotlight?
7. Are leaders and managers engaged to drive a culture of performance on their teams?
Source: [2].

Based on this analysis, concrete recommendations are provided to founders and leaders in contemporary business organizations in order to collaborate better with their employees (Table 3). But this leadership initiative should be viewed predominantly as an integral part of searching a new consensus and new balance with all firm's constituencies in their incessant quest of solving the issue of external adaptation [5].

Table 3. Preparatory leadership initiatives at the first stage of solving the external adaptation organizational issue

Leadership initiatives	Specific actions
1. Listen with empathy	1.1. Creation of safe space for employees to share their experiences and opinions without being reproached or punished. 1.2. Building employee trust through deliberate actions, incarnating “credibility, reliability, low self-orientation, and compassion”.
2. Measure and gather the voice of the personnel	2.1. Choosing an appropriate way of measuring the organizational culture. 2.2. Pursuing strong fit between dominating organizational culture and the expressed opinions by employees.
3. Renegotiate together	3.1. Producing win-win imaginative and innovative agreements with employees and all other stakeholders by means of renegotiations and cross-functional conversations. 3.2. Indirectly supporting renegotiations and cross-functional conversations among constituencies by applying acquired culture data insights.
Source: [3].	

The emphasis on the leadership contributions of the highest rank executives (CEOs) in solving business-related issues, originating from the Covid-19 pandemic, discloses the

existence of diverse attitudes to needed culture changes in the companies in order to retain their competitive advantage or gain a new one. These attitudes represent direct citations from interviews or public speeches, made by outstanding CEOs of leading companies or analyses by respective researchers, based on shared opinions by such organizational leaders (Table 4).

Table 4. Diverse attitudes to needed culture changes in the companies, expressed by CEOs

CEOs...	Expressed attitudes...
Dee Ann Turner, former vice president talent and human resources for Chick-Fil-A, CEO of Dee Ann Turner & Associates	Re-establishment of the balance in the existing “employer-employee” relationship due to an expected increase in employer bargaining power in times of Covid-19 pandemic and immediately after it.
James Rodgers, founder of The Diversity Coach, leading strategist in the field of diversity management	Conducting timely reassessment of the current organizational culture and outlining its advantages in congruence with the requirements of the “the new reality” in order to maintain or increase company competitiveness.
Jane Delgado, president and CEO of the National Alliance for Hispanic Health	Identified emerging organizational values in the pandemic as mutual trust, interconnectedness, mutual responsibilities.
Ginger Hardage, former senior VP of Culture and Communications at Southwest Airlines, founder of Unstoppable Cultures	Forming the employees as a priority constituency for a while – “when employees feel safe and heard can they begin to make customers feel the same way.”
Source: [3].	

Seeking a sustainable advantage through human resources during Covid-19 pandemic, stimulates organizational leaders to reassess implemented practices in workforce management in respective entities [6]. Thus, their leadership interventions become oriented to [6, 7, 8]:

- Coping with management of dispersed workforce, pursuing the achievement of high levels of flexibility.
- Applying creative approaches in scheduling of performed work activities, working time and workplace location for their employees while preserving the health and ensuring safety to their subordinates.
- Introducing mass use of IT solutions, supporting HR performance within most of the components in the implemented HRM system and/or talent management system in their companies.
- Finding and hiring the right people through intensive use of remote interviewing, assessments and electronic platforms that facilitate the connection between candidates and jobs, and demonstrations of high respect to temporary hired employees not only with IT background.
- Realizing the activities, associated with employee learning and career development in the business organization by implementing cost-effective digital training in several directions: (a) developing important managerial skills for the crisis (as remote working, crisis leadership, specific executional capabilities), (b) implementing industry and task-group specific upskilling, focused on changing work, and (c) stabilizing the new leadership behaviors that reflect formulation of clear goals,

formation of focused teams, practicing rapid decision making, and adhering to higher organizational agility.

- Managing and rewarding employee performance that always requires the maintenance of transparent link between preliminary defined goals of the incumbents and pursued business priorities, basely categorizing employees as high performers and truly lagging ones, but bearing in mind that Covid-19 conditions impose introducing larger flexibility in this HRM sub-sphere.
- Tailoring the experience of different personnel categories (individual contributors, middle managers, senior executives, remote and onsite employees, etc.) by introducing official norms of working, boosting employee engagement and inclusion. The decision analysis here may be based at least on several criteria as type of necessary talent, importance of performed roles, required collaboration intensity, etc.
- Optimizing workforce planning and strategy through reassessing the critical roles for the current business situation in the respective industries, intensifying the interactions with the specific skill pools of the respective companies, implementation of richer talent systems (i.e. artificial-intelligence-enabled tools).
- Paying closer attention to leaders' conduct of employee mourning process in companies through: (a) demonstrations of respect to human experiences, feelings, emotions, losses, challenges and provision of space for their public sharing with colleagues during virtual team meetings, and (b) search of the right mix between empathy and compassion in their daily employee relations.

Establishing appropriate organizational communications for the Covid-19 crisis represents another leadership challenge that is expected to contribute not only to ensuring adequate organizational responses to it, but also to gaining and retaining competitive advantage through human resources, because leader's efforts in this sphere may "create clarity, build resilience, and catalyze positive (organizational, team, individual) change" [9] by preserving employee safety, facilitating employee adjustment and emotional coping in the new situation, and helping them "put their experience into context and draw meaning from it", thus supporting a sustainable increase in employee job performance [9] (Table 5).

Table 5. Characteristics of organizational communications during Covid-19 crisis

Stage of crisis Characteristics...	Resolve	Resilience	Return/ reimagination/ reform
(1)	(2)	(3)	(4)
<i>Dominating feelings of employees...</i>	confused, anxious	Uneasy, worn down	ready for change, a sense of loss
<i>Strong needs of employees...</i>	Facts, not speculation Clear instructions for how to protect their safety	Clarity on longer term plans Positive stories Chances to connect	A new vision for the future A chance to grieve
<i>Ranking types of information to be communicated...</i>	1. Instructing (encouraging calm & staying safe) 2. Adjusting (to change and uncertainty) 3. Internalizing	1. Instructing (encouraging calm & staying safe) 2. Adjusting (to change and uncertainty) 3. Internalizing	1. Internalizing 2. Adjusting (to change and uncertainty) 3. Instructing (encouraging calm & staying safe)

Table 5. Characteristics of organizational communications during Covid-19 crisis (cont'd)

(1)	(2)	(3)	(4)
<i>Superior leadership practices...</i>	Applying different forms of information to support employee safety, coping mentally, and connecting to a deeper sense of purpose and stability. Providing needed information in a succinct way to the employees. Building mutual trust.	Multiple repeating of target information. Increasing the effectiveness of leadership and employee loyalty by demonstrations of honesty, vulnerability, and maintenance of transparency. Restoring confidence by emphasis on the positive and strong communal bonds.	Establishing a clear vision, or mantra, for how the organization and its people will emerge after the crisis.
Source: [9].			

The application of the socio-psychological management method “managers’ giving a lead” may also be used as an efficient means of bringing forth the valuable experience of prominent organizational leaders in coping with business-related aspects of challengeable organizational situations by exploring their interviews [10, 11, 12] (Table 6).

Table 6. Opinions of prominent business leaders in relation to effective coping with the crisis by companies – content analysis

#	<i>Expressed beliefs in successful leading of companies during the crisis</i>
(1)	(2)
1. Alain Bejjani, CEO of Majid Al Futtaim (MAF)	<p>CHANGE & CULTURE:</p> <p>1.1. Implementing purpose-driven digital transformation, supporting values (bold, passionate, and together) and related behavioral norms.</p> <p>1.2. Design and implementation of fundamental changes in operating business models.</p> <p>CRISIS MANAGEMENT:</p> <p>1.3. Exercising strict control over company costs (“What do we really need?”).</p> <p>1.4. Liquidity is considered as the most important buffer.</p> <p>1.5. Organizational resilience is built during good times.</p> <p>1.6. The essentials (strong health and well-being) are the greatest drivers of economic value creation.</p> <p>ORGANIZATIONAL MANAGEMENT:</p> <p>1.7. Selling of experiences, not services to customers.</p> <p>HRM:</p> <p>1.8. Employees are viewed as company’s most important and precious asset.</p> <p>1.9. Employee redeployment and reskilling is widely needed.</p> <p>1.10. Transforming to a 60/40 in-person/out-of-office experience and, eventually, to 40/60.</p> <p>LEADERSHIP:</p> <p>1.11. Desired qualities in leadership: (a) going forward, resilience and agility; (b) generalists solve complex issues that are multidisciplinary in nature; (c) calm & prudent leaders, driving optimism and inspiration.</p> <p>1.12. CEOs as leaders in the crisis: (a) managing in the background (very visible but not needed), (b) rebuilding the partnership between the private sector and the public sector through constructive dialogue (government, business & civil society).</p>

Table 6. Opinions of prominent business leaders in relation to effective coping with the crisis by companies – content analysis (cont'd)

(1)	(2)
2. Hubert Joly, a former chairman and CEO of Best Buy	<p>CHANGE & CULTURE: 2.1. Assessing company's reason for being (milestones: purpose and humanity, the link to competitive advantage, and managing stakeholders during the current crisis and beyond it).</p> <p>2.2. Incorporating the needs of all stakeholders into the organization's leadership choices.</p> <p>2.3. Transposing the purpose to key stakeholders (i.e. formulating a second purpose) in order to partner with them.</p> <p>2.4. Emphasizing win-win situations in stakeholder interactions.</p> <p>2.5. Treating shareholders as customers (sharing with them, making proposals to them, being transparent in actions)</p> <p>CRISIS MANAGEMENT: 2.6. Steps in implementing an organizational turnaround during the crisis: (a) addressing key operational-performance drivers (listening to the opinions of front liners), (b) creating a joyous, growth-oriented culture, human environment with a strong sense of employee belonging, (c) formulating a noble purpose.</p> <p>2.7. Balancing the mix of long-term and short-term orientations in different spheres of the company.</p> <p>ORGANIZATIONAL MANAGEMENT: 2.8. Formulating shades in meaning of <i>noble purpose</i>: (a) what the world needs (customer needs), (b) what the company is good at (proven abilities to achieve competitive advantage), (c) how the company believes, it can make a positive difference in the world, and (d) how the company can make money (its growth and profit engine).</p> <p>2.9. The right approach for the company: formulating a purpose, a long-term strategy, taking care of all stakeholders, and doing well by doing well to them.</p> <p>HRM: 2.10. Strong relations between individual purposes and the organizational purpose.</p> <p>LEADERSHIP: 2.11. The core of organizational leadership: the use of a balanced scorecard with key performance indicators, focused on: (a) customers (a customer-satisfaction score or revenue per customer, (b) employee engagement and turnover, (c) relationships with vendors, (d) company's impact on (reputation in) the community, (e) financial performance.</p> <p>2.12. Desired characteristics of leaders: (a) persons who lead with their brain, their heart, their soul, and their guts, (b) creators of environment where mistakes are allowed and employees may succeed.</p> <p>2.13. Leaders' performance is measured by how employees are treated, how customers and communities are dealt with, and not so much by share price or earnings guidance.</p>
3. Mike Henry, the CEO of BHP	<p>CHANGE & CULTURE: 3.1. Strong, win-win relationships among the company, its employees, communities, business partners (incl. suppliers), traditional owner groups, host governments, etc. predetermine business resilience.</p> <p>CRISIS MANAGEMENT/ ORGANIZATIONAL MANAGEMENT: 3.2. Social value is important in decision making: (a) balancing of long-term interests of stakeholders does not contradict to pursuing short-term financial or operational performance, (b) safety and operational performance are no more viewed as opposites, (c) the priorities, regarding the creation of social value are assessed by the degree of relevance to the business, and company's ability to make impact.</p> <p>HRM: 3.3. Prioritizing people by getting out, demonstrating empathy, and engaging with stakeholders (not only employees) to understand their concerns.</p> <p>LEADERSHIP: 3.4. Good leadership practices: (a) creating clarity on organizational priorities, some sense of certainty and hope for the employees, (b) demonstrating responsiveness and fluidity to the dynamics of the evolving crisis, (c) seeing the big picture, (d) adhering to context-specific leadership, (e) relying on capable people and a good culture.</p> <p>3.5. Appropriate roles of leaders: (a) providing context, perspective, and clarity on priorities, (b) getting support in the company, (c) getting out of the way of contributors, and (d) abstaining from the role of chief problem solver for the company.</p>
Sources: [10, 11, 12].	

Another key aspect of leadership, applied to disclose its manifestations during the current crisis, is revealed by adopting the depth perspective, i.e. analyzing it at organizational and individual level. The analysis of organizational leadership outlines successful overall development strategies and tactics, implemented by leading companies in their efforts to adapt to the current unfavorable conditions and prepare for “the next normal”. The results of case studies and empirical research disclose the necessity of conducting a thorough and simultaneous reassessment of company postures in relation with at least several strategy components as dynamic redeployment of talent, pivoting production, shifting operations to greater flexibility, launching new business models, and multiplying productivity. The desired changes in the aforementioned strategy components may be achieved predominantly by design and implementation of deliberate acceleration in speed through adopting of new ways of working, i.e. removing boundaries and silos, simplifying the structures in business organizations, introducing concrete measures for decision-making process acceleration, intensifying the relationship “manager-employee” by scheduling more time in direct (electronic) connection between them, applying new technology in business, matching the best people in the firm with the hardest issues to be (re-)(ab-)solved, relying heavily on cross-functional teams, and developing agile, resilient talent [13].

Another set of components, constituting the overall development strategy of the company that struggles to survive, prosper and retain the level of organizational excellence under Covid-19 pandemic, is identified, based on the logic presumption that this key marker event incarnates a great disruption for a number of industries [14]. These include adequate investment in core and emerging technologies, proactive preparation for losing the company benefits of some regulatory advantages, reassessment of relationships with customers and other stakeholders, and embracement of robust technology platforms (i.e. custom IT services, cloud providers, mobile network operators, and application developers) that are the means of company’s increasing its scalability, customization and its price advantage.

Special attention is paid to outlining important characteristics of adequate crisis management strategies, designed and implemented by companies in order to facilitate their reactions “to unfolding events, communicating, and extracting and applying learnings” [15]. Furthermore, diverse sets of varying tactics, implemented by contemporary business organizations in order to ensure safety to key stakeholders and maintain their profitability, are outlined in an empirical research by Sadun et.al [16]. In an attempt to decrease the observed great diversity of identified company tactics of coping in the current crisis, the scientists review, classify and critically analyze them. Thus, the researchers are able to ground the existence of some “shared common underlying principles” that are embedded in all these tactics. The strategic characteristics and shared principles may be viewed as an efficient means of retaining the success in the entity [15, 16, 17, 18] (see Table 7).

Table 7. Characteristics & principles of successful crisis management strategies, adopted by companies

<i>Strategy characteristic or principle</i>	<i>Description</i>
(1)	(2)
<i>Company intelligence</i>	Realizing daily updates of information. Changing the corporate stance, if needed.
<i>Attention to news cycles</i>	Balancing between newness & big picture. Developing a more calibrated view to news, challenges, etc. Critical appraisal of the essence and source of acquired (changing) information. Precisely categorize incoming information (facts, hypotheses & speculations).

Table 7. Characteristics & principles of successful crisis management strategies,
adopted by companies (cont'd)

(1)	(2)
<i>Regular updation of summary of facts and their implications</i>	Spare time from employee doubting in the veracity of facts. The employees make no assumptions about facts. High effectiveness and clarity in communicating with all constituencies.
<i>Applying multi-sourcing and casting suspicions on expert opinions and forecasts</i>	High unpredictability and uniqueness of each pandemic. Orientation to learning about its critical features, adopting an iterative, empirical approach (what happens?, what works?).
<i>Constantly reframing the comprehension of what's happening</i>	Creating and maintaining a living digital document, time-stamped by "best current view".
<i>Considering company bureaucracy with respect to communications</i>	Establish a small team of trusted employees, empowered to make rapid tactical decisions, regarding crisis communications. The key marker events from (business) environment pace the internal processes in the company.
<i>Target dimensions, balancing the corporate crisis response (through implemented policies)</i>	Communications, Employee needs, Travel, Remote work, Supply-chain stabilization, Business tracking and forecasting. The attitude to the business environment (i.e. cooperating with the broader range of constituencies, incl. competitors, and the higher rank systems).
<i>Embedding resilience principles in new or updated company policies</i>	<i>Resilience: "the ability to survive and thrive through unpredictable, changing, and potentially unfavorable events" [15].</i> Six common characteristics of resilient organizations to track: Redundancy, Diversity, Modularity, Evolvability (constant improvement in congruence with new opportunities, problems, or information), Prudence (scenario planning & testing resilience), and Embeddedness (holistically view to stakeholders).
<i>Preparation for the next (phase of the) crisis and preemption of emerging crisis-related events.</i>	Demonstrating proactive company behavior, based on organizational learning and quick adaptation. Planning of scenarios and practicing game simulations for crisis. Realizing of cumulative learnings and adaptations from previous crises in order to prepare the company for existence in a new, changed world after the current crisis.
<i>Multiple adapting and shifting the value proposition of the company</i>	The company has to reflect the continuously changing demand conditions. Leadership pursues new growth opportunities.
<i>Adapted HRM</i>	An emphasis on two complementary streams of leadership efforts in keeping: (a) the viability of the company (reshaping production and sales function) and (b) employees' safety and well-being. Leaders creatively search for new ways of interaction between humans and technology, relying on a mix of internal and remote leadership. Building appropriate skills and mindsets for employees to solve pending problems on their jobs.
<i>High speed of organizational activities</i>	<i>Speed: "getting things done fast, and well" [17].</i> Rethinking ways of working (accelerate decision-making process, delegation of rights and empowerment of employees, establishing new forms of engaging partnerships with constituencies). Changing organizational structures (flat, team based, hybrid work). Reshaping talent (leadership development, organizational learning, senior management increase their input as visionaries and energizers of their followers).
Sources: [15, 16, 17, 18].	

Assessing leadership and leaders at individual level during Covid-19 pandemic discloses a bundle of approaches to coping with pending issues as undertaken or prescribed for implementation strategies or strategic moves, initiated steps, demonstrated styles, recommended roles and/or behaviors, and cherished personal characteristics. For example by reviewing contemporary scientific and professional literature in the field of leadership Love [19] justified the utilization of some leadership styles, grounded on modern leadership theories (Table 8). Rao and Sutton [20] go even further by prescribing concrete behaviors, containing respective nuances, appropriate for business leaders under the current conditions, i.e.:

- Taking personal accountability while adhering to solve important and urgent organizational issues.
- Demonstrating care and compassion in order to gain the emotional and physical support of their employees in turning upsetting decisions into organizational reality, and decrease employee stress levels.
- “Re-onboarding” of all subordinates, aimed at the establishment of flexible cultures in which the success originates from the strengths and quirks of each employee.

Furthermore, Craven et.al [23] recommend to leaders in business organizations to apply specific messages and actions to different personnel categories (level, role, and geographic location), relying on appropriate adaptation of the so called “influence model” (understanding and conviction, reinforcement with formal mechanisms, confidence and skill building, role modeling) in order to change leadership and employee mindsets in desired direction. Other researchers even underline the heroism of the contemporary succeeding business leaders by comparing their demonstrated mindset to “a wartime” one, structured as a unique mix of “decisive crisis management, scenario planning and a human reflex” to emerging safety and economic issues [24].

Table 8. Appropriate leadership styles for the pandemic situation

Leadership style	Key nuances in its essence, facilitating leaders’ ability to cope with the crisis
<i>Servant Leadership</i>	Searching for a balance between the strategic facet and the operational facet of leadership. Simultaneous orientation to doing the right things and doing things right. Leaders are expected to serve and support the employees in their endeavors to satisfy successfully the clients of the company (i.e. ensuring clarity and transposition of the corporate purpose statement and values at each lower level of the organizational structure).
<i>Inclusive Leadership</i>	Leaders are expected to understand employee needs clearly. The unlocking of human potential should become a top priority for leaders. Leaders should have inclusive conversations with all the stakeholders.
<i>Decolonized Leadership</i>	Leaders should embrace a specific approach to their constituencies, i.e. of connecting, relating and belonging.
<i>Positive Leadership</i>	Leaders should create a radically positive environment, viewing at the organization as a system of diverse tensions.
<i>Anti-Racist Leadership</i>	Leaders should take steps to dismantle the systems of oppression on minority groups and marginalized communities. Leaders should become comfortable with being uncomfortable. Leaders should take the initiative to steer the company into discomfort in order to pursue organizational growth.
Source: [19].	

As far as the appropriate leadership qualities for the current pandemic are concerned, several sets of them have been already constructed:

- Four interrelated leadership qualities: awareness, vulnerability, empathy, and compassion [8].
- Two sets of simultaneously possessed personal qualities by succeeding leaders: (a) smart, confident, daring and (b) kind, humble, caring [21].
- Resilient, bold, empathetic and ethical, oriented to problem solving in the spheres as inclusion, equality, social justice, and transition to net-zero economy [22].

The perspective of the must-be-performed roles by leaders is also used as an appropriate means to outline the commonality in their specific trails to organizational survival and prosperity in unique companies and diverse industries, as follows:

- A set of two intertwined and wisely applied roles is identified, based on the level of visibility of exerted efforts by the leaders [21]: (a) The highly visible leadership activities include inspiration and assurance of respective teammates by promoting hope and vision, empathy and public commitment. (b) The covert leadership activities deal with daily reflecting on and coping with diverse aspects (financial, technological and human) of the sharpest current issues in a disciplined manner. The simultaneous, balanced performance of the aforementioned two roles is prescribed to be achieved by means of adhering to concrete behavioral norms as “Acknowledge the crisis in a serious way”, “Embrace the crisis as a team”, “Explain why and how you made decisions”, “Measure and adapt your strategies” [21].
- Assigning the role of attacker to the succeeding contemporary leader in the crisis, putting an emphasis on creative thinking, pursuing new opportunities and new markets, active portfolio management [22].

The business consulting experience of Pachod and Park [24] from the first six months of the current crisis permits them to propose persistently certain strategies or strategic moves to leaders in the companies, striving to survive and prosper in dangerous and hostile environment (table 9).

Table 9. Several strategic moves for succeeding leaders in the Covid-19 crisis

<i>Strategy</i>	<i>Measures, comprising the respective strategy</i>
Develop the leader's team of the future	Transitioning from long tenure in the organization and experience of leaders to persistent demonstration of outperformance as the main criteria for their promotion. Adhering to empathetic leadership and supporting diverse talent.
Identify and elevate key, tangible business skills	Leaders manage for a greater transformation. Leaders collaborate in a network of teams in order to get closer to customers and increase the agility of their company. Leader do not forget business fundamentals (cash flows, business cases, scenario thinking). Leaders introduce fast new business models. Leaders discuss and change supply chains.
Treat technological acumen in the same way as profit targets	Developing and measuring the technological skills of all leaders in the company as digitalization milestones are reached.
Liberate teams to solve problems rapidly from a customer-back perspective	Decisions are made faster by small teams of leaders.
Source [24].	

Some researchers even concentrate their interest only on the potential contributions of the highest rank leaders in companies (the CEOs) in generating appropriate organizational responses to the current crisis [25, 26]. For example Dewar et.al [25] propose four strategic moves to the CEOs, that are accompanied by respective sets of questions to reflect on and plan the needed behavioral changes in congruence with the ongoing conditions, i.e. formulating and pursuing higher (“10x”) aspirations (bigger, faster and bolder ones; substituting travel and commuting time for formulating and implementing aspirations), decreasing the gap between leader’s words and timely actions (with orientation to leading with greater humanity, boosting employee morale, making transparent decisions, providing vision and empowerment), adopting a balanced approach to the full set of diverse constituencies, utilizing the full benefits from participation in peer networks to (re-)(ab-)solve important organizational issues [25]. Furthermore, the prescribed “microhabits” to the CEOs in this crisis by Hatami et.al [26] may be used to enlarge the list of the appropriate strategic moves for them – i.e. taking care of themselves (i.e. to maintain their mental and physical stamina, introduce necessary changes in their work schedules, intensify their communications in a safe way), and personally demonstrate social responsible behavior and actions.

3. Conclusion

The performed literature review and content analysis permits identifying six main aspects of leadership, emerging under the conditions of Covid-19 pandemic and resulting from business leaders’ assiduous attempts of coping with pending organizational issues and overwhelming challenges (see Figure 1).

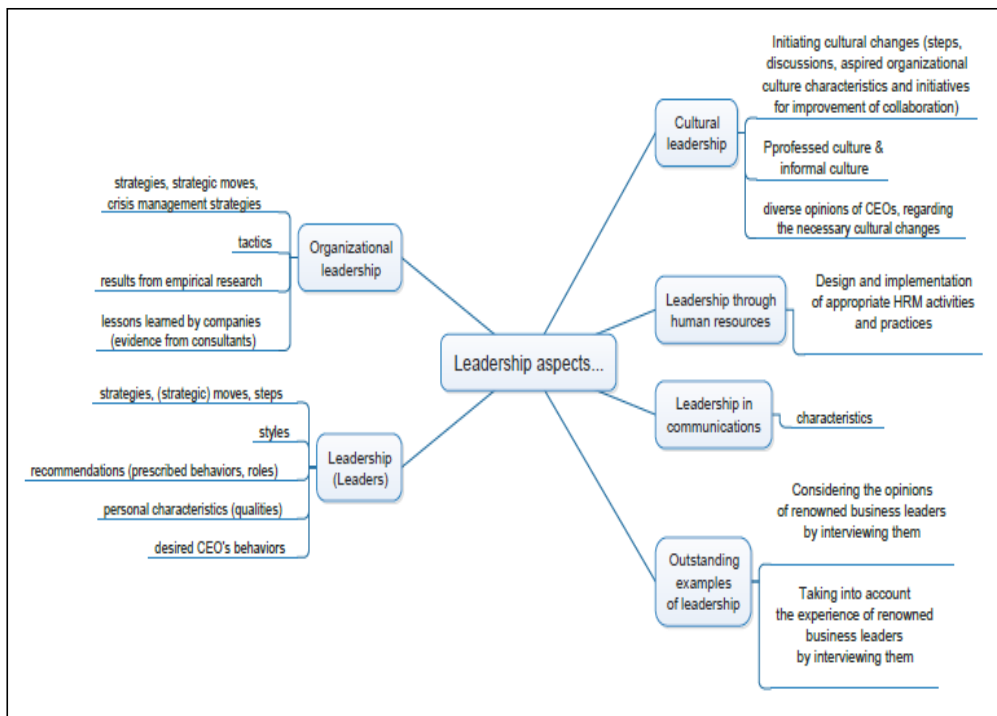


Fig. 1. The mind map of leadership, adapted to the Covid-19 pandemic

The forming depth perspective in outlining the emerging bundle of leadership facets is oriented to organizational and individual levels only, but the team level still seems neglected. Furthermore, there exists strong recommendation for collaboration among business organizations not only within certain value-chains that seems embedded only in the activities of highest rank executives (CEOs) in relation to their peers.

As far as the potential cultural changes in business organizations are concerned, it is evident that although reformulation of certain components of the official company culture is prescribed (i.e. purpose, mission and vision), these changes are reflected only through the lens of (re-)(ab-)solving pending business-related issues, originating from the new crisis. In fact the emphasis is put on the first stages in solving the basic organizational issue of adapting to the external environment, i.e. reflection on the current characteristics of the dominating company culture, having discussions with stakeholders whose interests are affected and staking on the assessed strengths of the dominating company culture in congruence with the current pandemic. Although many organizations claim to have undertaken and even completed deep changes in their business models and attitudes to their constituencies, it cannot be confirmed that the aspired new leadership behaviors, related to these changes, have become engrained in the minds of respective decision-makers and performers (followers) as the right ways to act, think and feel in relation to the performed activities.

The conquering of the leadership position through human resources seems inevitable in spite of the current pandemic and because of its occurrence, since it represents the only one sustainable competitive advantage for the contemporary companies. But now it becomes quite clear that the previously neglected in many industries component of “ensuring safety and healthy work conditions” as a part of an implemented and elaborated HRM system in the business organization comes to the foreground. The leaders’ main aim of securing the business continuity of the respective entity under the new conditions (some of them later on may be transformed into “the new normal”) also requires demonstrating assiduousness and creativity in finding new personnel members and timely adapting them to the new organizational and supply-chain situation, onboarding all current employees to boost their performance levels within the new hostile and highly digitalized business environment.

As far as the leadership in organizational communications is concerned, four aspects should be obligatory outlined, i.e. its strong association with full utilizing the potential of human resources, the pursuing of high extent of its congruence with the respective stage of the crisis, considering the peculiarities of human psychology during crisis events even in business context, and the efficiency of the implemented communication technology.

The critical analysis of advises by outstanding business leaders outlines the importance of at least several important topics for executives, performing comparatively successfully during the early stages of this crisis, to reflect on. These are the relationship “change & culture”, crisis management, holistic organizational management, the special accent on human resource management, and leadership that seems quite normal at this stage.

In conclusion, the past nine months of coping with the Covid-19 pandemic constitute only an early stage in its development that makes its prognostication almost impossible. Nevertheless, the literature review and content analysis, applied in this scientific paper, clearly reveals that the ambitious leaders in the companies have been assiduously trying to find their specific success trails and better prepare their organizational reactions and proactive actions not only in relation with the current crisis, but also regarding the emergence of unexpected events with great business impact in the future. It can be concluded with certainty that the content of presented bundle of leadership aspects, appropriate for coping with the Covid-19 crisis, will undergo numerous modifications, according to the changes, incurring in the business environment and the decisions, taken by senior executives in the companies.

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Analysis of Living Labor Costs in the Context of Digitalization

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Abstract. Labor is one of the main factors, along with fixed tangible assets and material resources, that are necessary for the operations of every entity and for the functioning of the economy. As a result of the use of labor provided by the employees of the entities, they (the entities) incur labor costs that comprise salary (remuneration) costs and their share of the social security costs. The increase of the effectiveness of the use of the labor factor (manpower), and in particular the labor productivity, is a driver for improvement of entities' competitive power. These are also subject to the influence of other factors, for example, capital structure, capital cost (equity and loans), innovation and investment policy, positioning of the product (brands) and of the entities on the dynamic market, entities' digital transformation, etc. This report highlights the methodological and methodical aspects of the analysis of salary costs of the entities. It consistently clarifies the methods for analysis of: 1) the amount, composition, structure, dynamics and effectiveness of salary costs; 2) the saving or overspending of salary costs both in comparison with the planned salary costs and with the previous period by salary items; 3) the average salary per employee; 4) the average rate per man hour, etc. It presents different methodical aspects of the analysis of salary costs. The author has used the opportunities of advanced information technologies to make a link between the analysis information base, the methods for analysis of salary costs in specific directions and the resultative analytical information, thus providing the management with scenario business decisions. The analysis of salary costs is made with the options provided by EXCEL. The aim is to suggest enhanced complex methods for analysis of salary costs of entities that pursue industrial activity as their core business under the conditions of digital transformation of their business processes.

Keywords. analysis, methodology, factors, living labor costs, salary costs, digital transformation.

1. Introduction

Business transformation by means of digital technologies is crucial for all entities under the conditions of globalisation and market competition. Digitalisation not only refers to the choice of technologies but also to the abilities and skills that such technologies provide people with. In its nature, digitalisation is expressed in the common use of information and technologies for enhancing the productivity of human resources. Ultimately, the productivity of the human factor is in the foundation of digital transformation.

Digitalisation of the financial and business analysis as a practical and applied activity should encompass the specific objects that such analysis contains.

Entity's costs are an important object of the general methodology of the financial and business analysis. Expenses on materials and labour costs, including wages and salaries and social security of entity's employees, have the biggest relative share in the entity's total costs.

The digitalisation of the analysis of the entity's labour costs requires smart combination of accounting information generated by the entity and any other information related to these costs,

and the information technology functionalities for the purposes of enhancing the human resources productivity. This can be achieved by means of optimising the way in which data are collected (incoming information necessary for the analysis), processed (through the elements of the analysis method), analysed (by applying the analysis methods), and shared (presentation of the resultative analytical information for the internal and external users) at all stages and phases of the entity's development.

2. Information Provision of the Labour Cost Analysis

In terms of accounting, the total amount of expenses on wages and salaries is presented in the „Wages and salaries “account in group „Expenses by economic elements “. Expenses on employee's social security paid by the entity are accounted under „Expenses on social security “account within the same group of accounts. M. Natchkova says that „the high public requirements to the social security system in the country determines the development level and the importance of social security, which is ultimately aimed at ensuring material benefits and maintaining the living standard of insured persons who for some reason or other are not able to work and do not receive any remuneration for the periods they have not been working.” [1, p.37-38]. With view of the above M. Natchkova further says that “expenses on social security of the employers – insurers with regard to the salaries of employees (those working under employment contracts – supplement by R.I.), are incurred with regard to the compulsory state social security and voluntary pension insurance and compulsory health insurance schemes.”[1, p.87].

3. Methodology for analysis of entity's labour costs

The methodology for analysis of labour costs is considered with view of the systematic approach. It should be formulated as a system, which comprises interrelated elements, for example, the methods, approaches and indicators for analysis, as well as the specific areas of the labour cost analysis. This is how a conceptual unity of mission, strategy, objectives and tasks may be achieved, and on the basis of the resultative analytical information proper and justified management decisions could be made for the optimisation of costs, increase of income and expense efficiency, improvement of the financial performance and business effectiveness. We believe that the methodology for analysis of labour costs should be considered as a system of consistent and interrelated stages, and at each stage, one has to formulate the objective, tasks and system of indicators for the labour cost analysis. The generation of big volumes of data requires their management, processing, storage, security and significant IT resources. The digitalisation of the general methodology for labour cost analysis allows to collect large amounts of accounting and other information, which could be easily, quickly and continuously processed, analysed and shared at all management levels within an entity.

To our opinion, the methodology for labour cost analysis may comprise the following stages:

- 1) general assessment of labour costs;
- 2) analysis of actually achieved savings or incurred overspending of labour costs in comparison both with the budget and the previous period;
- 3) analysis of expenses on salaries;
- 4) analysis of the average salary;
- 5) analysis of individual salaries;
- 6) analysis of the impact of changes of labour costs on the labour cost-based return;
- 7) analysis of expenses on social security – as a whole and by specific social security funds.

The following indicators can be used for the overall assessment of labour costs:

- 1) relative share of labour costs in the total amount of entity's costs;

- 2) relative share of labour costs in the operating costs;
- 3) revenue gained with labour costs of BGN 1;
- 4) operating revenue gained with labour costs of BGN 1;
- 5) labour costs attributable to revenue of BGN 1;
- 6) labour costs attributable to operating revenue of BGN 1;
- 7) book profit attributable to labour costs of BGN 100 (labour cost-based net return);
- 8) operating profit attributable to labour cost of BGN 100.

Different tables are made for the purposes of the analysis. Ultimately, the tables present structured data on the basis of which one could better understand the subject matter of the financial and business analysis as a whole (the complex methodology for analysis of the entity's business) and by its specific objects (private methodologies for analysis by analysed objects). Structured data are of fixed format, e.g. tables that can be readily filled in. In particular, this is their advantage. Structured data are arranged and organised in a specific way for the purposes of enabling their processing and storage. Structured data are mainly applied in databases. For example, they can be easily created, used and stored in EXCEL datasheets where data can be classified and summarised, depending on the objectives and tasks of the analysis, and with view of the information required for the needs of the entity's management. Different rows and columns as well as structures (aggregate rows and columns) containing detailed data for the constituent elements can be created.

We will illustrate the methodology for labour cost analysis with the business data of the industrial entity MM for two subsequent reporting periods. The information required for the analysis is presented in Table 1.

First methodological stage. With the data presented in Table 1, we can make overall assessment of labour costs based on the abovementioned indicators.

In terms of labour costs, the change of revenue gained by the entity during the current period in comparison with the previous period is determined by the impact of two summarising factors:

- 1) changes in the amount of labour costs; and
- 2) changes in the revenue gained with labour costs of BGN 1.

The impact of these factors may be identified with the help of the method of changes.

Table 1. Data from the financial statements of the enterprise and additionally calculated indicators

Indicators	Previous year	Current year	Deviation (+, -)	Percentage of dynamics
I. Data from the financial statements of the enterprise, thousand BGN				
1. Living labour costs, including:	15730	17670	1940	12,33
a) costs of wages	12270	13790	1520	12,39
b) expenses on social security	3460	3880	420	12,14
2. Total costs, including:	57255	57510	255	0,45
a) operating costs	52915	53645	730	1,38
3. Total revenue, including:	59895	61585	1690	2,82
a) operating income	56330	59155	2825	5,02

4. Balance sheet profit (item 3 - item 2), including:	2640	4075	1435	54,36
a) profit from operating activities (i.3a - i.2a)	3415	5510	2095	61,35
II. Additional calculated indicators:				
5. Relative share of living labour costs in the total costs, % (i.1 : i.2) x 100	27,4736	30,7251	3,2515	11,8350
6. Relative share of living labour costs in operating expenses, % (i.1 : i.2a) x 100	29,7269	32,9388	3,2118	10,8045
7. Achieved income with one lev living expenses, BGN (i.3 : i.1)	3,8077	3,4853	-0,3224	-8,4672
8. Achieved revenues from operating activities with one lev living expenses, BGN (i.3a : i.1)	3,5811	3,3478	-0,2333	-6,5146
9. Living labour costs per lev income, BGN (i.1 : i.3)	0,2626	0,2869	0,0243	9,2505
10. Living labour costs per lev income from operating activities, BGN (i.1 : i.3a)	0,2792	0,2987	0,0195	6,9686
11. Balance sheet profit per BGN 100 living labour costs (net profitability based on living labour costs), BGN (item 4 : item 1) x 100	16,7832	23,0617	6,2785	37,4092
12. Profit from operating activities, falling to BGN 100 living labour costs, BGN (i.4a : i.1) x 100	21,7101	31,1828	9,4727	43,6326

We proceed in analogical way in terms of the labour costs comprised in the full product cost. Necessary data are presented in Table 2.

Table 2. Efficiency of living labor costs included in the full cost of production

Indicators	Previous year	Current year	Deviation (+, -)	Percentage of dynamics
1. Net amount of revenues from sales of products, thousand BGN	52845	54524	1679	3,1772
2. Living labour costs included in the full cost of production, thousand BGN	14850	15125	275	1,8519
3. Net income from sales of products, falling to BGN 1 living labour costs in the full cost of production, BGN (item 1: item 2)	3,5586	3,6049	0,0463	1,3013

The increase or decrease of net sales revenue is determined by the impact of two factors:

- 1) changes in the amount of labour costs comprised in the full product cost, and
- 2) changes in the net sales revenue attributable to labour costs of BGN 1 comprised in the full product cost.

Second methodological stage. Analysis and assessment of achieved savings or incurred overspending of labour costs, in comparison both with the planned costs and with the previous period (e.g. the previous year) or with previous periods for the purposes of monitoring the trends in their dynamics.

Third methodological stage. Analysis of expenses on salaries. Expenses on salaries for the reporting period may be calculated with the following formula:

$$R^{rz} = SSB_g \times \overline{RZ}^{lp}. \quad (1)$$

where:

R^{rz} is the total amount of expenses on salaries of the employees;

SSB_g – the average number of employees;

\overline{RZ}^{lp} – the average salary per employee.

With the help of this ratio, we can identify the impact of two factors on the difference between the actual and reference (for the previous year in this particular case) amount of expenses on salaries:

- 1) changes in the average number of staff, and
- 2) changes in the average salary per employee.

Table 3 is made according to the business data of the entity in question.

Table 3. Average salary of one staff member and one core business worker

Indicators	Previous year	Current year	Deviation (+, -)	Percentage of dynamics
1. Wage costs, thousand BGN	12270	13790	1520	12,3879
2. Expenditures for salaries of the workers from the main activity, thousand BGN	9850	10120	270	2,7411
3. Average list number of staff	250	252	2	0,8000
4. Average list number of workers in the main activity	209	211	2	0,9569
5. Average salary of one person from the staff, thousand BGN (item 1: item 3)	49,08	54,72	5,64	11,4960
6. Average salary of one worker from the main activity, thousand BGN (item 2: item 4)	47,13	47,96	0,83	1,7673

Analysis should go further to identify the strength and direction of impact of the direct factors on the changes in the average salary per employee.

Fourth methodological stage. Analysis of the average salary per employee. The average salary per employee (\overline{RZ}^{lp}) may be determined with the following formula [2, p.88]:

$$\overline{RZ}^{1.p.} = \frac{D_i^{ssb} \times \overline{RZ}_i^{1.p.}}{100} \quad (2)$$

where:

D_i^{ssb} is the relative share (%) of different categories of employees in the total number of employees;

$\overline{RZ}_i^{1.p.}$ – the average salary per employee within the respective category.

With the help of this formula we can identify the impact of two direct factors:

- 1) changes in the structure of employees, and
- 2) changes in the average salary per employee of each category of employees

on the changes that have occurred in the average salary per employee in the entity.

The above dependence is a typical example of internal analysis. The entity's management is able to optimise the expenses on salaries by means of making decisions in different versions for the structure of employees, of course, depending on the needs of employees of the respective categories. Here one should optimise the number of employees of each category in accordance with the National classification of occupations and jobs in the Republic of Bulgaria of 01.01.2011. International Standard Classification of Occupations – 08 (ISCO-08) is developed by the International Labour Organization and is approved by Resolution of 06.12.2007 of the Conference of Labour Statisticians. It is approved as a European standard with Regulation (EC) № 1022/2009 (OJ, L 283/30.10.2009) and Commission Recommendation 2009/824/EC of 29.10.2009 on the use of the ISCO-08 in the European Union member states. The national classification of occupations and jobs of 2011 (NCOG-2011) ensures the application of the International Standard Classification of Occupations, effective from the beginning of 2008 ISCO-08, and the requirements of the European legislation for its use.

From this perspective, the employees working in the entity under employment or official relationships (as full time and part time employees) are classified in the following categories: managers; professionals; technicians and associate professionals; clerical support workers; service and sales workers; skilled agricultural, forestry and fishery workers; craft and related trades workers; plant and machine operators and assemblers; elementary occupations. Furthermore, salaries may be optimised by different categories of employees. The actions undertaken in this respect may result in changes in the average salary per employee and then in optimisation of expenses on salaries of employees.

Fifth methodological stage. Analysis of individual salaries.

The reasons for the changes in the average salary for each category of employees are related to the way in which individual salaries of different categories of employees are formed. Here comes the next task of the analysis, and namely to analyse the individual salaries of the entity's employees. The way in which they are formed depends on the applied forms and systems of salary. Under the existing conditions, complex systems of salaries prevail.

We will make a review of the methodology for analysis of direct expenses on salaries of the category of workers.

We have the data for the production of a specific type of units in one of the workshops of an industrial entity (see Table 4).

Table 4. Internal analysis of the direct wage costs of workers in production

Indicators	Normative	Factual data	Deviation	Percentage of dynamics
1. Number of details	3840	3640	-200	94,79
2. Production time of one part, including:				
a) minutes	24	27	3	112,50
b) hours (i.2a : 60)	0,40	0,45	0,05	1,125
3. Production time of all parts, including:				
a) in minutes (item 1 x item 2a)	92160	98280	6120	106,64
b) in hours (item 1 x item 2b)	1536	1638	102	106,64
4. Hourly rate (payment for one man-hour), BGN	15	16	1	106,67
5. Direct labour costs of workers for the production of parts, BGN (i.3b x i.4)	23040	26208	3168	113,75
6. Time spent according to regulations, but for the actual (according to the report) volume of produced parts, hours ($\frac{3640 \times 24}{60}$)	x	1456	x	x
7. Direct costs for salaries according to the norm, but for the actual volume of produced details, BGN (1456 hours x 15 BGN)	x	21840	x	x

The data in the table show that the direct expenses on workers' salaries are overspent. Such overspending is calculated as a difference between the actual and the reference amount of direct expenses on salaries of workers who manufacture the units in terms of actually manufactured units. The resultative data show that this overspending is in the amount of BGN 4368. It is due to the impact of two direct factors:

- 1) changes in worked-out man-hours (changes in the use of the working hours);
- 2) changes in the hourly rate (pay) per man-hour.

The impact of these factors may be determined with the help of the method of changes.

1) Impact of the first factor:

$$(1638 - 1456) \times 15 = (+182) \times 15 = +2730 \text{ lv.}$$

As a result of the fact that actually worked-out man-hours have increased by 182 hours in comparison with the reference man-hours (1638 – 1456), there is an overspending of direct expenses on salaries of workers in the amount of BGN 2730.

2) Impact of the second factor:

$$1638 \times (16 - 15) = 1638 \times (+1) = +1638 \text{ lv.}$$

As a result of the increase of the actual hourly rate (pay per hour) by one Bulgarian lev in comparison with the reference hourly rate (16 – 15), there is an overspending of direct expenses on salaries in the amount of BGN 1638.

Otherwise, under the parallel impact of the two factors, the overspending of salaries for the category of workers who manufacture the units is in the amount of BGN 4368 [(+2730) + (+1638)], i.e. exactly the difference between the actual and reference amount of the direct expenses on salaries, while eliminating the impact of changes in the production amount (the number of actually manufactured units in comparison with the reference).

K. Chukov says that “with the help of the information in the primary documents, one can understand the specific reasons for the changes in the use of the working hours and the payment rate.” [3, p.189]

Table 5 presents the data of labour costs per hour in the European Union member states.

Table 5. One hour labour costs for 2019

Countries	Designation	Labour costs per hour, euro	Labour costs for one hour, BGN
I. Member States of the European Union:			
1. Denmark	DK	44,7	87,43
2. Luxembourg	LU	41,6	81,36
3. Belgium	BE	40,5	79,21
4. France	FR	36,6	71,58
5. Netherlands	NL	36,4	71,19
6. Sweden	SE	36,3	71,00
7. Germany	DE	35,6	69,63
8. Austria	AT	34,7	67,87
9. Finland	FI	34,0	66,50
10. Ireland	IE	33,2	64,93
11. Italy	IT	28,8	56,33
12. Spain	ES	21,8	42,64
13. Slovenia	SI	19,1	37,36
14. Cyprus	CY	17,5	34,23
15. Greece	EL	16,4	32,08
16. Malta	MT	15,0	29,34
17. Portugal	PT	14,6	28,56
18. Czechia	CZ	13,5	26,40
19. Estonia	EE	13,4	26,21
20. Slovakia	SK	12,5	24,45
21. Croatia	HR	11,1	21,71
22. Poland	PL	10,7	20,93
23. Latvia	LV	9,9	19,36
24. Hungary	HU	9,9	19,36
25. Lithuania	LT	9,4	18,38
26. Romania	RO	7,7	15,06
27. Bulgaria	BG	6,0	11,73

II. Average labor costs per hour in the European Union	EU	27,7	54,18
III. Labour costs per hour:			
1. Euro area	EA	31,4	61,41
2. Norway	NO	50,2	98,18
3. Iceland	IC	41,7	81,56
4. United Kingdom	UK	27,7	54,18

Source:

https://ec.europa.eu/eurostat/statistics-explained/index.php/Wages_and_labour_costs/bg
and own calculations (BGN 1.95583/EUR)

The data in table 5 show that the difference between the labour costs per hour in Denmark (the highest rate) and Bulgaria (the lowest rate), as an absolute value, is equal to EUR 38,7 (44,7 - 6), i.e. BGN 75,69 (EUR 38,7 x 1,95583). As a relative value, the labour costs per hour in Bulgaria in comparison with Denmark are 13,42 % $[(6: 44,7) \times 100]$, and the difference is 86,58 % $[(38,7): 44,7) \times 100]$ or (100 - 13,46).

The gap in the labour costs per hour in Bulgaria in comparison with the average labour costs per hour in the European Union member states in total is EUR 21,7 (27,7 - 6), i.e. BGN 42,44 (EUR 21,7 x 1,95583) as an absolute value. The gap is even bigger in terms of the Eurozone countries. In terms of absolute values, the labour costs per hour in Bulgaria are EUR 25,4 (31,4 - 6), i.e. BGN 49,68 (EUR 25,4 x 1,95583) less than those in the Eurozone countries.

Data about the minimum salaries in the European Union member states are also interesting. As at 1 January 2020, twenty-one European Union member states have national minimum salaries, and no minimum salary is set by law in six EU member states. These are Austria, Denmark, Italy, Cyprus, Finland and Sweden.

Data of minimum salaries in the European Union member states are presented in Table 6.

Table 6. National minimum wages in the countries of the European Union
as of January 1, 2020

Countries	Minimum wage, euro	Minimum salary, BGN
1. Luxembourg	2142	4189,39
2. Ireland	1656	3238,85
3. Netherlands	1636	3199,74
4. Belgium	1594	3117,59
5. Germany	1584	3098,03
6. France	1539	3010,02
7. Spain	1050	2053,62
8. Slovenia	941	1840,44
9. Malta	777	1519,68
10. Greece	758	1482,52
11. Portugal	741	1449,27
12. Poland	611	1195,01

13. Lithuania	607	1187,19
14. Estonia	584	1142,20
15. Slovakia	580	1134,38
16. Czechia	575	1124,60
17. Croatia	546	1067,88
18. Hungary	487	952,49
19. Romania	466	911,42
20. Latvia	430	841,01
21. Bulgaria	312	610,22

Source:

<https://bnr.bg/post/101223378/evrostat-nai-niskata-minimalna-zaplata-v-es-e-v-bulgaria>
and own calculations (BGN 1.95583 / EUR)

The data in the above table show that in terms of the minimum monthly salary, Bulgaria ranks last among the European Union member states. The minimum salary in the country is EUR 1830 (2142 – 312) less than the highest one in the European Union (the minimum salary in Luxembourg), which is equal to BGN 3579,17 (EUR 1830 x 1,95583 BGN/EUR).

Here we should note that at the beginning of 2021, the minimum salary in Bulgaria will be increased to BGN 650 and is not expected to change during the next two years (2022 and 2023).

Sixth methodological stage. Analysis of the impact of changes in the labour costs on the change of labour cost-based return.

Literature references present a model for analysis of labour cost-based return (Prof_C^l). [4, p.119]

$$\text{Prof}_C^l = \frac{L^P}{\frac{S}{N} + \frac{CI}{N}} \times \frac{\text{Pr}^{PS} \times 100}{N^{SR}} = \frac{L^P}{\frac{\sum D_i^S \times RZ_1^{LP}}{100} + \frac{\sum D_i^S \times \overline{CI}_1^S}{100}} \times \frac{\text{Pr}^{PS} \times 100}{N^{SR}} \quad (3)$$

or

$$\text{Prof}_C^l = \frac{L^P}{\frac{\sum D_i^S \times RZ_1^{LP}}{100} + \frac{\sum D_i^S \times \overline{CI}_1^S}{100}} \times \frac{\text{Pr}^{PS} \times 100}{N^{SR}} \quad (4)$$

The above formula shows that the following direct factors have impact on the dynamics of the labour cost-based return:

- 1) changes in the labour productivity (L^P);
- 2) changes in the structure of entity's staff (D_i^S);
- 3) changes in the average salary per person of each category of employees (RZ_1^{LP});
- 4) changes in the average amount of social security costs per person of each category of employees (\overline{CI}_1^S);
- 5) changes in the return on sales ($\frac{\text{Pr}^{PS} \times 100}{N^{SR}}$).

The model for analysis of labour cost-based return presented above provides the entity's financial management with important and useful information on the basis of which modern and proper management decisions on the optimisation of expenses on salaries and social security could be designed and made. This is crucial under the conditions of crisis caused by various economic, financial, health, force majeure and other events. The entity's management is able to optimise both the structure of employees and the average expenses on salaries and social security of every category of employees of the entity separately, thus increasing the level of labour cost-based return.

The changes in labour productivity also have impact on the dynamics of labour cost-based return. The indicator for labour productivity describes the effectiveness of manpower use – one of the production resources that are required for the implementation of the activity and the business plan of every entity. Therefore, the factors that have impact on the change of the annual labour productivity also influence the dynamics of labour cost-based return. These factors comprise the changes in:

- 1) man-hours worked out by one worker;
- 2) average duration of the workday, and
- 3) the labour productivity per hour.

The changes in the labour resources-based return also have impact on the change of labour cost-based return. This is due to the fact that labour resources-based return is an element of the labour cost-based return. The last formula shows that this fact is manifested through the labour productivity and the return on sales. As K. Chukov says, the labour resources-based return growth rate should be higher than the labour cost growth rate per employee. [4, p.121] In this particular case, the labour cost-based return will increase.

Seventh methodological stage. Analysis of expenses on social security. Analysis should be performed both in terms of expenses on social security in aggregate and by social security funds separately. We speak about analysis and assessment of entity's costs by social security funds:

- 1) expenses for state social security scheme (SSS Scheme), including expenses for: a) Pensions Fund, b) General Disease and Maternity Fund, c) Unemployment Fund;
- 2) expenses for Occupational Accident and Occupational Disease Fund (OAOD Fund);
- 3) expenses for health insurance;
- 4) expenses for compulsory supplementary pension insurance (CSPI) for those born after 31.12.1959.

4. Conclusion

The methodology for analysis of labour costs allows to interrelate the individual methodological stages of the analysis and to identify and assess the impact of the direct factors on the dynamics of the resultative indicators that characterise this type of entity's expenses.

The low level of salaries in the country is due to a number of factors that have adverse impact, for example: low labour productivity in entities from different sectors of the economy; corruption practices; business environment in which entities operate; direct foreign investments; condition of the judicial system in the country, etc.

As a conclusion, we could systemise the benefits of digitalisation of the financial and business analysis in general. They may be presented in the following order:

- 1) achieving decrease of entity's costs;
- 2) ensuring computer security of the database (incoming and outgoing information);

- 3) achieving timely processing of data and obtaining resultative analytical information;
- 4) ensuring flexibility and adaptability of the database;
- 5) ensuring automatic software update;
- 6) opportunities for mobility of incoming and outgoing analytical information;
- 7) ensuring various resultative analytical information in different aspects;
- 8) providing opportunities to control the internal business processes of the entity and to make operational management decisions for their development;
- 9) achieving sustainability of the management decisions designed and made for the development of the entity from operational and strategic perspective;
- 10) achieving decrease of entity's losses;
- 11) establishing and maintaining competitive advantage for the entity.

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Minimum Requirements for IDS Based on “Cost-Benefit” Approach

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Abstract. The problem addressed in this article is maximizing the effect of the Intrusion Detection System (IDS) with limited resources allocated by the cybersecurity organization. The object of the article is the IDS models, and the subject is the minimum requirements for the system. The methodology used to assess these requirements is "cost-benefit" analyses. The analysis compared IDS models, and case studies were applied to achieve an economic justification for the significance of the problem. The minimum requirements, i.e. the benefits are seen as "technical or technological" features that provide a sustainable product - cybersecurity. Concerning costs, different approaches have been proposed for their evaluation. The publication indirectly affects the return on investment in cybersecurity.

Keywords. Intrusion Detection System, “Cost-Benefit” analyses, Cybersecurity

1. Introduction

The main goal of security is to protect and add value to the organisation assets. As such is also cybersecurity. It has to have quantity and quality measurement values.

The problem of this article is captured in the implementation of "cost-benefit" analyses. When we speak about digital infrastructure one of the deciding factor of taking a decision is the effectiveness and efficiency of it. We made this by analyses. One of the models that are used is "cost-benefit" analyses that are often misunderstood or wrongly implemented. One of the restrictions of this methodology is that we can compare only things in the same class or category. We can't compare for example IPS (Intrusion Protection System) with IDS, even that one of them can include the other as a package or other.

The goal of this article is to show how “cost-benefit” analyses can be implemented as an objective measuring tool for cybersecurity.

The object of this article is the cybersecurity system (CS) and the subject is the implementation of the “cost-benefit” analyses. Off-topic the CS can be considered and managed as a project with its goals and products (Fig.1.Example of goals in the project of CS). These goals can be tools or capabilities that interact through people with help of organisation and cybersecurity culture. By organisation, the author means all forms of organisation – country, company, administration directory, corporation, etc. This means that in analyses we apply the deductive approach.

The analytic needs to acknowledge how the goals interact between themselves. Are they give the added value to the whole security system? Is there a synergistic effect on the system? It is very hard to measure these "added values" before the implementation of the project and all its goals. Often the benefits came long after the implementation and completion of the goals. According to this, the CS have to be managed as a cycle. We also have to acknowledge that all the goals in the project are in the state of competition for resources. As

we can see, there are a lot and different goals. The main goal of CS is to create a sustainable system for usage of the information (information technologies) and connected to its processes. The goal of the analyses is to provide the best possible (optimal) solution to the decision-makers. With this solution, cybersecurity can be strengthened and by this, it achieves its goal. By achieving the go of cybersecurity, we can achieve the goal of security as a whole.

The methodology in this article is the “cost-benefit” analyses. This methodology is universal for measuring the effectiveness and efficiency of an alternative. Economists use it when we cannot measure the profit from investment and we cannot apply other financial tools such as ROI (Return of Investment). This methodology is not typical in the implementation of tools for cybersecurity.

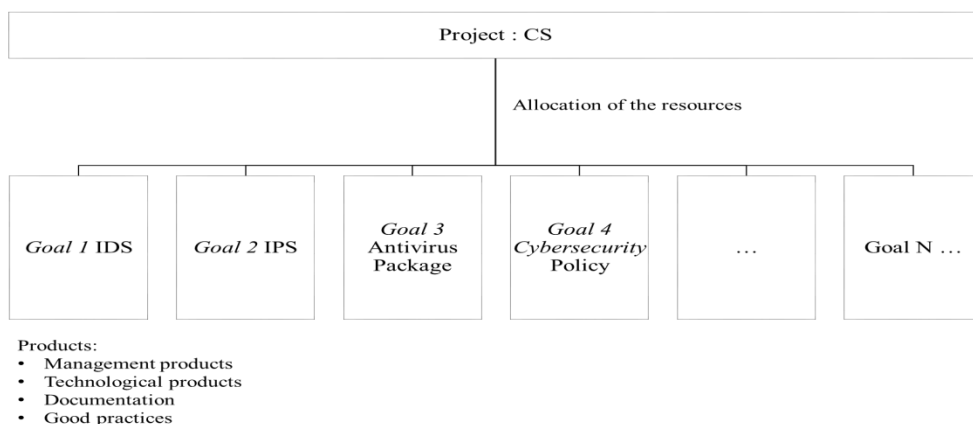


Fig.1.Example of goals in the project of CS

There are three main ways to determine minimal requirements:

- 1)The lowest costs;
- 2)The highest benefits;
- 3)The combination of costs and benefits.

Disclaimer: This article just presenting the model as it is not providing the correct or the full solution or result/s of the analyses. The data that is used is just for the example.

2. Basic scheme of the analyses

For this type of analyses, we have to adopt a systematic approach. The four important milestones are:

- 1) Definition of the problem;
- 2) Set the clear goal;
- 3) Collect information;
- 4) Analyze and provide a solution.

The *problem* in our case is that we do not have or we do not have working IDS. “An IDS monitors network traffic searching for suspicious activity and known threats, sending up alerts when it finds such items. A long-time corporate cybersecurity staple, intrusion detection as a function remains critical in the modern enterprise, but maybe not as a standalone solution.” [1].

The *goal of the analyses* is to solve the problem. This can happen as the analytics provide a solution to the decision-makers that can solve this problem. This solution must meet the pre-set time, location, and range restrictions. The vendors provide the information on costs

and technological parameters of the alternatives. Some of the alternatives may be dropped out because of the pre-set restrictions. Fig. 2 shows the starting model for the analyses.

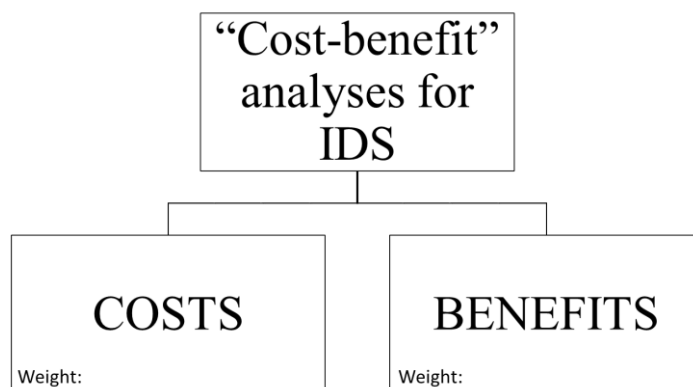


Fig.2. A starting point in the model for the analyses

By analyses, we are looking for *efficiency in the measurement of the costs*. Efficiency also can be met in literature as cost-efficiency. This means the lowest value of costs with a fixed effect. In this case, the effect is constant. The organisation defines project costs in its budget. The best possible scenario for them is to be pre-defined. This effect can be some technical/technological parameter or some work. In most of the simple models, calculations can be concentrate only on this value. We measure it by:

$$Cost/Effect = \frac{Cost}{Effect} \quad (1)$$

The lowest is the value the better is the solution. However, in most systems, the measurement of a single effect is almost impossible, because the combination of the effects of all elements is bigger than the effects of a single element.

If we separate the cost from the effect, we are looking for economy/ inexpensiveness. Therefore, the lowest cost will be the best result. This approach collaborates with the restrictions of the analyses. Not every time the most expensive solution provides the biggest combination of the cost-benefits.

The benefits mean the largest combination of the effects that an alternative/solution provides. We are looking for effectiveness, in the measurement of benefits. Effectiveness means the biggest effect on the fixed cost. The cost is a fixed value (constant), for all the alternatives. The bigger is the result the better is the solution:

$$Effect/Cost = \frac{Effect}{Cost} \quad (2)$$

In a defined simple system, this model can operate. In complicated systems where the benefits are, a combination of all the effects the results can vary from the required.

We solve the problem of choosing between efficiency and effectiveness, by *weight* evaluation. The *weight assessment* determines the importance of each of these indicators for the organization. The analytics determine weight by the organisation capability, culture, and policy and so on. The combination of weights always has to give a whole (1 or 100%). Management of the organisation determines the weight value. Different heuristic approaches are the instruments for that.

We can prefer effectiveness if we have bigger financial resources. In cases with limited budgeting, we prefer efficiency. For the model, we will assume that the costs will have 60% of the weight and 40% of the weight for benefits.

3. Cost analyses

When it comes to cybersecurity costs, investment efficiency is usually sought. The standard approach is by “calculating the effectiveness of investment projects is a prerequisite for the selection of the investment portfolio generated by the investor, and based on several traditional criteria: NPV (Net Present Value), IRR (Internal Rate of Return), PP (Payback Period), PI (Profitability index) and NFV (Net Future Value)” [2]. In security, this approach is very hard to implement, because the negative event may or may not occurs. In most cases, we approach the effectiveness of the investments by calculating the eventual financial, reputational and legality losses which the organization will suffer in the event of a negative event. In most cases, we assume that the loss of the information will create greater harm than its purpose. The ultimate goal of *cost-loss* comparison could prove that the benefits of deployment and effective management outweigh the costs of technology and its management.

In the case of the complicated system as the example of IDS is, as part of the cybersecurity system, we have to apply a complicated system of cost analyses. To pre-determine the costs of the project, an organization can use the “**lifecycle costs**” methodology. This cycle past in four main stages (Fig.4):

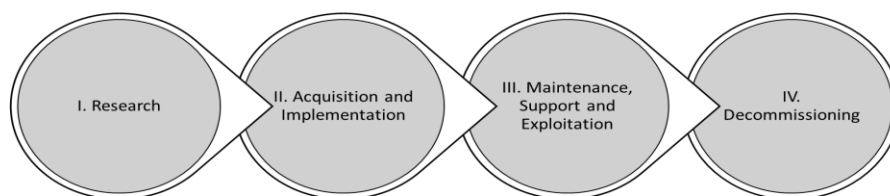


Fig. 4. “Life-cycle costs” methodology stages

Calculation of the costs only for acquisition is one of the often-made mistakes by an organization. This is a widespread practice in all kind of projects. In most cases, when the project is off-budget, management finds out that the costs for support and exploitation are greater than the costs of acquisition. Other problem for accurate budgeting we observe in the change management process. Depending on the object the change management cycle can start at the beginning of the exploitation phase for the previous [3].

A detailed list of the costs we make by application of costs analyses by elements. These elements can be hundreds. They have the role of different categories in the “lifecycle”. To analyze them we make tables (Fig.4). For our case, we will limit the lifecycle to 5 years. It is very important to create tables for all the alternatives, and for all the pieces that we acquire. The *total costs* in the tables show the costs of all the pieces not for one.

For the determination of the elements of the costs, we can apply different concepts. This choice depends on the object and the subject, the organization practices and accounting standards. The concept that we can apply in most cases is *absolute and alternative costs*. The absolute cost is the payments that we are obligated to pay. They can be salary, taxes, related

resources, etc. The alternative costs depend on the alternative and specific costs for it. By applying this cost concept, we can differ the different alternatives by their *efficiency*.

Table 1. Lifecycle and element costs (example)

Costs	Year					Total by element
	1	2	3	4	5	
I. Research	Total costs for the stage:					
1.1. Project creation	x					
1.2. Tools	x					
1.3. Expert payments	x					
1.4. Testing	x					
...						
1.n.	x					
II. Acquisition and implementation	Total costs for the stage:					
2.1. Acquisition	x	x	X			
2.2. Training and education of personal	x					
2.3. Delivering	x					
2.4. Installation	x					
...						
2.n...	x					
III. Maintenance, Support and Exploitation	Total costs for the stage:					
3.1. Maintenance	x	x	X	x	x	
3.2. Support	x	x	X	X	x	
3.3. Personal training	x	x	X	X	x	
3.4. Personal payment	x	x	X	X	x	
3.5. Payment for maintenance and replacement of the old system	x	x				
3.6. Payment for management of the project	x	x	X	X	x	
3.7. Modernisation and updating			X	X		
3.8. Cybersecurity auditing	x	x	x	x	x	
...						
3.n...						
IV. Decommissioning	Total costs for the stage:					
4.1. Decommissioning of the project					x	
4.2. Personal payment for decommissioning and replacement					x	
...						
4.n...						
Total costs per/year						

In most cases, the cost is only in the first year for the Research stage. Another interesting moment is the acquisition payment. We can do this in different ways - the total amount, credit, lease, etc. In a better case, we can calculate the *future value of the money* and make this decision. We can call total costs by the year, cash flow for the year. If these tables are enough detailed, they can be used as budget tables. We have to be very careful in calculations because in most of the cases the payment for salaries is not dependent on the product. In this case, we will have the same amount of money. In other cases, our organization already has employees, responsible for cybersecurity, so we will not have to pay them for the application of the new product, etc.

ABC analysis can be used to select the categories. This is an analysis that divides cost groups into three categories according to their importance and value. Usually, the costs of category A are the smallest in number and form the largest value, which is many times greater than the costs of other categories taken together. This allows us to focus on the most important cost categories without looking at others in detail, thus simplifying the model. The same approach can be used in the *benefits analysis*. We choose the important characteristics that influence the process and ignore the irrelevant ones. Experts or statistical data determine these characteristics and the costs, which will be calculated.

The easiest way to make cost analyses is to make the first table for each alternative with *fixed costs*. This means that the costs are taken from the moment of analyses. To be precise in analyses we will have to use also the variable costs. This means we have to calculate the future value of the money. We make this by calculation of NPV(Net Present Value) and costs with inflation. This will also show us the future value of the investment if we pay at the moment, and eventually, it will show us how much will be the cost, if we delay the project and pay and realize it in the future.

$$NPV = \sum_{t=0}^n \frac{C_t}{(1+r)^t} \quad (3)$$

where:

C_t - Net cash flow during a single period t

r - Discount rate or return that could be earned in alternative investments

t - Number of timer periods

The cost with calculated inflation (Future price(FP)) or *variable prices*. We calculate these prices for the year that we will make the payment, on the prognostic value of inflation.

$$Future\ price = Current\ price \times (1 + IRI_n)^n \quad (4)$$

where:

IRI_n - annual inflation for the specific year

n - year

For example, we will need the total amount of costs for each alternative. Depending on the object, method of payment, type of contract, policy, etc. we can choose one of the totals NPV, fixed costs, the cost with inflation, etc.

Table 2. Example total cost of alternatives for “10 products”

Alternatives	Total cost for alternative	Notes
A1	125 000 USD	Free product
A2	140 000 USD	Free product
A3	225 000 USD	The cost of the product starts from 9 500 USD
A4	245 000 USD	The cost of the product starts from 12 500 USD

*Note that the costs are just example, to demonstrate the model

On the bases of cost analyses, we can conclude that the best alternative is A1 because it is the cheapest one.

4. Benefit analyses

If the benefits of each alternative are equal, the arrangement of the alternatives can be done simply by their cost. This is a very rare case. In most cases, an in-depth analysis of the benefits is required, as they will be a factor in ranking the alternatives [4]. We have to determine the exact number of technological characteristic, for the benefit analyses. For the example model, we will shorten that list.

Analysis of the benefits (*technical/technological characteristics*) is effective when output can be quantified. With less precision, the analysis can be applied in other cases - with quality meters, shown by relative utility - normalized assessment (NA).

The first step in benefit analyses is to determine the technical/technological characteristics. For IDS, that is a very difficult process and there are several approaches to measure effectiveness. For a more detailed approach, there can be used asset evaluation, their exposition, treats and vulnerabilities. We make this by the implementation of risk analyses. This is not in the objectives of this article, but it can be calculated by the calculation of *consequences, probability* and *intensity* of the treat. Risk analyses have a direct connection to the costs that will be made for the implementation of tools that correlates to the treat.

One of the most popular is measuring Intrusion Detection Capability (CID). It calculates the possible/prognostic costs for alarms. The model is based on objective data for performances of different IDS and is a good solution for calculating the cost-effect value [5]. It is based on four types of alarms managed in a matrix:

- „- True positive (TP): Intrusions that are successfully detected by the IDS.
- False-positive (FP): Normal/non-intrusive behaviour that is wrongly classified as intrusive by the IDS.
- True Negative (TN): Normal/non-intrusive behaviour that is successfully labelled as normal/non-intrusive by the IDS.
- False Negative (FN): Intrusions that are missed by the IDS, and classified as normal/non-intrusive.“[6].

The alarms are signature-based detectors that scan the abnormal behaviour of the system. The key element that the vendors try to reduce is the false alarm rate. This can be done by layering filtering [7]. The main problem for the application of this method is that there have to be collected correct data for the performance of the alternatives. There are many data, but in most cases, they do not correlate very well with the dynamic of cybersecurity vulnerabilities. At this stage, the prognostic data can be implemented in the support and maintenance of the cost analyses. It is a good method but from a management point of view, it cannot be applied universally, but only for the effectiveness and efficiency of IDS. In other words, although we can use the benchmarking of other organizations, we will have to test several different alternatives (free or paid), allocating the appropriate financial resources to the qualified staff who will test and operate them. The question is which is more cost-effective – handling the false alarms or handling the loss of personal data.

There are two main technical characteristics about the type of IDS that may concern the cost and eventual benefits of the analyses:

1) Network-based intrusion detection system (NIDS) detects malicious traffic on a network. NIDS usually requires promiscuous network access to analyze all traffic, including all unicast traffic. NIDS are passive devices that do not interfere with the traffic they monitor [8]. We include the passive and reactive setting in the benefit analyses.

2) A host-based intrusion detection system (HIDS) monitors and analyzes system configuration and application activity for devices running on the enterprise network. The HIDS sensors can be installed on any device, regardless of whether it is a desktop PC or a server [9]. In HIDS sensors monitor data changes by taking a snapshot of existing system files and compare them with previous snapshots. They look for unexpected changes in the data system and monitor the behaviour. Alerts are sent to administrators to investigate activities that are different from the usual module.

For the implementation of benefit analyses in this article we have to more subjective (manageable) and heuristic approach.

The basic distribution of IDS characteristics is in Table 3.

Table 3. Components, Types and Kinds of IDS

	Components	Types	Settings
Technological characteristics	Sensors	Signature-based	Reactive
	Console	Anomaly-Based	Passive
	Engine		

For the sensors, we will take the technical characteristics of - *Attack detection capability, False alarms and Accuracy of detection*.

For the types, we will use *Signature-based* and *Anomaly-Based* types. “The signature-based methodology tends to be faster than anomaly-based detection, but ultimately a comprehensive intrusion detection software program needs to offer both signature and anomaly procedures. This is because there are metrics and disadvantages to both signature-based and anomaly-based intrusion detection software, which are largely compensated for when the two are combined.” [10]. Also, we will add *Cloud compatible* and *CPU usage*.

For setting, we will use *Reactive* and *Passive* mods in addition to *User Friendly*. For user-friendly, there has to be an additional study between the users, so they can provide their opinion on the subject for the scale (the used scale is 1...5). A passive intrusion detection system detects that there is a potential security breach and signals an alert on the console. A reactive intrusion detection system detects a potential security breach it responds to the suspicious activity and can change a firewall set to block the traffic or resets the connection to stop the anomaly.

The second step is to select technical/technological characteristics into goals. Also, we have to assign the weight for each objective and each characteristic. The total sum of the weights of the objective has to be 1 or 100%. The total sum of the weights of the characteristics in an objective has to be 1 or 100%. This is just an example of the arrangement and weight assignment for demonstration of the model. For example, there are very good possible capabilities like zero-day exploit detection and implementation of artificial intelligence, which can significantly change the weight structure if we include them. There is a very common niche in the use of IDS in collaboration with AI. AI /Deep learning is being widely applied as a solution to problems in detecting various network attacks [11]. Through AI training and a tool for marking and analyzing true and false data, AI and IDS capture extremely complex attacks. For example, AI helps to write and improve Snort rules (Rules are a different methodology for performing detection, which brings the advantage of 0-day detection to the table. Unlike signatures, rules are based on detecting the actual vulnerability, not an exploit or a unique piece of data. Developing a rule requires an acute understanding of how the

vulnerability works [12].) for signature-based IDS based on newly identified system models. Alternatives to the Snort are Palo Alto Networks Next-Generation Firewall, AlienVault USM (from AT&T Cybersecurity), McAfee Network Security Platform, and Ossec.

The minimum requirements for the IDS can be based on the weight of technological characteristics.

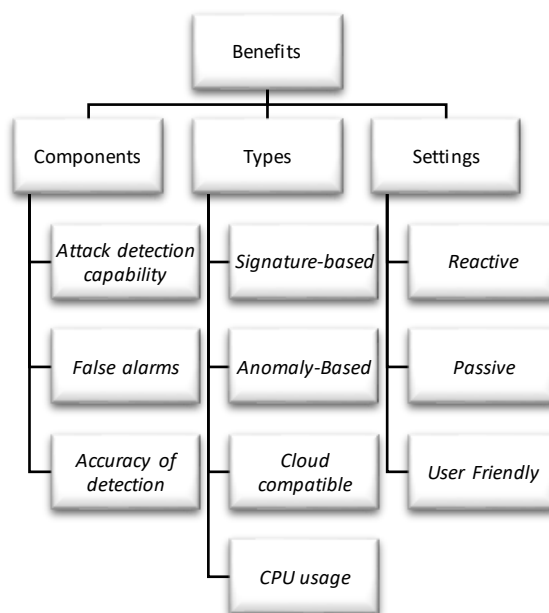


Fig. 5 Distribution of objectives and characteristics

Table 4. Distribution of technical/technological characteristics by objectives and assigning weight estimates

		Weight		Weight		Weight	
Objectives	Components	0,45	Types	0,3	Settings	0,25	100%
Characteristics	Attack detection capability	0,4	Signature-based	0,35	Reactive	0,45	
	False alarms	0,2	Anomaly-Based	0,35	Passive	0,35	
	Accuracy of detection	0,4	Cloud compatible	0,2	User Friendly	0,2	
			CPU usage	0,1			
		100%		100%		100%	

Table 5. Distributed technical and technological characteristics of the alternatives

Alternatives	Attack detection capability	False alarms	Accuracy of detection	Signature-based	Anomaly-Based	Cloud compatible	CPU usage	Reactive	Passive	User Friendly
A1	0,85	0,35	0,9	Yes	No	Yes	0,35	No	Yes	No
A2	0,75	0,25	0,85	No	Yes	Yes	0,34	No	Yes	No
A3	0,92	0,2	0,95	Yes	Yes	Yes	0,15	Yes	Yes	Yes
A4	0,93	0,15	0,95	Yes	Yes	Yes	0,2	Yes	Yes	Yes

The third step is to make a normalized assessment of technical/technological indicators. The first thing that we have to do is to choose the “standard” for the given characteristic. In other words, this is the best value. We calculate the *Normalized Assessment* (NA) in three ways:

1) When the standard is the highest value:

$$NA = \frac{CV}{SV} \dots \quad (5)$$

where:

CV – Current value for the alternative

SV – Standard value

2) When the standard is the lowest value:

$$NA = \frac{SV}{CV} \dots \dots \dots \quad (6)$$

where

CV – Current value for the alternative

SV – Standard value

3) When the standard is a quality characteristic when it exists it takes 1 and if not take the value of 0.

The normalized values have to be between 0 and 1.

Table 6. Normalized values of technical and technological characteristics of the alternatives

Alternatives	Attack detection capability	False alarms	Accuracy of detection	Signature-based	Anomaly-Based	Cloud compatible	CPU usage	Reactive	Passive	User Friendly
A1	0,913978	0,42857	0,94736842	1	0	1	0,429	0	1	0
A2	0,806452	0,6	0,89473684	0	1	1	0,441	0	1	0
A3	0,989247	0,75	1	1	1	1	1	1	1	1
A4	1	1	1	1	1	1	0,75	1	1	1

The fourth step is to calculate the *Integral Measure of the Effect* (IME) for each alternative.

$$IME_i = \left(\sum_j^n W_j \cdot NA_{ji} \right) WO_n \dots \dots \dots \quad (7)$$

where:

i – The number of alternatives

IME_i - Integral measure of the effect

W_j – Weight of j technical/technological indicator

NA_{ji} - Normalized assessment of j technical/technological indicator of i alternative

WO_n – Weight of objective n

The IME values have to be between 0 and 1.

Table 6. Integral Measure of the Effect of all alternatives

Alternatives	IME
A1	0,638971
A2	0,625949
A3	0,975565
A4	0,9925

According to the calculation of IME, the most effective alternative is A4.

5. Ranking of alternatives and Sensitivity analysis

Ranking of the alternatives is a combination of the Cost Value(CV) and IME for each alternative or the Integral Effect(IE):

$$IE_i = CV_i \cdot W_{costs} + IME_i \cdot W_{benefits} \dots \quad (8)$$

where:

i – Alternative

CV_i – Cost value of i alternative

W_{costs} – Weight of the costs

IME_i - Integral Measure of the Effect of the i alternative

$W_{benefits}$ – Weight of the benefits

The IE values have to be between 0 and 1.

One of the things that we have to do is to normalize the values of the costs. For the standard, we choose the lowest value.

Table 7. Normalizing the values of the costs

Alternatives	Total cost for an alternative in USD	Normalized value
A1	125000,00	1
A2	140000,00	0,892857143
A3	225000,00	0,555555556
A4	245000,00	0,510204082

Table 8. Ranking the alternatives by their IE

Alternatives	IME
A1	0,855588
A2	0,786094
A3	0,723559
A4	0,703122

The integral measurement of the effect for the first alternative is the highest so we have to recommend to the decision-makers to choose it. Because of the pre-determined criteria, we can see clearly that the A1 alternative is in the first place because of the lowliest costs and the weight of the costs. To fix this obvious issue we make a *Sensitivity analysis*. In most cases, is based on changing the weight values in the model. For example, we will change the weight value of the costs to 40% and the weight value of the benefits to 60%.

Table 8. Ranking the alternatives by their IE Sensitivity analysis

Alternatives	IME
A3	0,8075609
A4	0,7995816
A1	0,7833826
A2	0,7327124

After Sensitivity analysis, the A3 alternative stands in the first place. The difference with alternative A4 is too small and this requires further analysis. They can be made by changing the weight estimates of the technical characteristics of the individual alternatives.

6. Conclusions and future studies

One of the goals for the future is to attempt to implement the Intrusion Detection Capability method in the overall cost-benefit analyses. There are interesting indicators that can be studied in details Classification rate (CR), Detection rate (DR), Precision (PR), etc. The future study will try to compliment the cost analyses with the Intrusion Detection Capability method in more depth. In addition, there will be made a study with collected objective data.

If it is possible, there will be a study about the effectiveness of capabilities - zero-day exploit detection and artificial intelligence.

Cost-benefit analyses are the universal method to recommend alternatives in the field of security and defence. It can be applied to all types of tools and defence mechanisms.

The conditions for application are the availability of data and expert assessment. In the field of cybersecurity, there is no equality between the expertise of different experts. This is due to the extremely rapid development of technologies, attack and defence technologies, which require the accumulation of huge amounts of specific knowledge. For this reason, we need universal tools for choosing alternatives.

The minimum requirements for alternatives are determined by their effectiveness and efficiency. Concerning technical indicators, the minimum requirements are determined based on required technological indicators. The preference for these technical indicators is expressed in weight estimates.

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Some Aspects of the Students' Projects on Statistics

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Abstract. The paper discusses some issues related to the development of practical projects on Statistics in seminars on informatics and information technologies and as projects with which students participate in student sessions of the Bulgarian Academy of sciences and in the European Olympiad in Statistics. Examples of student statistical surveys are considered as follows: a project proving / rejecting a hypothesis about the success of students in school; project examining the prevalence of diabetes mellitus in some region, etc. There are also some ideas for direct and active inclusion of students in the learning process of principles such as "Learning by doing" and "The social commitment of the pupils creates the future professionals and experts and active citizens".

Keywords. Conceptual knowledge, Research approach, Integrating skills, Teamwork.

1. Introduction

The modern development of the information technologies and the student of today's world set inherently new tasks for education and its workers - the Teachers. In order for the student to learn and prepare for his future realization as a person and as a professional in a given field, he/she must acquire knowledge and skills, but more importantly - he must also learn to choose from the ocean of information reaching him/her and to process it properly. And importantly, he / she must learn to think conceptually, globally, to see (define) the problems, to try to be creative and to solve them. And last, but not least, the student must look at himself as part of a whole, and not just integrate his knowledge and skills into the larger whole (the organization, the community to which he belongs) and weave them successfully, for to meet the challenges of a dynamically changing world.

Given the dynamics of changes, the main task of education should be for the student to learn to learn. Therefore, project-based learning should be practiced as widely as possible in school. On the other hand, there are many competitive initiatives that allow students to participate in them with their own projects and to validate what they have learned during the development of the projects, and of course to win prizes.

The second aspect of the report is statistics as a science and a "boring" and "incomprehensible" subject in school, which in Bulgaria is studied from 8th grade. The student projects on statistics make this subject much more useful and satisfying for the students. In this work we will consider three such types of student projects in statistics, thanks to which for the third year students from Ivan Vazov High School of Natural Sciences and Mathematics (HSNSM), Dobrich touched the science of statistics, adopted basic principles and learned useful things, while contributing to raise the prestige of the high school and did some useful research for the public: European Statistics Competition [1], International Poster Competition [2] realized on International Statistical Literacy Project [3], Student Conference organized by High School Institute of Mathematics and Informatics [4], Student Conference of the High School Institute of Bulgarian Academy of Science [5].

2. European Statistics Competition

The European Statistics Competition (ESC) is organized by Eurostat and some EU Member States. The goals are several: to increase the statistical culture of students and teachers; to increase interest in statistics by showing its role in public life and in people's daily lives. At the same time, the aim is to encourage students to work in a team as a means of finding common solutions, to learn to analyze statistics, to illustrate them and make the necessary conclusions and predictions.

The initiative to participate in the ESC was received with enthusiasm and great interest from students. Neither the pandemic, nor the distant form of training, nor the fact that the profile of their classes is quite different from the topic - statistics, their decision to participate, to form teams and prepare. On the contrary, the difficult times and conditions seemed to make them even more ambitious. They easily spent their free time organizing the preparation. They especially liked the teamwork, the discussion of the different opinions and the understanding until the final decision was reached.

Several teams of students from 9th, 10th, 11th and 12th grades of the HSNSM - Dobrich teaching Informatics and Biology actively participated in the European Statistics Competition.

The competition was held in two stages at the national level.

The first stage involves solving three tests with 10 multi choice questions. In the first test, students had to demonstrate knowledge and understanding of statistical concepts, skills in interpreting graphs and elementary probability calculations. In the second test, students answer questions with varying difficulty using statistics from official sources. The third test includes 10 questions about the interpretation of a statistical text, in this case a Eurostat publication "Key Indicators for Europe", issued in 2020.

The second stage of the ESC is an analysis of official statistics on a pre-set statistical topic and a specially set database published immediately before the start of the second stage. Use of data from additional sources was not considered. The developed presentation has to contain: purpose of the analysis, technique of the analysis, results - tables, graphs and final conclusion.

The type of the table with the condition of the task "Water services" for ESC'2021 is shown in fig. 1, and in fig. 2 and fig. 3 are shown the presentations that ranked highest among the HSNSM teams in ESC'2021.

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	
Област	2014																									
	Население (стабилно) в средната му годишна промяна	Население (стабилно) в средната му годишна промяна	Население (стабилно) в средната му годишна промяна	Население (стабилно) в средната му годишна промяна	Население (стабилно) в средната му годишна промяна	Население (стабилно) в средната му годишна промяна	Население (стабилно) в средната му годишна промяна	Население (стабилно) в средната му годишна промяна	Население (стабилно) в средната му годишна промяна	Население (стабилно) в средната му годишна промяна	Население (стабилно) в средната му годишна промяна	Население (стабилно) в средната му годишна промяна	Население (стабилно) в средната му годишна промяна	Население (стабилно) в средната му годишна промяна	Население (стабилно) в средната му годишна промяна	Население (стабилно) в средната му годишна промяна	Население (стабилно) в средната му годишна промяна	Население (стабилно) в средната му годишна промяна	Население (стабилно) в средната му годишна промяна	Население (стабилно) в средната му годишна промяна	Население (стабилно) в средната му годишна промяна	Население (стабилно) в средната му годишна промяна	Население (стабилно) в средната му годишна промяна	Население (стабилно) в средната му годишна промяна		
България	99.3	0.0	56.8	18.1	74.9	99.3	5.7	62.3	13.2	75.5	99.3	2.1	63.1	12.6	75.7	99.4	3.8	63.4	12.6	76.0	99.5	1.1	63.9	12.3	7	
Бургас	99.7	0.0	3.0	36.6	36.6	99.7	0.0	3.0	36.6	36.6	99.7	0.0	3.0	36.6	36.6	99.7	0.0	3.0	36.6	36.6	99.7	0.0	3.0	36.6	36.6	
Варна	99.0	0.0	33.3	23.3	33.3	99.0	4.3	33.3	23.3	33.3	99.0	0.0	33.3	23.3	33.3	99.0	0.0	33.3	23.3	33.3	99.0	0.0	33.3	23.3	33.3	
Велико Търново	99.0	0.0	13.0	41.2	22.9	99.0	11.4	36.0	12.3	99.0	99.7	29.3	36.0	12.3	99.0	99.7	29.3	36.0	12.3	99.0	99.7	0.0	36.0	12.3	99.0	
Видин	99.4	0.0	34.3	24.0	34.3	99.4	3.0	34.3	24.0	34.3	99.4	0.0	34.3	24.0	34.3	99.4	0.0	34.3	24.0	34.3	99.4	0.0	34.3	24.0	34.3	
Витеш	100.0	0.0	41.3	15.4	36.7	100.0	0.0	41.3	15.4	36.7	100.0	0.0	41.3	15.4	36.7	100.0	0.0	41.3	15.4	36.7	100.0	0.0	41.3	15.4	36.7	
Враца	99.0	0.0	2.4	44.0	22.0	99.0	99.0	2.4	44.0	22.0	99.0	99.0	2.4	44.0	22.0	99.0	99.0	2.4	44.0	22.0	99.0	99.0	2.4	44.0	22.0	
Габрово	99.0	0.0	66.0	18.4	66.0	99.0	36.0	74.0	10.0	66.0	99.0	36.0	74.0	10.0	66.0	99.0	36.0	74.0	10.0	66.0	99.0	36.0	74.0	10.0	66.0	
Горно Орязково	100.0	0.0	45.0	0.0	45.0	100.0	2.3	45.0	0.0	45.0	100.0	2.3	45.0	0.0	45.0	100.0	2.3	45.0	0.0	45.0	100.0	2.3	45.0	0.0	45.0	
Грозница	100.0	0.0	64.5	3.5	68.0	100.0	0.0	68.0	3.5	68.0	100.0	0.0	68.0	3.5	68.0	100.0	0.0	68.0	3.5	68.0	100.0	0.0	68.0	3.5	68.0	
Гюмря	100.0	0.0	4.3	48.3	31.3	100.0	0.0	7.0	48.3	31.3	100.0	0.0	48.3	31.3	100.0	0.0	48.3	31.3	100.0	0.0	48.3	31.3	100.0	0.0	48.3	
Девня	100.0	0.0	86.0	0.0	86.0	100.0	0.0	86.0	0.0	86.0	100.0	0.0	86.0	0.0	86.0	100.0	0.0	86.0	0.0	86.0	100.0	0.0	86.0	0.0	86.0	
Добрич	99.0	0.0	70.0	0.0	70.0	99.0	0.0	70.0	0.0	70.0	99.0	0.0	70.0	0.0	70.0	99.0	0.0	70.0	0.0	70.0	99.0	0.0	70.0	0.0	70.0	
Долна Екстра	99.0	0.0	13.0	44.1	13.0	99.0	0.0	45.0	13.0	99.0	10.0	45.0	13.0	99.0	10.0	45.0	13.0	99.0	10.0	45.0	13.0	99.0	10.0	45.0	13.0	
Долна Екстра	99.0	0.0	44.7	14.0	38.3	99.0	0.4	38.3	3.7	38.3	99.0	4.3	38.3	3.7	38.3	99.0	4.3	38.3	3.7	38.3	99.0	4.3	38.3	3.7	38.3	
Дунав	99.0	0.0	14.4	14.7	74.1	99.0	0.0	44.0	13.0	74.1	99.0	0.0	44.0	13.0	74.1	99.0	0.0	44.0	13.0	74.1	99.0	0.0	44.0	13.0	74.1	
Евксино	100.0	0.0	37.0	7.7	68.0	100.0	0.0	37.0	7.7	68.0	100.0	0.0	37.0	7.7	68.0	100.0	0.0	37.0	7.7	68.0	100.0	0.0	37.0	7.7	68.0	
Евксино	99.0	0.0	37.0	15.0	37.0	99.0	0.0	61.0	15.0	37.0	99.0	0.0	61.0	15.0	37.0	99.0	0.0	61.0	15.0	37.0	99.0	0.0	61.0	15.0	37.0	
Евксино	100.0	0.0	3.0	66.0	74.0	100.0	0.0	4.7	66.0	74.0	100.0	0.0	4.7	66.0	74.0	100.0	0.0	4.7	66.0	74.0	100.0	0.0	4.7	66.0	74.0	
Евксино	99.0	0.0	26.0	39.0	77.0	99.0	0.0	31.0	39.0	77.0	99.0	0.0	31.0	39.0	77.0	99.0	0.0	31.0	39.0	77.0	99.0	0.0	31.0	39.0	77.0	
Евксино	99.0	0.0	61.0	13.0	74.0	99.0	0.0	61.0	13.0	74.0	99.0	0.0	61.0	13.0	74.0	99.0	0.0	61.0	13.0	74.0	99.0	0.0	61.0	13.0	74.0	
Евксино	99.4	0.0	74.0	5.0	79.0	99.0	0.0	73.0	5.0	79.0	99.0	0.0	73.0	5.0	79.0	99.0	0.0	73.0	5.0	79.0	99.0	0.0	73.0	5.0	79.0	
Евксино	99.0	0.0	26.0	47.0	72.0	99.0	0.0	45.0	39.0	72.0	99.0	0.0	45.0	39.0	72.0	99.0	0.0	45.0	39.0	72.0	99.0	0.0	45.0	39.0	72.0	
Евксино (Евксино)	100.0	0.0	96.0	0.0	96.0	100.0	0.0	96.0	0.0	96.0	100.0	0.0	96.0	0.0	96.0	100.0	0.0	96.0	0.0	96.0	100.0	0.0	96.0	0.0	96.0	
Евксино	99.0	0.0	3.0	96.0	10.0	99.0	0.0	37.0	9.0	96.0	99.0	0.0	37.0	9.0	96.0	99.0	0.0	37.0	9.0	96.0	99.0	0.0	37.0	9.0	96.0	
Евксино	99.0	0.0	27.0	42.0	76.0	99.0	0.0	44.0	26.7	77.0	99.0	0.0	44.0	26.7	77.0	99.0	0.0	44.0	26.7	77.0	99.0	0.0	44.0	26.7	77.0	
Евксино	99.0	0.0	24.0	24.0	76.0	99.0	0.0	24.0	24.0	76.0	99.0	0.0	24.0	24.0	76.0	99.0	0.0	24.0	24.0	76.0	99.0	0.0	24.0	24.0	76.0	
Евксино	99.0	0.0	36.0	29.0	68.0	99.0	0.0	40.0	29.0	68.0	99.0	0.0	40.0	29.0	68.0	99.0	0.0	40.0	29.0	68.0	99.0	0.0	40.0	29.0	68.0	
Евксино	99.0	0.0	46.0	24.0	72.0	99.0	0.0	74.0	17.0	72.0	99.0	0.0	74.0	17.0	72.0	99.0	0.0	74.0	17.0	72.0	99.0	0.0	74.0	17.0	72.0	

Fig. 1. Table with the condition of the task, with data on water services by districts and by years for the period 2015-2019

All teams successfully passed the first stage of the European Statistics Competition and performed well in the second stage. After the end, they expressed opinions that they should participate in the next competitions. HSNM "Ivan Vazov" participates with the most ESC teams compared to other schools in Dobrich.



Fig. 2. Statistical study named "Monitoring of water services in Veliko Tarnovo district" made by STATATTACK team (12th grade)



Fig. 3. Statistical study "Areas by water supply regime" - PMGSEE team (9th grade)

3. International Poster Competition

In the International Poster Competition'2021 (IPC'2021) participated 3 teams from HSNSM "Ivan Vazov", Dobrich: two from 11th grade, and 1 team from 7th grade, which performed best.

This year's theme of the statistical poster competition was - environment. The work of making the poster was very interesting for the students and especially useful, learning certain new information and applying the IT skills acquired at school.



Fig. 4. The statistical posters produced by the teams of HSNSM "Ivan Vazov", Dobrich

The statistical poster is a one-page presentation (1 slide) that tells the story of a data set. It should: not be complex and show a logical sequence (contain: purpose, approach, main findings and key conclusions); include graphs, tables and summary text for the data used; contain comments on the importance of the data; be autonomous (viewers do not need additional materials or information to understand the message); be visually attractive [2, 3].

In the national (second) stage of IPC'2021, were highly rated these posters, in which the high students themselves conducted a study and analyzed and summarized the results. Thus, they studied the types of diagrams to represent numerical dependencies: histograms, bar charts, line charts, pie charts and others. And they learned what statistical terms mean and what they are used for: mean, arithmetic mean, median, standard deviation. Students learn [2]: *"to properly plan the indicators needed for the study; to build appropriate graphs and charts for analysis and presentation of data and to comment on them, to interpret their findings, to formulate their conclusions in the light of the original topic or question"*. The Conclusions step in making the poster is important because ultimately the purpose of the statistical poster is "not just to present graphs or charts or to reveal the student ability to perform statistical calculations, but also to show that the student can think statistically and share the own views on the significance of the made findings and how they help answer the research topic or question." [2]

The advantages of this type of training and the success of the educational purposes of IPC'2021 are evidenced by the social commitment and the creativity of the student teams from Bulgaria, which qualified for participation in the international (final) stage of IPC'2021, and correspondingly their final ranking in the final:

1st prize Older age division (born in 2001 and younger, upper secondary school) won the team "Sacrementum" from the High School of Natural Sciences and Mathematics - Blagoevgrad [3], with a poster on "The environment surrounding us - What I do and can do in order to live in a clean and orderly world", which introduces us to the consequences of human intervention in the environment and ways to protect it [2].

3rd prize Younger age division (born in 2004 and younger, lower secondary school) ranked team "Michelle" from "Kozma Trichkov" Secondary school, Vratsa [3], with a poster "Vultures and Young People Today", which shows the attitude of young people in Bulgaria to vultures and effective methods for raising public awareness for the conservation of biological diversity in the country.

The analyzes and conclusions in both posters are based on their own research among students and young people, who express their attitude on the current topic of environmental protection [2].

4. Analysis of the success of students in mathematics (2005-2019)

The other type of statistical projects, apart from the competitive type of research that students can develop, these are studies with which to set and prove (or reject) statistical hypotheses. This type of research, for example, is the project called "Analysis of the success of students in mathematics (2005-2019)". The results were published in [6] and refute the verbal accusations of representatives of other schools in the city that the education in the HSNSM - Dobrich today is not up to standard. Before the publication in [6] the project was presented at the student conference 2019 organized by [5] and the student was awarded for the conducted research.

In this project, the high student conducted the research learned how to collect and analyze data using, for example, term and annual grades recorded in sources such as school diaries of selected classes for certain years. The data for 2 graduates were extracted and processed, respectively, for 2 teachers from HSNSM "Ivan Vazov", Dobrich: V. Radoeva (for short VR) and N. Nedelcheva (for short NN) and the analysis of the samples with the grades for five curricula was made. Years of graduation: 2005-2010/VR, 2010-2014/NN, 2011-2015/VR, 2015-2019/NN.

The grades in mathematics for the first and second terms and the annual grades of each school year are compared with a *T-test* [7], *F-test* [7] and a *Kruger-Spearman rank correlation* [7]. The most important goal of such a project is for students to understand and appreciate the diverse applications of statistics in human activity and management not only in different fields, but even as an aid to teachers who are not specialists in mathematics. With the help of MS Excel spreadsheets [8] the data were systematized and processed with the built-in functions of the software.

The project work consists in solving the following task:

- 1) Extraction of grades in mathematics for students in a sample for five years, starting from their entry into 8th grade [6];
- 2) Design of appropriate tables for representation of numerical rows;
- 3) Compilation of appropriate tables with the obtained numerical series in the spreadsheet MS Excel [8];
- 4) Calculation of Student's t-test [7] for comparison of averages (formula 1) and Fisher's F-test [7] for comparison of the dispersions at an appropriate degree of reliability. The empirical value of Fisher's *F*-criterion is calculated by formula 2. The larger deviation (D_I) is in the numerator;

$$t = \frac{Av_1 - Av_2}{\sqrt{\frac{(n_1 - 1)SD_1^2 + (n_2 - 1)SD_2^2}{n_1 + n_2 - 2}}} \sqrt{\frac{n_1 n_2}{n_1 + n_2}} \quad (1)$$

where:

Av_1 and Av_2 are the average values measured in the samples;

SD_1 and SD_2 are the standard deviations in the samples;
 n_1 and n_2 are the volumes of the compared samples.

$$F = \frac{SD_1^2}{SD_2^2} \quad (2)$$

5) Performing a correlation analysis by the *Kruger-Spearman* method [7]. The empirical value of the Kruger-Spearman R -coefficient is calculated by formula 3. The quantities x_i , and y_i are the values (ranks) of the first and second compared distributions, n - sample size (number of pairs of numbers) [7].

$$R = 1 - \frac{6 \sum (x_i - y_i)^2}{n(n^2 - 1)} \quad (3)$$

6) Proof or rejection of statistical hypotheses [7] for the success of students in mathematics.

For all compared samples, the value of the T -criterion calculated according to formula 1 when comparing the success at the end of the training with the success at the beginning of the training and comparing the maximum average success with the minimum turned out to be higher than the tabular value of the T -criterion [6] (the tabular value of T is calculated with the built-in function of Excel *TINV()* [8] with probability $\alpha=0.05$). With few exceptions, there is no statistically significant difference between the initial, intermediate and final results for each of the surveyed samples (and students) for each school year, which can be considered as a very good overall development.

There is a statistically significant difference between the maximum average success and the minimum average success in each of the classes. Table 1 shows the values obtained for Student's T -test in the four samples. A comparison was made of the arithmetic mean of the students at the beginning and at the end of the high school education, as well as between the minimum and maximum average success, whose values for each of the classes were obtained for a different period. For only one sample (2009 - 2014NN), the maximum average success coincides with the success at the end of the training, and the minimum coincides with the success at the beginning.

Table 1 Values of the Student's T -test and the Fisher's F -test

2005 – 2010VR		$t_{\alpha 0.05}=2.01$	$f=46$	$F_{\alpha 0.05}=2.01$	$f_1=23$
End - Beginning	12/annual - 8/I term	5.55	1	1.09	0
Max - Min	12/annual - 9/II term	14.02	1	1.17	0
2010 – 2014NN		$t_{\alpha 0.05}=2.01$	$f=48$	$F_{\alpha 0.05}=1.98$	$f_1=24$
End - Beginning	12/ annual - 8/I term	25.47	1	5.25	1
Max - Min	12/annual - 8/I term	25.47	1	5.25	1
2011 – 2015VR		$t_{\alpha 0.05}=2.02$	$f=40$	$F_{\alpha 0.05}=2.12$	$f_1=20$
End - Beginning	12/ annual - 8/I term	14.48	1	2.62	1
Max - Min	12/I term - 8/II term	17.03	1	2.28	1
2015 – 2019NN		$t_{\alpha 0.05}=2.02$	$f=40$	$F_{\alpha 0.05}=2.12$	$f_1=20$
End - Beginning	12/ annual - 8/I term	4.59	1	1.01	0
Max - Min	10/I term - 11/II term	20.79	1	1.36	0

In order to check whether the teaching (in mathematics) is effective (ie the grades not only increase, but also become less variable as values), the standard deviations in the samples are also compared. For this purpose, Fisher's F -test for comparison of variances too is applied. The null hypothesis H_0^2 states that there is a statistically significant difference in the standard deviations in the samples between the first term in 8th grade and the annual grade in 12th grade. In other words, if we assume that upon entering the high school students are grouped around a higher average, then at the end of their education the grades should vary more, ie to have a statistically significant difference in the standard deviation from the mean. In table 1 in the last two columns are given the tabular values for the F -criterion, calculated using the standard Excel function $FINV()$ [8] and the corresponding degrees of freedom f [7]. In the rows "End - Beginning" in the penultimate column of the table 1, the values of the F -criterion are calculated when comparing the variance of the grades at the beginning of the training and the variance of the grades at the end of the training.

The latest analysis (Kruger-Spearman rank correlation) confirms the strong relationship between the samples with the students' grades for the compared periods. Table 2 shows the values of the correlation coefficient R for the samples compared in table 1. In three of the comparisons the correlation strength is significant - *Strong*, and in the other five – *Very strong*. This shows that we are working purposefully to improve the success of high students in mathematics.

Table 2. Kruger-Spearman rank correlation

2005 – 2010VR		R	Correlation strength
End - Beginning	12/annual - 8/I term	0.6296	<i>Strong</i>
Max - Min	12/annual - 9/II term	0.5657	<i>Strong</i>
2010 – 2014NN		R	Correlation strength
End - Beginning	12/annual - 8/I term	0.8737	<i>Very strong</i>
Max - Min	12/annual - 8/I term	0.8737	<i>Very strong</i>
2011 – 2015VR		R	Correlation strength
End - Beginning	12/annual - 8/I term	0.8524	<i>Very strong</i>
Max - Min	12/I term - 8/II term	0.8061	<i>Very strong</i>
2015 – 2019SNN		R	Correlation strength
End - Beginning	12/ annual - 8/I term	0.5947	<i>Strong</i>
Max - Min	10/I term - 11/II term	0.7289	<i>Very strong</i>

The results of the study categorically reject the hypothesis that the success in mathematics in the high school of natural sciences and mathematics for the considered classes becomes lower: There is a statistically significant difference between the initial and final fixed success. For all grades, the success at graduation is higher than the fixed first term grade, which is confirmed by the correlation strength between the initial and final grades of the students, as well as between the minimum and maximum success in the samples. When the project was presented to one of the classes in the high school, it was accepted with great approval, as and by the principal's management too, because it refutes the unfriendly rumors that the education in HSNSM - Dobrich today is not up to standard.

As with the previous two types of statistical projects, the high students learn a lot about spreadsheets (especially Microsoft Excel) and when they need to format and process spreadsheets in the future, they will be confident. And accordingly they will be able to use the spreadsheets and built-in statistical functions for useful purposes.

5. Project on Diabetes Mellitus as a Serious Medical and Social Problem

The Diabetes Study was done by an 8th grade student (ie at the beginning the topic Statistics in the textbook in mathematics had not even been studied yet!) and the project aimed to show, on the basis of data collected from patients in the Dobrich region, about the danger of increasing obesity among young and old. Data on the patients from 2017 to March 2020 (the study was conducted at the end of March 2020) were collected, as follows: age, height, weight, Body Mass Index (*BMI*), measured blood sugar (Blood Sugar Profile - *BSP*), glycated hemoglobin additional diseases and medications. The average of the Student's *T*-test for *BMI* (*BMI* is calculated by formula 4) and blood glucose was analyzed.

$$BMI = \frac{W}{h^2} \quad (4)$$

where:

W – weight in kilograms,
h – height in meters.

For the purposes of the study, tables with primary data are separated by data tables by year. It is shown in fig. 5 a diagram of the number of people suffering from diabetes for the period 2017 - 2020. After a short fall (2018, 2019), there is a trend of increasing the number of patients. Fig. 6 shows the diagram of the change in the average body mass index over the period. Comparing the *BMI* rate, it can be seen that the mean body mass index of patients with diabetes remains high (*BMI* > 29) and closer to the upper limit (to extreme obesity - 35 kg/m²).

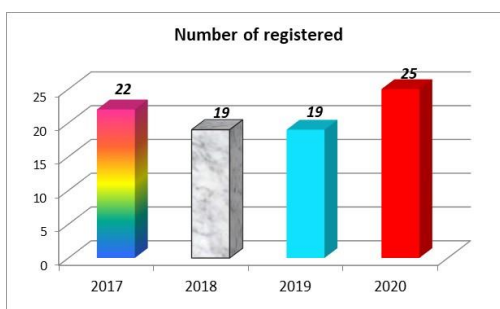


Fig. 5 Number of people with diabetes for the period

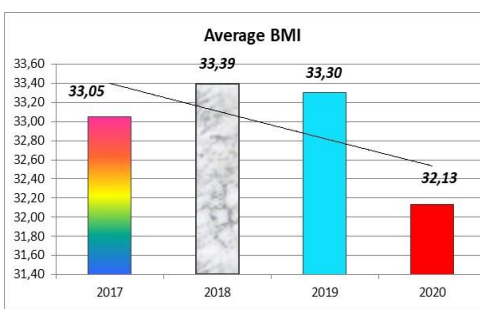


Fig. 6 Average body mass index

The results of the analysis of the average values for body mass index (Table 3) indicate that it has not changed statistically significantly for the period 2017-2019 and remains high. A critical factor in this regard is the rate of obesity in patients with diabetes.

This is confirmed by the *t*-test for the mean value of the blood-sugar profile of the diabetic patients included in the study (the calculated value of the *t*-test (row 12 in Table 3) is

lower than the table value of the t-test, listed in row 10 of table 3), which is about 3 times higher than that of healthy people [9].

To confirm the results of the Student's *T*-test, they compared the deviation in the samples for 2017 and 2019 and for 2017 and 2020 using the *F*-test of Fisher [7]. The empirical value of Fisher's *F*-criterion is calculated by the formula 2.

Table 3. Comparisons of BMI averages and blood glucose profile

	A	B	C	D	E	F	G	H	I
1									
2		<i>Year</i>	<i>n</i>	<i>Average BMI</i>	<i>StDev</i>	<i>D</i>	<i>Average BSP</i>	<i>StDev</i>	<i>D</i>
3		2017	22	33,05	7,10	50,35	17,64	3,33	11,06
4		2018	19	33,39	6,93	48,02	19,44	4,72	22,26
5		2019	19	33,30	7,57	57,27	17,12	5,19	26,92
6		2020	25	32,13	6,04	36,50	19,92	6,91	47,70
7		<i>Average BMI</i>		<i>Average BSP</i>		<i>Average BMI</i>	<i>Average BSP</i>		
8		2017-2020	2017-2019	2017-2020	2017-2019	2018-2020	2018-2019	2018-2020	2018-2019
9	<i>f</i>	45	39	45	39	42	36	42	36
10	<i>tin_v_{0,05}</i>	2,0141	2,0227	2,0141	2,0227	2,0181	2,0281	2,0181	2,0281
11	<i>tin_v_{0,01}</i>	2,6896		2,6896		2,6981		2,6981	
12	<i>ttest_{function}</i>	0,3171		0,0828		0,5227		0,0733	
13	<i>ttest_{formula}</i>	0,4791	0,1091	1,4096	0,3907	0,6445	0,0402	0,2608	1,4436
14	<i>H_{0/1}</i>	0	0	0	0	0	0	0	0

The results of the analysis of dispersions show that for the blood-sugar profile the differences in the deviations (for 2017 and 2019 and for 2017 and 2020) are statistically significant. The *F*-criterion calculated in the rows named *F*-test in table 4 for the *BSP* just confirms the apparent difference in the deviations for 2017 (table 3, cell I3) and 2019 (table 3, cell I5) and 2020 (table 3, cell I6).

Table 4 Comparison of dispersions of the BMI and the blood-sugar profile

	<i>BMI 2017-2019</i>	<i>BMI 2017-2020</i>
<i>Finv</i>	2,1791	2,0146
<i>Ftest</i>	1,1376	1,3793
<i>H_{0,05} 1/0</i>	0	0
	<i>BSP 2017-2019</i>	<i>BSP 2017-2020</i>
<i>Finv</i>	2,1791	2,0146
<i>Ftest</i>	2,4345	4,3132
<i>H_{0,05} 1/0</i>	1	1

Figure 7 shows a diagram of the change in the percentage of *BMI* rates for the period. There is a trend of increasing the percentage of obese diabetics. To test whether there is an increase in the proportion of patients categorized as obese and extremely obese, was applied an alternative analysis [7] using the *U*-criterion of formula 5.

$$U = \frac{|p_1 - p_2|}{\sqrt{\frac{p_1(1-p_1)}{n_1} + \frac{p_2(1-p_2)}{n_2}}} \quad (5)$$

where:

$p1$ and $n1$ are the relative proportion and volume of one sample;

$p2$ and $n2$ are the relative proportion and volume of the other sample [7].

The U -criterion calculated by formula 5 for all three norms is “normal”, “obese” and “extremely obese” when comparing 2017 and 2019 and the samples for 2017 and 2020 are lower than the table value of U criterion ($U_{0,05}=1,96$). This means that there is no statistically significant difference in the percentage of BMI rates, that is, during the observed period the more frequent norm of body mass index is “obese” and “extremely obese”.

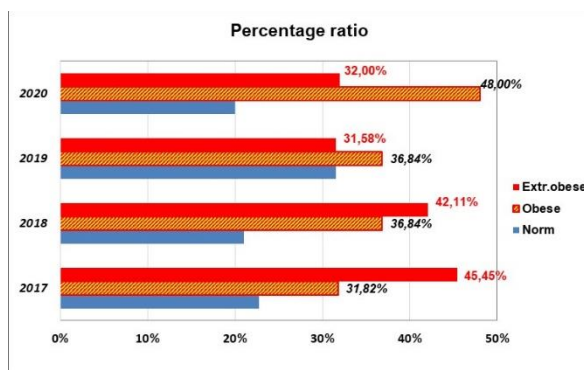


Fig. 7 Change in norms of body mass index

Table 5. Comparison of relative proportions of BMI norms

	1	2	3	4	5	6	7	8	9	10	
	P_{norm}	n_{norm}	P_{ob}	n_{ob}	$P_{extr.ob}$	$n_{extr.затл}$	Norm	Obese	Extr.obese	$U_{0,05}$	
2017	22,73%	5	31,82%	7	45,45%	10	0,3319	0,1982	0,5627	1,96	$U_{2017-2019}$
2018	21,05%	4	36,84%	7	42,11%	8	0,1053	0,7110	0,5901	1,96	$U_{2017-2020}$
2019	31,58%	6	36,84%	7	31,58%	6	0,0605	0,1982	0,1425	1,96	$U_{2017-2018}$
2020	20,00%	5	48,00%	12	32,00%	8	0	0	0		

The analysis of the results showed: The calculated values for the Student's T-test gives reason to reject the hypothesis that there is a statistically significant difference in the average annual values of body mass index and CFP of patients with diabetes. The data for the period 01.01.2017-01.03.2020 show the following dependencies:

There is an increase in the number of patients with diabetes mellitus (fig. 5), which is expected to be statistically significant at the end of 2020. The rate of obesity in these patients also increased (fig. 6 and table 3). Although statistically insignificant, due to an increase in the standard deviation from the mean for the body mass index of patients, this should not be reassured, since the relative proportion of patients with diabetes with a body mass index „obese“ does not change (fig. 7). The alternative analysis (table 5) showed that the average body mass index did not change. There is a tendency of reduction in the number of patients with the rate of body mass index "extremely obese" (fig. 7) which is not yet, statistically significant (table 5). The comparison of the existing change to higher values in the body mass index of patients with diabetes for the period (table 3, column D) is confirmed by changes in the average annual values for their blood-sugar profile (table 3, column H).

An increase in the standard deviation from the mean values was observed for both body mass index and measured blood sugar profile (table 3). The deviation from the average annual value of the blood-sugar profile for all years of the period is greater than the BSP of a healthy person (3,5 to 5,5 mmol/l [10]): In column I of table 1, the deviation from the average BSP is greater than 3 mmol/l. The increase in the deviation from the mean value for the blood sugar profile was confirmed by Fisher's *F*-test (table 4). This indicates an increase in the variation of blood sugar profile measurements to larger values.

All three analyzes on the data on diabetes patients reject the hypothesis that for the period there has been a change in the direction of improving the health status of patients with diabetes: the average annual values of the body mass index and blood-sugar profile of patients with diabetes in the Dobrich region do not decrease. The study results were presented at the Student Conference organized by [4] and the student received a special (incentive) award for her Socially Significant Project [11] from the Joint Training Simulation and Analysis Center (JTSAC) at the Bulgarian Academy of Sciences.

6. Conclusion

In the new curricula in mathematics, the topic Statistics are compulsory from the 8th grade, and students usually have a hard time understanding the material or at least think that "statistics are boring and unnecessary". And the participation of students in the statistics competitions, such as the described International Poster Competition and European Statistics Competition, in addition to being fun and "something different", because students work in a team, but also show the serious and significant role of statistics as in society, as well as for the individual, making them empathize with the results of official statistical surveys in Bulgaria and in Europe. These competitions make it possible to study statistics by detecting, analyzing, and showing (possibly solving) real-life problems.

The described research projects are emotional and satisfying because the students feel significant that they are working on researches that are useful for the high school, for society, and just for people. Projects to analyze the success and to study the development of a disease in a region are real and genuine science and an opportunity for students to discover their future profession and simply to improve as people, acquiring additional knowledge and skills.

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Application of Digital Technologies in ERP Systems

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Abstract. The integration of the digital technologies in an ERP system is an innovative and modern ITC solution for the re-engineering of the business models and processes in a company. Their usage in specific stages of the whole lifecycle of a project or of a company process can improve the final decision tremendously. We have analysed the options for integration of parts of the digital ITC technologies, responsible for the world wide and accepted good practices in ERP systems.

Keywords. ERP systems, cloud computing, blockchain, virtual reality, augmented reality, IoT

1. Introduction

The process of digitization includes significant changes to all business models and processes, supported by the ERP (Enterprise Resource Planning) system in each and every company, regardless of its size and business (production, transport, wholesale and retail, insurance, construction and more). The digitization mentioned is an assortment of tasks involved with the transition of analog information resources in digital copies and their input, storage, usage and protection.

The process of digitization also includes the usage of different modern digital IKT technologies, which represent the world renown good practices like Cloud Computing, Artificial Intelligence (AI), Business Intelligence (BI), Blockchain Technologies, Virtual and Augmented reality (VR&AR), Data Warehousing, Internet of Things (IoT) and many more.

2. Cloud computing

What cloud computing offers through internet access to different types of resources like informative resources (BaaS), different service models (SaaS, PaaS, MaaS) and technical resources (IaaS, CaaS), is a distributed across servers which are spread far apart information and supported and governed by the service providers.

Due to the widespread acceptance of the cloud computing technologies in ERP systems, the price needed to afford this service has become quite affordable, reaching the budget of small and medium enterprises, commonly predominating in Bulgaria. Some of the services offered are the following: - online consultation via live chat, IT support from the provider, access from everywhere at all times via the 7/24/365 scheme, usage of mobility devices and integration with other software solutions like CRM (Customer Relationship Management) and SCM (Supply Chain Management), saving from expenses for licenses and other software expenses, integration, hardware, storage space and staff costs. The clients are not dependent on work time, queues, holidays and weekends.

3. Artificial Intelligence - AI

Artificial Intelligence has the feature of analysing its surrounding environment and taking actions, which increase the likelihood of achieving specific results. The artificial intelligence theory is based on the hypothesis that a main human quality like intelligence, could be described so accurately that it can be simulated by a machine.

ERP systems based on artificial intelligence (AI) use advanced face and voice recognition, machine learning software with behavioral algorithms that adapt to our preferences. These systems improve their skills and usefulness using a large set of data. AI applies precision technology that offers consumers the goods and services they would like to receive. To make the most accurate proposal, a large set of information about consumer behavior and preferences is analyzed. The more information is analyzed, the more accurate the assumptions become, and this stimulates users to spend more time in the system.

Artificial Intelligence finds a wide usage in ERP systems, adding new features and transforming the ERP system in a new class software - iERP (intelligent ERP) [2]. The usage of Artificial Intelligence widens their capabilities for automation of business processes, saves time and errors, increases the satisfaction of clients and the competitiveness of different enterprises.

4. Business Intelligence – BI

Business Intelligence systems work with obscene amounts of information, which is summarised (consolidated) by different dimensions and returns a result form in either graphical or numerical format. The identification of new opportunities and the usage of effect strategy, based on knowledge, could give the companies/enterprises a competitive long term advantage via this method.

Nowadays the different companies collect much more data about production processes, sales, client behaviour in shopping centers, marketing campaigns and much more consumer data. This transitioned the business modules from ERP system, as well as the systems for Business Intelligence (like Tableau, Qlikview, Microstrategy, Power BI and more), into a more accessible versions of the software which enabled the wider acceptance of this software as well as its usage by non specialist. The business intelligence analysis is used by all different departments, managers, employees, allowing them to make the most of the data that they have. [3]

Example - Analysis of quantitative data

Quantitative data analysis can include the identification of a different number of orders of items and their geographical distribution. This statistic uses quantitative data in order to explain and forecast specific occurrences. In practice you can combine data for the purchases made with demographic characteristics of the clients leading to conclusions and forecasts based on sex, education, incomes or religion and how it will affect future sales of this kind of products.

5. Real time analytics

The companies which make their tactical strategy or operative decisions based on databases, using real time data are much more successful and take more optimal decisions. In order to achieve this goal, they need to possess programming tools for constant monitoring and analysis of a stream of information which is generated every second. This requires a big amount of both storage and hardware to be achieved.

The ERP system enables access to company data in real time. This feature enables better control, faster and more accurate senior leadership decisions based on more up to date information, fast and flexible reaction even in small market changes, better servicing of clients resulting in higher sales[4]

6. Blockchain Technologies

The ERP system offers its clients some core features like: Safety, Accessibility, Security and Visibility/Transparency. The blockchain technology is created in order to answer these requirements and can be used for each transaction (offers, orders, sales, payments with crypto currencies and tracking of transactions [5].

The advantages are many - the increased transparency of transactions as well as the increase in security reduces the need from middleman assistance, and due to this reduces the costs of their servicing. Via the usage of smart contracts all business processes that are used can be automated.

Accessibility - via the blockchain technology the users of an ERP system can easily get shared access to all of the stages and processes of the lifecycle of the product. The users can check what processes it has gone through, any documents associated with them, like design creation, production, packaging, storage, distribution, sales, delivery, usage, support and recycling.

Security - the information which is stored in blockchain chains cannot be modified, which means that it is impossible someone to make a one sided partial change due the way it is processed (hashing of transactions in the block, as this part of the hashing process represents the header part of the next block and secures the connection between them) and the storage is done by many computers using a decentralized approach.

The technology is conducted via storage and updating on different computers (decentralized approach) of copies of a distributed database with blocks of transactions, which are hashed with a hash function. This hash participates in the main part of the next block of transactions establishing a connection between them.

The blockchain technology can be used for re-engineering of business processes in an ERP system, reducing the participation of the staff and allowing communication machine to machine. By using technologies like internet of things (IoT), radio-frequency identification (RFID) and QR codes, the blockchain allows registration, processing and access to big sets of data, storage via a decentralized and secured approach.

7. Virtual and Augmented reality – VR & AR

Virtual reality – VR is a computer generated environment, which enables the employees and the clients of the company to view everything which is offered to them via special VR glasses equipped with 3D sound. The VR video is a better marketing and business instrument than a regular video because it generates up to 6 times more views, up to 7 times more shares in social networks and much stronger of an effect on the audience.

With VR glasses you can enable a virtual walk across all the necessary stages of the lifecycle of the goods (production, storage, delivery, usage, and maintenance), governed by an ERP system, while the clients are accommodated in a special VR space in the office. By using computer graphics you can interpret future innovations and services even before they are actually created.

The technology Augmented reality - AR allows through a camera of a mobile device, the visualization of additional information about physical objects, marked beforehand with an AR marker, like goods, buildings, faces, people, enables viewing videos about them, enables

connections to 3D objects, and enables a hyper connection to different web-resources. Generally speaking what an AR is, is an environment which combines virtual reality with elements from the real world. For example, the user can wear see-through glasses, via which he can see both the real world, as well as images generated by a computer and projected onto pictures of the real world he is seeing.

The VR and AR [6,11,12] technologies allow the merchants to demonstrate everything, without the need to have the product on hand. This also enables the client to test the products before they are brought, allowing the merchants to receive additional marketing insight about customer behaviour.

They create a more interactive learning environment which allows for the presentation to the employees of the different stages in the way the company works as well as their participation and work duties they need to perform. This includes incoming, intermediate and outgoing documents, processing of orders in a storage database and work with different modules of the ERP system.

8. Payments with a digital wallet

Every merchant or client can possess a digital wallet, which can be used via a smartphone. The digital wallet is the most innovative and modern way of conducting payments that has transpired on a global scale. The smartphone is used as a virtual wallet and you do not have to carry any money in cash, debit cards or credit cards.

The digital wallet is a mobile application in which you can register (tokenize) a bank card or request a bank card and the creation of a virtual card account. By using this card you can conduct contactless payments with a smartphone or other mobile device which supports the NFC technology. This mobile wallet allows fast and easy payments in all retail outlets and places of business (warehouses and stores) (over 99% of PoS terminals in Bulgaria are contactless). The integration of a mobile application with an ERP system [7] allows for the processing of payments to multiple administrations (the state administration, the tax administration and the customs administrations), as well as other contractors, the payments of communal taxes, as well as easy tracking of all conducted transactions. Such applications are Phyre, A1 Wallet, Pay by Vivacom, Revolut, Apple Pay and more as well as several banks having their own applications.

9. Multifactor protection with Biometric data

A new emerging way of protection and security is the introduction of biometric data. This is used in ERP systems in addition of – **password, PIN code and Templates** in order to maximize the security. They use a unique physical characteristic like iris, face or most oftenly fingerprint.

The biometric way for protection uses a scanner, integrated in the computer or the mobile device in order to access the ERP system and verify the information.

Iris Scanner - The form and coloring of the iris are unique. The data for the iris could be used for a number of other purposes like a two-factor authentication required in order to access a profile as well as numerous other systems and applications.

Face recognition - Face recognition is a property that identifies the features of the face of the user and compares them to the already saved face features in order to grant access. The smartphone scans the face with its front camera. It is as simple as just holding your face in the shown marker.

Intelligent Scanning - Intelligent scanning uses the face and the irises, in order to grant access to the system or device, which increases the grade of the security that is provided and makes the usage much easier.

Scanning a Fingerprint - Similarly to the iris data, a fingerprint can be used as well to increase security and regulate access.

10. Integration with 3D Printing

3D printers are commonly used in ERP systems already. These machines are innovating at an astonishing rate, becoming more and more complex and find use by different enterprises most often for prototyping, 3D projects, Design concepts, as well as for production of a small number of details, small spare parts and more. The 3D print is an industrial solution, which saves materials, increases the efficiency, speeds up the work on the design of new products as well as the process of reaching the final version which will be used for production. The ERP systems here are used for planning of the resources, as well as the materials, used in production of 3D printers and the management and the optimization of the whole production process.[8]

11. Data warehouse

In some cases the ERP systems have an interface that has access to data in different data warehouses. Those warehouses offer two possibilities and opportunities. First they give the user an opportunity to get access to information, required to make decisions, in an environment, created for the sole purpose of generating reports. Second, the data warehouse could store both outgoing and incoming flows of data, for both for the internal and external users.[9]

The data warehouses can be both physical real objects, stored in the same space or virtual, as in multiple parts of the data warehouse will be stored across multiple physical geographical places.

Discovering Knowledge

The data warehouse could be used not only for querying and providing reports to be used for analytical purposes. Since the data is in one place, the companies can create or find new discoveries/breakthroughs in the data. For example, the interactions between the different measures and dimensions can be examined with the assistance of statistical approaches and methods of artificial intellect. Such knowledge allows the acquisition and presentation of added value to each of the transactions during processing.

Advantages of Data Warehousing

The manufacturers of ERP systems are looking more than ever into the option to integrate data warehouses in their own systems. Companies like Oracle and SAP were one of the first manufacturers of ERP systems, which have successfully managed to integrate a data warehouse in their products.

The data warehouses offer information which is already optimized for querying. As the processes of making decisions are heavily impacted by the dimensions and measures in a data warehouse, that warehouse can be used to offer new reports in real time.

12. Internet of Things - IoT

The internet of things is a technology with very big potential in the usage of ERP systems. The technology uses many Internet of Things devices (Sensors, cameras and other physical devices) which are connected to the software system and communicate to it without any human interaction necessary. The technology offers the acquisition and processing of

extremely big chunks of data from the ERP and BI systems even in real time. The data is stored in data warehouses or with any of the available BIG DATA technologies. The integration between an ERP system and an Internet of Things device [10] will optimize the process of production, improve the control, provide more resources and materials, bigger storage capacity, more orders processed, payments to clients and suppliers met as well as many many other processes.

13. Conclusion

The integration of the digital technologies in an ERP system is an innovative and modern ITC solution for the re-engineering of the business models and processes in a company. The discussed solutions for digitalization like cloud computing, artificial intellect, business analysis, blockchain technologies, virtual and augmented reality, internet of things, data warehousing and others. Their usage in specific stages of the whole lifecycle of a project or of a company process can improve the final decision tremendously. We have analysed the options for integration of parts of the digital ITC technologies, responsible for the world wide and accepted good practices in ERP systems.

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Impact of the Covid-19 Health Crisis on Education in Bulgaria

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Abstract. The paper examines the problems of the health crisis with Covid-19 in Bulgaria in 2020. The current health situation is presented. The impact of the crisis on the higher education system is outlined. On this basis, a small part of the technological possibilities for solving these problems are presented. Finally, conclusions are drawn, and recommendations are made.

Keywords. Information technologies, Software, Education

1. Covid-19 health crisis in Bulgaria

The global health crisis associated with Covid-19 has changed people's lives, the economy and public attitudes around the world. Although Bulgaria is a small country, the crisis has seriously affected the life, education, work, and daily life of Bulgarians. After the first wave of the pandemic in March 2020, an information portal was created. Its purpose is to maintain up-to-date information on the state of the crisis in Bulgaria. According to data from the portal as of 31.12.2020, the tests performed are 1,149,545, of which 201,220 confirmed cases (17.5%). Of these, 118,335 are cured patients, 7 515 are deceased (3.73%). Fig. 1 shows the main screen of the information portal.

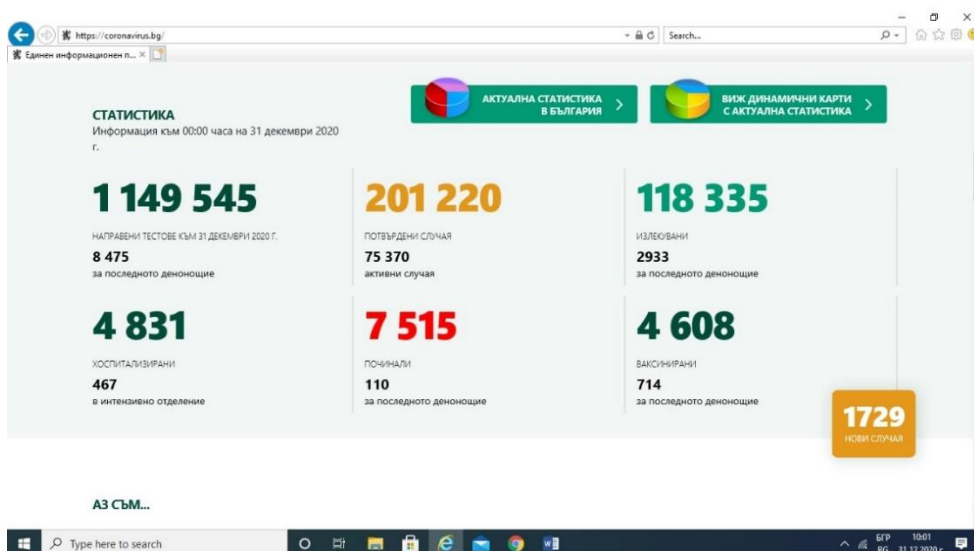


Fig. 1. Covid-19 portal, 31.12.2020 [3]

The information portal (Fig. 2) provides interactive possibilities for tracking the main parameters by individual geographical areas. In addition, it is possible to use detailed statistical information. The portal also has a mobile version.

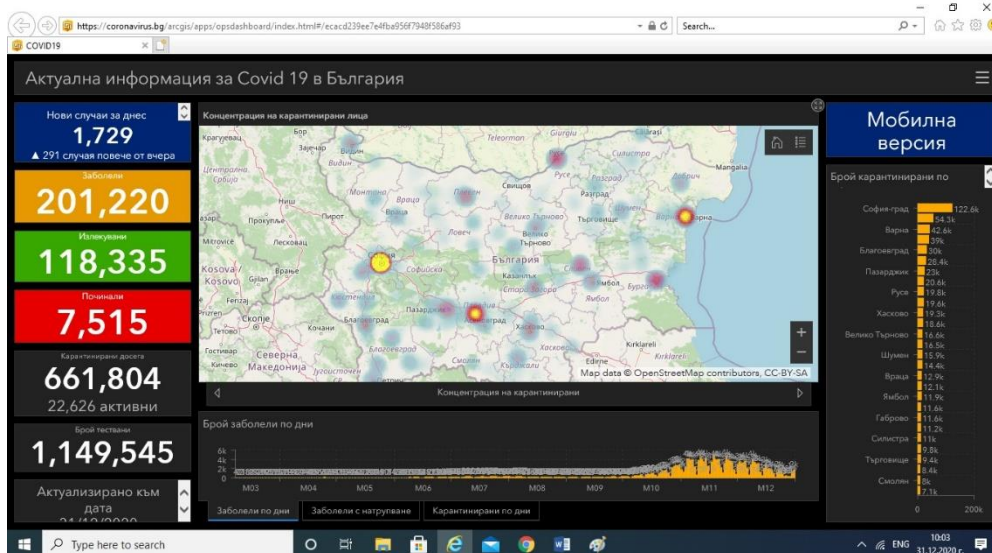


Fig. 2 Covid-19 Actual information for Bulgaria, 31.12.2020 [4]

The health crisis has changed the way people work and live in different areas of the economy and industries. Serious changes have also taken place in the field of higher education. They call for the urgent need to introduce new technologies and technological solutions to meet the new challenges.

2. Technological solutions

The global health crisis has changed many aspects of higher education in Bulgaria. The system had to be set up very quickly from face-to-face training to e-learning. Such a transition requires each institution to develop its own plan for the selection, implementation and maintenance of relevant technological solutions and public electronic services of a different nature [1]. They should be used both for conducting the student learning process and for conducting online exams, as well as for administrative services for students. The main stages that the analysis and selection of a technological solution should go through can be:

- Defining alternative strategies;
- Actual data;
- Choice of strategic alternative;
- Technological realization;
- Implementation of the technological solution;
- Support.

The described approach is shown graphically in Fig. 3.

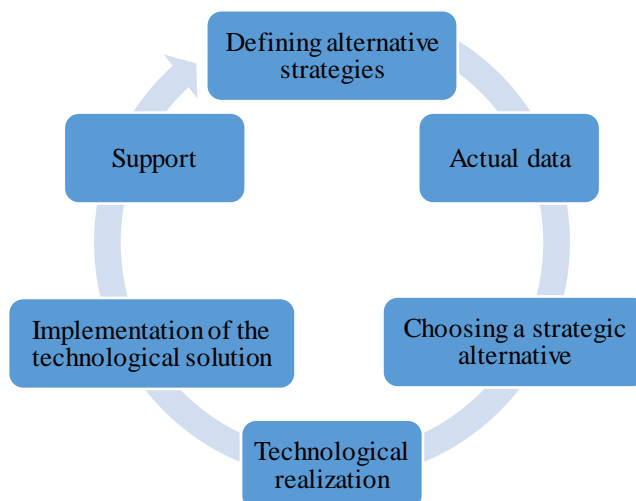


Fig. 3 Main stages in choosing a technological solution

The application of such an approach guarantees the selection of the best environment in a specific situation. This technological environment should offer opportunities both for the learning process and for conducting exams and tests. The main screen of an electronic test conducted in a Microsoft Teams environment is shown in Fig. 4. The test was conducted with 202 students.

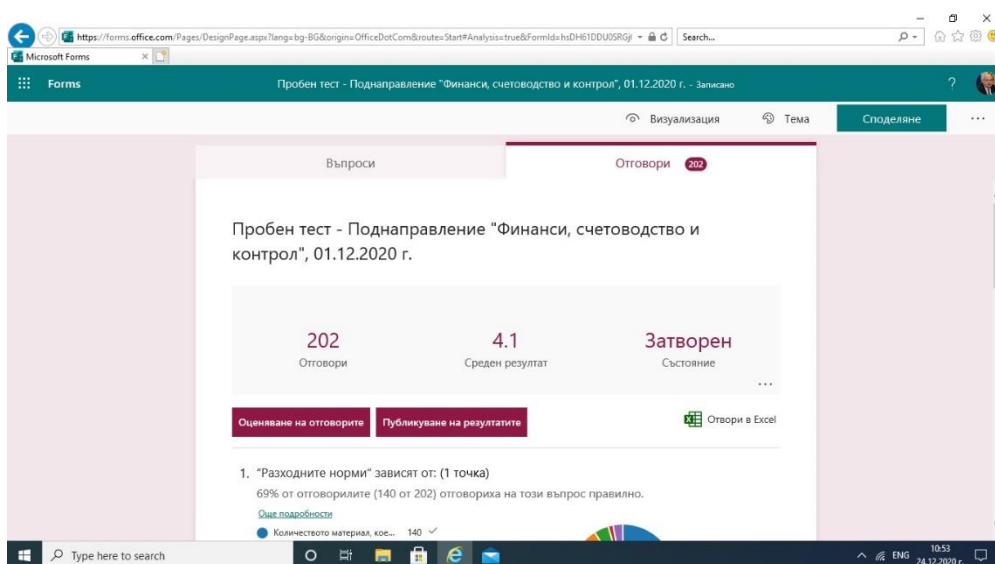


Fig. 4 Conducting online tests with 202 students

In the environment of MS Teams there are many interactive opportunities to analyze the answers to individual questions. This allows to determine the degree of complexity of a question. In addition, the distribution of the received answers and its correspondence with the normal distribution is very indicative. A similar sample screen from the study conducted

among 202 students is given in Fig. 5.

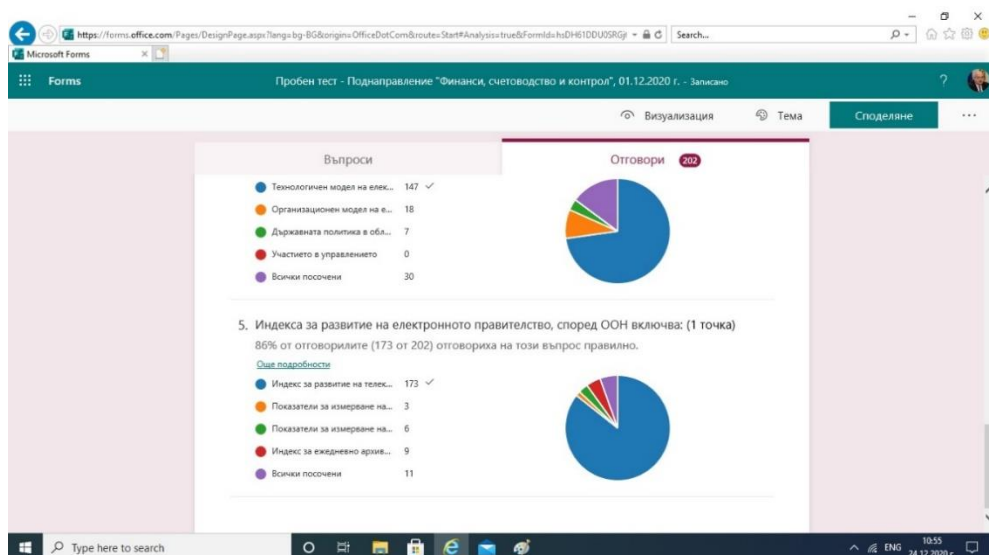


Fig. 5 Received answers to questions 4 and 5

Analyzing the received answers can provide very good conditions for improving the questions that are included in the test. Data models in web applications with data analysis are specific and need to be tailored to the business needs and functional requirements of the relevant analysis [2]. In the specific example, it is most appropriate to use data analysis in the form of a bar chart, but there are different means of presenting data in web applications.

3. Conclusion

Because of the research we can draw the following conclusions:

- The health crisis has imposed new requirements and rules regarding the functioning of higher education systems in Bulgaria;
- The choice of technological solution is very important for conducting effective e-learning;
- Carrying out a constant analysis of the results obtained from the electronic tests can allow a significant improvement of the questions that are included in the exam tests.

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Information Problems of Practical Training in a Real Work Environment

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Abstract. The paper addresses some of the information problems in conducting practical training. It analyzes some of the features of the project BG05M2OP001-2.013-0001 of the Ministry of Education and Science "Student practices - Phase 2". On this basis, specific information solutions and software systems are presented. They support the processes of conducting practical training in a real work environment. Finally, conclusions are drawn, and recommendations are made.

Keywords. Information technologies, Software, Education

1. Information problems of practical training

In 2020, the Ministry of Education and Science launched another opportunity to conduct practical training in a real work environment. This is project BG05M2OP001-2.013-0001 "Student practices - Phase 2" [3]. It provides very good opportunities for students to conduct practical training in real companies and organizations. The organization of the practical trainings on this project is done through a unified information system (Fig. 1).

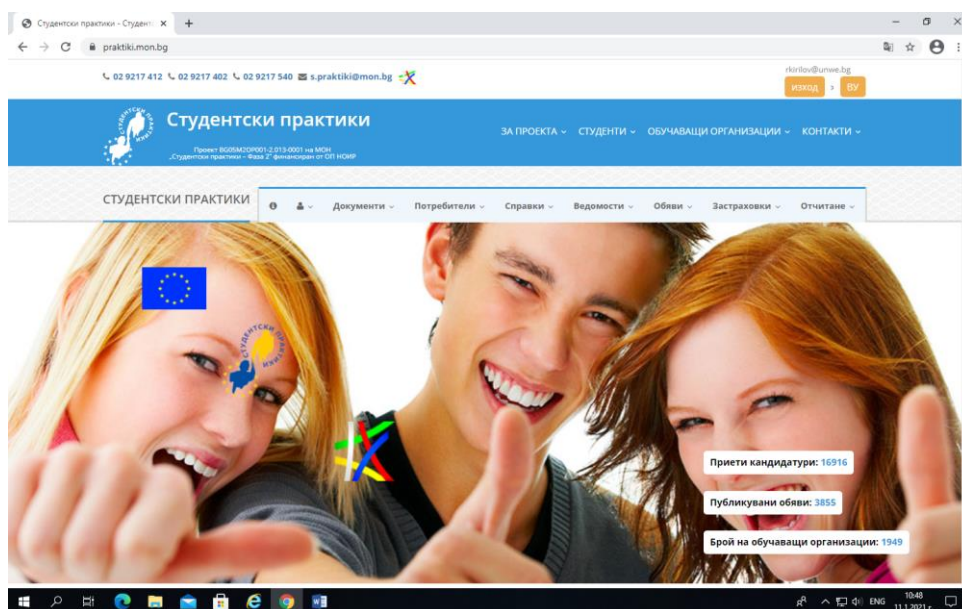


Fig. 1 Information system of the project [3]

In this way the students could get acquainted with the conditions and the way of working in the companies. Students with the best performance may be offered permanent employment.

According to the rules of the project, students who have already completed an internship in a similar previous project are not eligible to apply. This creates preconditions for defining an information problem. It is related to the need to automatically check student participation. Fig. 2 shows such a need, which is part of the portal interface.

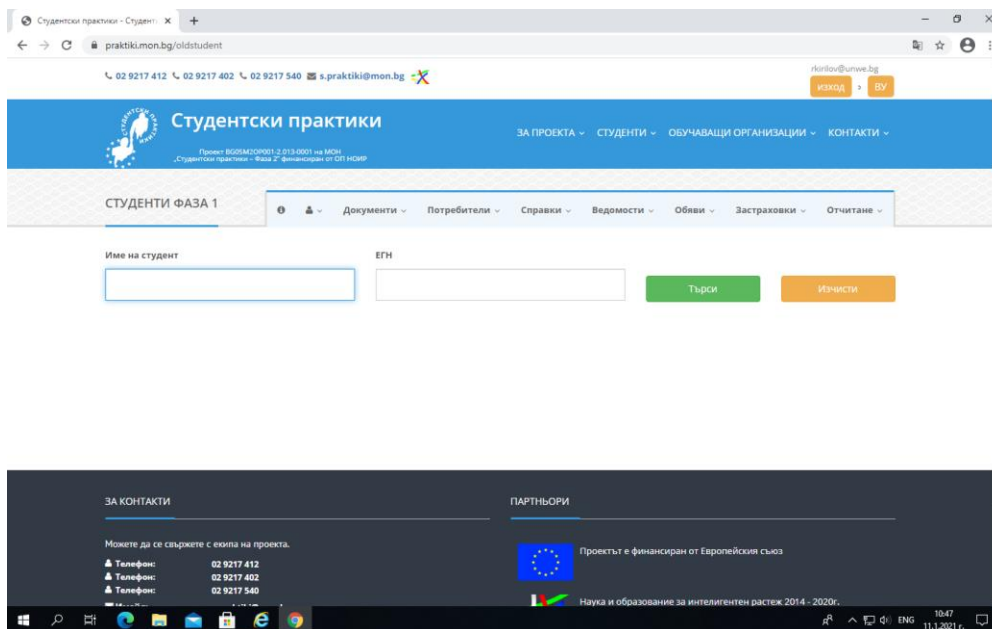


Fig. 2 Check of student status [3]

In order to solve this information problem, the University of National and World Economy has developed appropriate program functionality.

2. Software solution

The software solution of the mentioned information problem was developed especially for the project. In essence, it is an information system that improves the administrative service of students and companies. The use of a specialized record keeping system for this type of project proves to be a very serious tool for improving service. This is an important aspect of improving the provision of administrative services and facilitating the work of all actors [1]. The designed and implemented application is an additional functionality to the project management system. The need of integration of software solutions can be seen from different aspects, but in the context of the current study the most important aspect is the possibility that different software solutions work with common data [2]. In this sense, when an attempt is made to enter a relevant contract for a new student, the system checks his status in the database of the previous project for practical training of students. If it turns out that the student has taken part in a previous project for conducting practical training in a real work environment, then the documents cannot be included in the system. In this way one of the main principles of the

project is realized, related to the opportunities for participation of the individual students. Fig. 3 shows a screen of the implemented functionality.

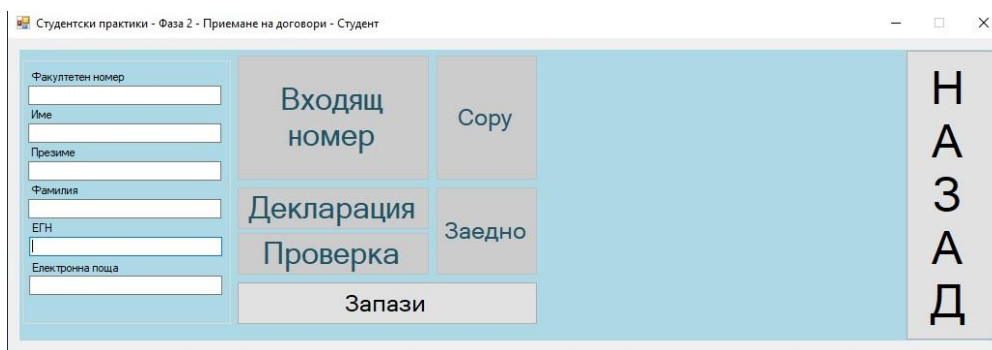


Fig. 3 Screen of the software solution

The application of such an approach guarantees compliance with the established rules of operation. Fig. 4 presents a fragment of program code that implements the functionality.

```
LiteDatabase db = new LiteDatabase(LITEDBF1);

using (db)
{
    LiteCollection<Student> students = db.GetCollection<Student>(STUDENT);

    Student s = students.FindOne(Query.EQ("IdNumber", this.textBoxEGN.Text));

    if (s != null)
    {
        copyData = false;

        FormStudentF1 fs = new FormStudentF1();
        fs.rNumber = s.ReferenceNumber;
        fs.fMain = this;
        fs.ShowDialog();

        if (copyData)
        {
            this.textBoxEGN.Text = s.IdNumber;
            this.textBoxName1.Text = s.FirstName;
            this.textBoxName2.Text = s.MiddleName;
            this.textBoxName3.Text = s.LastName;
        }
    }
}

using (db)
```

```
{
    LiteCollection<Preceptor> preceptors = db.GetCollection<Preceptor>(PRECEPTOR);

    LiteCollection<Student> students = db.GetCollection<Student>(STUDENT);

    Student s = students.FindOne(Query.EQ("ReferenceNumber", this.rNumber));

    if (s != null)
    {
        this.textBoxEGN.Text = s.IdNumber;
        this.textBoxFN.Text = s.FacultyNumber;
        this.textBoxName1.Text = s.FirstName;
        this.textBoxName2.Text = s.MiddleName;
        this.textBoxName3.Text = s.LastName;
        this.textBoxReference.Text = s.ReferenceNumber;
        this.textBoxContract.Text = s.ContractNumber;
    }
}
```

Fig. 4 Fragment of program code

The analysis of data on the basis of 1000 concluded contracts of students under the project shows that the solution is working, provides the necessary verification of the data and at this stage is effective.

3. Conclusion

Because of the research we can draw the following conclusions:

- Conducting practical training in a real work environment is a difficult and responsible process;
- The processes of conducting internships for students are accompanied by a number of information problems and challenges;
- The development of modern software solutions should be carried out in the direction of improving the administrative service of students.

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Nature and Main Features of Technology Startups

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Abstract. The object of this study is a technology startup company with activity development, maintenance, and support of software products and in this regard, it is necessary to outline the scope of the concept in the context of this study. Similar concepts can be found under the names "technology startup", "startup company", "tech company", etc. For them to be clearly distinguished, we should indicate the criteria by which they differ from all other companies.

Keywords. Technology startup, Business models, Entrepreneurship, Software development.

1. Introduction

It is known that a key role in the creation and operation of technology startups has the so-called entrepreneur. Its main activity is to organize different in nature and structure work processes to achieve a certain goal. Every entrepreneurial activity has a limited entrepreneurial window of time and opportunities, as well as limited resources. Therefore, management needs to be at a high level, including in terms of proper team organization, tasks, resources, and interaction with the external environment, so that the startup company can make the most of certain opportunities.

2. Establishment, operation, and management of technology startups

Technology startups are usually created by an entrepreneur - a person or a responsible employee in a company who is willing to take economic risk to make a profit. The organizational arrangements for setting up technology startups must go through several stages.

At the zero stage, through marketing research, a market needs for a good or a service is established. The potential amount of the expected profit is estimated by calculating the probable revenues and probable expenses from the activity of the technological startup companies. It is good idea to develop a business plan to assess how realistic the expectations are. If the idea is feasible and the levels of profit or benefits (in case no direct profit is aimed) are satisfactory, then can move on to creating a startup. Otherwise, the project is unprofitable, and it makes no sense to create technology startups [23].

At the first stage, based on the set goal, a list is created with all basic and supporting procedures that must be performed in connection with its achievement. A list of available resources - people and companies, and their capabilities is compiled.

In the second stage, a detailed specification is created, in which each procedure is divided into sufficiently small sub procedures to be monitored and evaluated. This specification defines the activities that the startup must perform.

In the third stage, for each sub procedure contractor, the start and execution period are set. It is appropriate to apply a Gantt network schedule to determine the workload and time distribution of each performer.

At the fourth stage, each contractor is provided with a list of sub procedures performed by him, description of the sub procedure, start, period of implementation, from whom to receive data, to whom to transmit the result of the activity, during which period the work will be coordinated, etc. At the same time, a list of sub procedures and those responsible for their implementation is compiled, which will be used by the manager of the startup to control the implementation of activities. In control, managers must pay special attention to the specific resources, which is critical for the implementation of procedures. For those sub-procedures for which there are no contractors, additional contractors should be sought to be included in the technology startup companies.

One of the advantages of using external services is that the amount of the initial funds for starting a new business is reduced, as most of the resources are paid for in the process of performing the work, i.e., resources are considered as services and not as tangible assets. Among the first technology startups to use this principle are: Amazon.com, an online bookstore founded in 1994 in the United States as an example of a successful startup corporation in the field of commerce, and the first bank to operate entirely online - Security First Network Bank (SFNB) founded in 1995 in the United States. Other examples in bank's sector also exists [21, 22].

Technology startups place qualitatively new requirements on managers who manage such business structures. One of the main tasks of the manager is to set group and individual goals, to unite and motivate employees, and more. To perform his managerial duties in a technological environment, the manager needs skills to work with information technologies [7, 14, 20] and to know how to use them to achieve certain goals. There is a need for a new type of manager to apply a specific management approach in technology startups. Without a good knowledge of information technology in general, the manager will not be able to properly account for the impact of technology and make optimal management decisions for technology startups. Therefore, the technical knowledge of the manager is just as important for the successful operation of technology startups, as well as his organizational skills.

3. Nature and definition of technology startups

The legal framework in the European Union and Bulgaria uses the term enterprise and divides enterprises into four categories - micro, small, medium, and large. The division is based on the number of employees and the value of the assets or the annual turnover. Using this classification, we will focus mainly on micro and small enterprises - up to 50 employees and up to EUR 10 million in assets or turnover [8]. Alternative methods of determination are measuring annual revenue or level/stage of investment, as well as "before becoming a large company" [3]. We can consider them as analogous, and we will use the above criterion for micro and small enterprises. In addition, to differentiate the startup companies, we will set a limit on their age. Definitions in the literature are different - up to 3 years, up to 5 or 10 years, "have little experience or no operational history" [3]. The short cycle of innovation and technological development, especially in IT, requires us to choose age up to 5 years as a criterion.

The organizational legal form of a technology startup with an entrepreneur and team developing a new software product and business model to demonstrate vitality and growth potential may vary depending on the circumstances. Typically, this is a stand-alone new trader within the meaning of the Commercial Code or a new business unit in an existing large company that has the same purpose and size until it proves growth potential. In the context of

the conditions in Bulgaria, with predominant micro, small and medium software enterprises, it is difficult for the existing ones to start a new product with a team of more than a micro enterprise. Also, practice usually shows that startups are micro or small enterprises, until they prove significant growth, in which the organization itself grows.

There is a similar English term in the literature called "startup" or "startup". A short and popular definition of its essence is "a newly created business venture to develop a viable business model to meet a market need or problem. The founders of the startup effectively develop and validate a scalable business model" [25, 26]. We can assume that a startup company and a startup are similar. In our opinion, the main difference from the so-called "general entrepreneurship" is that the goal is to test ideas and models that start from customer needs to create larger companies later. The time span is about three years. In this regard, clear stages of development and growth have been developed, types of participants by stage, and instruments [3, 5, 26, 30]. For our purposes, we will exclude questions about resources, legal aspects, and others that are important but outside the scope of the present development.

We need to clarify that there are two separate approaches to the initial idea from which a problem is solved. The first is based on creating a new product for a customer problem (market need). The second is a technological opportunity for which an application is sought. Additionally, there may be differences between companies in terms of model, strategy, processes, product type, team, type of entrepreneurs.

Another feature is that often startup companies are designed to be subject to planned external financing and acquisitions to accelerate growth. There are different classifications of the types of "startup" companies according to their purpose, type and development, stage of growth, etc. For example, Alvarez [2] identifies six types of startups according to what they aim to achieve in the future: freelancers, small (family) businesses, scalable with a global vision, marketable startups, social and large-scale companies. From this point of view, the groups that create a new product independently and for growth (scalability) are of interest for the present study.

When we mention a product, for the purposes of this dissertation we mean a generalized concept because of the company's activities. It can take many forms. Often in the literature on innovation, entrepreneurship, and startups, business modeling uses different terms. These are product [26], solution [19], service, value, customer value [3, 17, 24]. To avoid this discrepancy, we will use the generalized concept of "product" because of the innovation process for a startup software company. Such a definition is "everything that customers experience from their interaction with the company should be considered part of the company's product" [26, p.38]. The product is defined as a technological innovation based on innovation in IT technologies. The term "technology" is defined in the literature as "knowledge, skills, and artifacts that could be used to develop products and services, as well as systems for their production and delivery" [4]. We use the term "innovation" in the sense of "the result of an innovation process that represents all activities that lead to products, services, or their production and supply systems and could be successfully implemented in markets" [10].

4. Main features of technology startups

One of the main features of a startup company is the key goal in the business. It is: to develop a new product, to apply a business model, to prove vitality and growth potential [27]. A definition that exists in the literature from this perspective is "a company or project initiated by an entrepreneur to search for, effectively develop, and validate a scalable business model" [26]. A similar goal is "to achieve a satisfactory product-market fit, to develop a customer base where the focus is on customer demand, product adaptation, and a business model that fits (fits) market conditions. called in English literature Customer Development Model) [2]. In the

literature, there is a definition of a startup company as "a newly created business venture in order to develop a viable business model to meet a market need or problem" [3]. Another wording is if we keep in mind that such companies may target new markets. These new markets are characterized by poor structure, high unpredictability, and limited understanding of customers, competitors, and market segments [12, 29]. "Movements that explore the market for opportunities, rather than movements that use existing positions, seem to be particularly important" [11]. This leads to the logical conclusion that the established company focuses on the exploitation of existing positions and uses the so-called Product Development Model to optimize the processes and structures for the established products and markets. Therefore, we believe that this criterion - a goal in business and a model of behavior, is one of the most important to distinguish which company is a startup.

Other feature that should be considered and described by some authors on the topic of startup is whether the company wants to become large. In a more precise description, we can cite the following: "to develop and validate a scalable business model" [3]. Blank describes several types of startups. We will not consider companies that plan to stay small and meet only the personal needs of the founders, such as freelancers, family businesses or other businesses. Therefore, we will accept and add the definition of "looking for growth and a scalable model" [3]. A scalable (business) model should be understood as a model that allows the repeatability of the model, effectively increases the size of the business (quickly, economically, easily), and ensures the growth of the company; a model that allows scale. Such a model allows you to increase sales, the number of customers served and is not limited easily and quickly by static factors, such as location (location), owner service, etc. Another good definition of a startup is given by Paul Graham, founder of Y combinator. "A startup is designed to grow fast. The only important thing is growth. Everything else we associate with a startup comes from the growth" [9].

Other feature by which we can distinguish the startup company is its orientation towards innovation, new products, new business model. Many forms of entrepreneurial activity can be found in the business literature. Many of them are activities that borrow an activity or product of another company, use, or duplicate a finished product, business model, technology, and brand with a high level of coverage, such as franchising, business acquisition, copying a competitor and others. Even when a company uses third-party components, a familiar business model, it has to some extent a new own commercial product in a certain form and realization (products, services, components, etc.). The company has a unique combination of products, business model, brand, and technology, which distinguishes it as innovative.

Another distinguishing feature that we will indicate is the type of product - software or product related to software development. Many technology startups have software, services, or software development solutions. For the purposes of the dissertation, we will use the definition of the term software of the American IEEE Association. It states that the software is computer programs, procedures, rules and possibly accompanying documentation, as well as data relating to the operation of a computer system. An equivalent name for software is a software product. It has specific properties, such as a variety of shapes, functions, abstraction, uniqueness, composition, quality, reliability, performance, etc. More interesting for the set topic is these characteristics regarding the creation process, such as uniqueness, resource intensity, multidisciplinary, high risk, and quality. By uniqueness, we mean that creating software requires significant initial effort before the first working instance appears, spreading defects (also called bugs) in all copies, and replacing older ones with newer versions. The resource-intensive feature is available due to a lot of effort before the first copy is ready for sale. Multidisciplinary exists due to the need for different specialists. High risk is understood

as complexity of production, gaps in requirements and product quality, non-compliance with delivery time, and others.

As a last feature, we will point out that startups are created by one or more entrepreneurs. For brevity, we will use the term entrepreneur for both one person and a team of entrepreneurs. In some sources, the term "founders" is also used. The role of the entrepreneur is key in the creation and operation of technology startups. There are studies [6, 32] that show that the main factor for the success of micro, small and medium enterprises and growth is related to the entrepreneur and his personal goals, motivation, market orientation, ability to grow and professional management. This further proves the importance and relevance of this thesis, as well as the need for knowledge and tools as a specific information system to support the management of the startup company.

We propose the following working definition for the term technology startup in software development - a newly created technological micro or small enterprise run by an entrepreneur or a team of entrepreneurs with a short history (up to 5 years). with the main goal to create a new product, to effectively develop and validate a scalable business model for it, to prove viability (niche market validation) and ensure growth. Product development is directly or indirectly related to software development. The way to achieve this is through innovation in a product, technology, business model, or organization, as well as actions to find market opportunities to meet market needs.

An important distinction to be made is that one or more technologies in themselves can be considered as a discovery, as knowledge, but a successful marketing in the form of a product (products, services, solutions, values, etc.). realized with this technology makes it already a technological innovation. There are different classifications in the innovation literature, but here we will mention one of the more important ones [4]:

- Evolutionary - aim at optimization of existing systems, products, and structures.
- Radical - changing existing processes, products, and structures.
- Architectural - changing components of existing processes, products, and structures.

At its core, developing a new software product in a startup is entrepreneurship. It obeys certain laws and follows a certain process. In general, the theory of entrepreneurship is well developed the idea of the content of the entrepreneurial process. One of the most popular notions of this content is that of Stevenson consisting of four phases:

- identification and assessment of opportunities.
- development of the entrepreneurial plan.
- determination of necessary resources.
- enterprise management.

On this basis, various authors describe the structure and content of the process of entrepreneurship and innovation. For example, Koev [13] describes a process with 12 steps, content, and decisions to be made. Some steps are grouped as it is possible to repeat until a satisfactory result is achieved. These steps are:

1. Choice of subject of activity
2. Decision to start your own business
3. Discovering the new idea
4. Assessment of opportunities and limitations of the new product.
5. Creating the new product
6. Analysis of the external environment
7. Entrepreneurial analysis of resources
8. Localization of entrepreneurial activity
9. Institutionalization
10. Creating a plan

11. Management of entrepreneurial activities

12. Closure of entrepreneurial activity

This model is common to all entrepreneurial activities. Due to the peculiarities of software development, as well as the dynamics in the environment, we believe that the model cannot be adequate. For example, the definition of the object determines the subject of activity and the decision to own business. Moreover, due to the dynamics in the environment and the need for market validation, it is more realistic to analyze the environment before creating the product. Therefore, due to the specifics of the product and its development, a more specific process should be considered to meet the needs of a startup software company. It will integrate steps from the overall entrepreneurial process. The literature describes in detail the conditions of the entrepreneurial process in startup companies and mainly they can be summarized in the following [1, 3, 5, 13, 19, 25]:

- limited resources.
- limited opportunity time.
- high uncertainty.
- need for market validation.
- partnership.
- development of a business model.

The conditions listed in this way have their rational basis for explanation. Since the company is a startup and is not a product of a large company, it is normal to expect limited resources, for example material, financial, human, information, time, etc. resources. They are just what the team of entrepreneurs has and possibly a circle of their mentors. The limited time of opportunity is caused by the fact that entrepreneurship is possible within a certain time limit or the so-called entrepreneurial window of opportunities. In the intensive development of technology and innovation, it is normal to expect this important limiting factor. Hence, the high uncertainty, which is also because the level of failure of startup companies is very high.

There are many reasons for failure, but one of the important ones brings to the fore the next condition - market validation. It means that the problem and its solution are evaluated as a market and validated empirically before it is developed. This is essential and every source for entrepreneurship and startups indicates it [3, 5, 19, 26, 30]. The very need for market validation requires that decisions be made that are key in making a solution to a problem that is the basis for a company's product - to find the problem (also called market need), even implicit, and to overcome possible errors and deviations.

Market needs and its discovery is known in the English literature as the customer development method [2, 5, 15]. Compliance with it, discovery and definition require flexible design and rapid effective discovery of knowledge to accommodate the entrepreneur with the lack of clarity in needs and requirements, to adapt to uncertainty, dynamics, and time constraints. The partnership reflects the need for the entrepreneur to work with partners, partners, suppliers, customers, mentors, advisors, and others. The result of the process is a created product and a validated business model for it. This business model answers the questions about the marketing and validation of the product.

As a feature of software development in a startup technology company we must note the specifics of this activity. In general, two important concepts in successful software development are user involvement and description and stability of requirements. For the startup technology company, these concepts are not valid or are not in this form. She often works in uncertainty. At first, the consumer or customer may not be clear, the requirements may not be obvious, they may not be known, or they may change during the search for a niche market. Feedback from the user / client does not exist or is not always direct. It is usually not by asking questions directly and getting answers. It is possible to obtain it by observation,

research, data analysis, experiments to validate a hypothetical requirement, and other methods. Furthermore, each requirement should have an analysis of the marketing and financial effect, as its inclusion would attract or not customers, and would also cost resources its very development and implementation.

An important aspect that is mandatory to note in the topic is about the entrepreneur (or a team of entrepreneur partners) in a startup company. Various authors share the need for certain psychological attributes, sociocultural environment, entrepreneurial attitude, motivation, mastery of ways, skills, and tools for entrepreneurial discovery, organization, and leadership, as well as relevant training (individual or group) [3, 26]. To this end, before or with the normal process, an entrepreneur should have undergone validation and training steps to be prepared for entrepreneurship. A team of entrepreneurs should also have skills training for teamwork to work successfully over a long period of time and with the necessary key competencies. For example, for a software company, it is often recommended that the team have competencies in technology, marketing, and business development.

As can be seen from the definition of a startup technology company, it must develop and validate an effective business model. The market success of a product is realized through a specific business model. The development of a business model is part of the innovation process. As some researchers point out, "we notice for almost all successful founders is their ability to work on a very concrete and very abstract level... they try to find the best business model" [5].

For a business model to be successful, a management organization must be created to implement and improve it. Organization is considered a key concept in management theory and can be defined as "a system of consciously coordinated activities of two or more people to achieve a common goal" [31] or "targeted social entities that are designed as consciously structured and coordinated systems of activities and that are related to the external environment" [28]. The established management organization can achieve a defined goal that is beyond the capabilities of a single person through more productive methods - division of labor, larger and more modern technologies, cost savings, and more.

From this point of view, technology startups perform specific activities and through their results the goal is achieved. In turn, the structure determines the behavior of technology startups, which is extremely important because it creates attachment to common goals and values and has an impact on connecting employees with the external environment, as the result of the activity is manifested outside the organization.

For startup technology companies, decision-making is mainly in conditions of risk and uncertainty. Therefore, a more detailed definition of management functions can significantly improve performance, as it is possible to avoid some problematic situations at an earlier stage, which is more optimal for the overall functioning of the organization in the long run.

In software development, the methods of empiricism and the principle of feedback are widely used:

- the processes are based on the principle of "towing" (also known as Kanban).
- the manager is present on site, among his people and where the product is created.
- everything is always tested and evaluated, incl. and for employee evaluation - this may not be appropriate for the initial stages of the startup operation due to lack of time and resources.
- strategic management has a process, not an analytical approach - the strategy is formed by an active and flexible internal environment, gradually, in interaction with the external.
- experimental adaptation by learning from experience, instead of preliminary long-term forecasting.

These principles build on the classical theories of management in the direction of working in smaller markets, more flexible product models, in a more unstable environment. On this basis, a model for the learning organization is created - learning through experience and system groups and improvement processes, benchmarking model - comparison with an industry leader, the double circle model - to receive feedback from partners and competitors for changes in the environment, the network model - the external environment is not only a generalized market, but a complex network of interactions with many organizations in different dimensions; offering solutions based on small permanent groups, continuous improvement [24]. Based on these formulations, the Lean Production methodology was subsequently built and in the 1990s Lean Development for development without redundancies, which is adaptable to change, based on the experience and integrity of all parts of the organization, with high quality and integrity production [24].

The elements of intellectual capital (with different definitions) are human, social / consumer, and structural capital and can generally be defined as [16, 18, 33]:

- Human capital - consists of knowledge, skills, know-how; ability to create value; creativity, innovation, experience, working knowledge, quality.
- Consumer capital - is expressed in relationships with customers, trust, knowledge of their requirements, and brand; Some authors see it as a capital of relationships with partners.
- Structural capital - synthesis expressed in business processes, systems, procedures, information systems and databases; Also, organizational learning skills culture [16].

On this basis, the learning organization should be considered as a structure that adequately provides opportunities for coordination, integration, and learning in the organization. Externally, it is with the partners in the business network in which it participates. Internally, employees should be able to exchange information freely, to cooperate with people from other units and functional specialists, as far as possible to remove barriers. Experts in the teams should be empowered to make decisions on how to perform their work. Thus, by building trust and increasing responsibility, the need for strict control is reduced. Managers approach to support motivation, leadership using an approach of shared values and cooperation.

Through such employee empowerment mechanisms, information exchange and learning, trust, and support, the training organization can be suitable for working in a market with uncertainty and a variety of products. The organization can also apply an adequate methodology based on these principles to work in such a market, such as the so-called Lean Development of products. Its principles are based on the second principle "Amplify learning", which means that training is the key to product success and development. Another principle is "Empower the team", which means that the team has provided the necessary expertise and led by a leader will make the best technical and process solutions for their task.

5. Conclusion

From the study of the topic of organization, its place in management, the historical and theoretical review, we can conclude that the issues related to the management of technology startups are significant. Based on standard known organizational structures, coordination methods and communications, we can offer suitable options for organizing a startup software company. We can conclude that these development methodologies cover most of the steps of the overall entrepreneurial process.

The choice of methodology, process, model, and solutions should be judged according to specific circumstances (problems, resources, entrepreneur's mission, product and market risks, etc.). Combinations with a basic process of the listed and for specific elements methods, tools, and indicators from other approaches are possible, so that step by step with the

development of an idea, business model, and product to reach the standard stages of business management.

Startup technology companies have a specific definition goal and must develop both their own product and an adequate business model to prove viability and achieve growth. Entrepreneurs need to be supported with training, mentors, and information systems to overcome typical problems in the initial stages of development of the organization.

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Development of Software Systems by Using Interaction Business Scenarios

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Abstract. One of the main points in the development of an information system is the creation of interaction scenarios. It can be expanded and supplemented according to the needs in specific situations if necessary. Interaction scenarios usually are prepared by a business expert or an expert user. In many cases, the leading role is played by the client, who defines the overall conception through the main interaction scenarios. The main scenarios can be further detailed in subordinate business interaction scenarios, which are focused on individual standard roles in software development such as product owner, business development/marketing, coordinator, architect, developers, quality assurance specialist, support specialist, team participant, and client. In our opinion, it is appropriate to use an architecturally centered model based on interaction scenarios. We can say that a key point in the design of the information system is the business scenario for interaction with the system, which reflects the goals and scope of the future information system, the interaction with users, and what services are provided. Based on it, they can effectively develop a conceptual business model that shows how the employees and the objects they manage are connected statically or dynamically.

Keywords. Information system, Modeling, interaction, Business scenarios, Software development.

1. Introduction

The software system for managing the production of software in a software company must cover all areas of management. Information about the processes is necessary to achieve the objectives and sometimes is legally required. Software companies are a specific type of enterprise. They are described in the literature mostly as a company that creates a new product to meet a market need or to introduce innovative technology. In this regard, they usually: create a new product for a specific need; research and establish a product-market business model that sometimes is unpredictable and poorly structured; develop and validate a scalable business model.

One of the main points in the development of a software system is the creation of interaction scenarios, which if necessary, can be expanded and supplemented according to the needs in specific situations.

2. State of the art

A significant difference between the software start-up companies, compared to those already established on the market, is the goal of the business and the model of behavior. Therefore, "activities that explore the market for opportunities, rather than activities that are based on existing positions, are extremely important" [17]. From the standpoint of the theory of entrepreneurship, the most prominent characteristics are [29, 31]: limited experience and

resources, small-time window and entrepreneurial potential, novelty and ambiguity, the presence of a high dose of uncertainty, and a correspondingly high risk of failure. Entrepreneurs usually start with their own resources and experience. This includes not only material and financial resources, but also motivation and personal interests, human resources (so-called "intellectual capital" - knowledge, competencies, experience in marketing, technology, and organization), teamwork, management of the business organization, and the individual processes. Several studies have shown that industry experience and experience with start-ups [8, 27] are crucial as success factors. There are ways in which an entrepreneur can obtain the necessary resources to increase the likelihood of project success - training, attracting co-founders and investors, mentoring, partnership, and transfer of know-how, as well as the use of a specific software system for process management.

Software entrepreneurship is possible in a certain entrepreneurial window of opportunity. With the intensive development of technology, globalization, and innovation, this time window is often very short. The novelty and ambiguity like features follow from the lack of detailed clarity about the product, the sales market, and the management organization to be built. Hence, the perception of conditions of insecurity and high risk of failure - less than 5-20% success rate [8, 13, 27, 28]. There are several studies on the factors influencing the success of start-ups and the measures that can be taken to reduce the risk of failure by stages of development [10, 31].

The specific conditions, from the point of view of the industry for creating software applications, are generally a fast and dynamic change of the market environment and technologies, the technological complexity of the developed product, the variety of suppliers and components, and high complexity of the set requirements in terms of quality. , significant investment before the first sale, an initially high degree of uncertainty regarding most of the requirements, the complexity of development activities, the need for regular maintenance and upgrading of the product, especially the importance of the human resources factor and their high cost, multi-, and interdisciplinarity, high dependence on knowledge, management, and storage of knowledge [14, 15, 26].

Due to these features, small companies are characterized by activities related to research, support for innovation, invention, validation, adaptability, low degree of formalization, light procedures and rules, partnership, and participation in business networks. Product development methodologies suitable for start-up software companies are light agile methodologies with software development activities. They support innovation and are suitable to cope with the given constraints and conditions, accept change, allow developers to follow the business strategy, and reduce the time for realization from idea to implementation [1, 2, 33] without burdening the team with many processes. Popular and commonly used methodologies are extreme programming (XP), Scrum, a combination of the Kanban and Scrumban approaches, and concise software development [4, 26, 33]. We support the opinion of some researchers that in the creation of software very often in practice only selected practices from one or several different approaches are used, which work best in the specific case. The limitation of these approaches is that they prescribe how to develop software more quickly and gradually, but do not specifically answer the question of what exactly product to develop when it is not known in advance [4]. Therefore, the highest risk is at the "Requirements" stage, when (initially) the characteristics of the product are unclear and are the result of research, invention, market research testing, and customer feedback. For this reason, several methodologies include the concept of Minimum Viable Product (MVP), which is actively worked on and regularly tested through feedback [2, 9, 28]. Individual authors have developed approaches and models of the entrepreneurial process, as they have 4 or 5 stages. Popular ones are presented in Table 1.

In the "Formation" stage, the team prepares and based on the problems chosen to solve, generates a variety of ideas for solutions (the "brainstorming" method is appropriate). In the "Validation" stage, the so-called Minimum Functioning Product (MVP). Its usefulness is validated by consumers (with tests, sales, and feedback). At the next stage of "Growth", the application is already designed, accepted by the market, and in this situation a targeted increase in sales. When the growth reaches a relatively good value, with market share and sales becoming predictable and stable factors, the Stabilization level follows. This level is also referred to as "Exit" because this is often the moment when the start-up company has reached its final goal and can no longer be considered as a "start-up".

Table 1. List and comparison of the individual stages in a software start-up company

№	Stage	By Lean Startup	By Ries' Engine of Growth	By Crowne
1	Formation	Customer Development	Empathy	Startup
2	Validation	MVP building	Stickiness	Stabilization
3	Growth	Organic growth; Monetization	Virality; Revenue	Growth
4	Stability	Inorganic Growth	Scale	Exit / Maturity

At the "Formation" stage, some details on the problem and the product are not yet known, so it is advisable to use a method to identify market needs, known in the literature as "Customer Development" [2, 9]. The method uses the following main steps: "client discovery", "validation", "client creation" and "organization creation". It is appropriate to use flexible process design, as well as the timely discovery of knowledge so that the entrepreneur can adapt to the constraints, the market situation, and its inherent uncertainty. Based on the Customer Development method, a model has been created with experimental establishment and validation of the requirements of the application and the business model. By "experimental" we mean based on pre-raised hypotheses, in which the steps of definition, development, testing, and feedback are cyclically repeated, which accumulates knowledge for validation and improvement of a product and business model. The authors of the approach call it "Lean Startup" and it is an adaptation of the "Lean Development" approach to product development. There is also an option for "tight production" (Lean Production) [19, 20, 26, 28]. According to some researchers, parallel and interdependent development is appropriate because the experiment of testing a product on the market can give feedback about the new requirements to be implemented in the product, or its intermediate or initial version (prototype). Then it is possible to start testing with clients again. Other authors argue that the accelerated development of IT in recent years and the high dynamics in the industry do not allow to invest funds for continuous processing. Therefore, the development of the technological solution should have proceeded after the requirements and the model of the system have been validated in advance.

The peculiarity of these approaches is that they need to be adapted according to the team. It is known that a large part of enterprising people, as well as programmers, are flexible and creative in nature, which implies light processes and a low level of formalism, emphasis on communication, relationships, and initiative. In the process of finding a scalable business model for stable growth, products should be developed for a market with great potential (and not for a separate individual case - a customer). This type of development is known in the literature as "market software development". In this case, a strategic key goal is the rapid launch of the product. A weakness in team performance may be the tendency to define

requirements before they are validated. Other weaknesses may be post-marketing validation (i.e., hypotheses without a test), adding and releasing poor quality functionality, or missing a deadline. The risk of failure is due to noncompliance with customer requirements, insufficient quality functionality, or omission of an important deadline [22]. Therefore, the organization of work requires not only the use of so-called. "light processes", but also control over the implementation of the task and the efforts made for development. There are two particularly useful key practices in the 'tight design' approach: 'elimination of redundant requirements' and 'deferred rapid development' [26]. Another important feature is that the software is created based on a certain architecture, technological solutions, and ready-made components. To achieve the required development speed, developers can temporarily ignore good architectural solutions in the beginning, which creates the so-called "technical debt", future problems, and high costs for their elimination. Therefore, a balance between structuring and fast delivery is needed [16, 22]. It is considered a good practice from the very beginning to use generally accepted and approved architectural solutions, templates, open widely accepted standards, and the use of ready-made components. An alternative is to revise the solution at each stage and expand it according to the scale of the market served.

For the purposes of our study, we accept the restriction that the main activity of a start-up software company is the development of software products and their maintenance. For the first or some clients, they may be private solutions adapted for the client. They are achieved on projects, as each product has separate variants/versions or adaptations for the client. Each version and adaptation were developed in a separate project. It is part of the life cycle of developing and maintaining the overall product. Requirements and other data are defined and reused in individual projects as valid for the product version.

To be successful, the team of entrepreneurs or entrepreneurs needs to create and manage a business organization. For this purpose, the team needs a software system [18, 23, 25]. The proposed IP model is concentrated only on the main activity - production and maintenance of software products, and the most necessary details for it. Any other part of the general IP of a start-up software company can be achieved with a standard model/product at a low price, with additional office tools or virtual office systems [11, 21, 24]. The model of the software system is aimed at successful management and to support teamwork. It should serve the entire production and product management cycle through individual stages, projects and iterations, team members and roles, product features and documentation, customers, market segments, tests and research, quality assurance, process improvement, status, and efficiency of the process (efforts, resources, results), communication and documentation [5, 12]. Product support features such as customer requests and regular monitoring results are also included. They become defects for repair, new features, and tasks for product upgrades, as well as the distribution in the team status, and efficiency of maintenance, customer satisfaction. Regarding the properties of the software system, we assume that the highest priority is the usefulness of the software system for process management and ease of use.

3. Scope of the software system

We assume that the software system for a start-up software company must cover a certain set of functionalities, avoiding the great complexity and entering detailed purely technical issues regarding design, programming, testing and integration, document management, configuration, etc. They can use specialized software at their discretion. Only a basic set of features and scenarios is included so that the team has only the essentials to develop and implement a useful customer product. At the same time, it is possible to use templates and implement a specific individual process. The proposed model of the software system covers the following areas, describing its scope in Table 2.

Table 2. Areas describing the scope of the software system.

Nº	Area	Description
1	Products	One or more products being developed - product, problems, solution, market, specifics, versions
2	Customers	Market segments, criteria, profiles and description, specific customers, restrictions, requests, and preliminary assessments
3	Projects	Product, version, description, goals, restrictions, and conditions, term, budget, features, implementations (implementations)
4	Business model	Description, model, map, links, versions
5	The market valuation of the business model	Indicators and reporting by market segment, project/version, indicator, time
6	Market tests	Version, method, hypotheses, tests, results
7	Product distribution	Product modules, deployment environments, technologies, licenses
8	Requirements	Product characteristics by project, hierarchical structure, and thematic grouping; value/risk ranking
9	Iterations	Each project is executed on certain time intervals called iterations (flexibility terminology)
10	Tasks	Defining, evaluating, ranking a specific job on demand for a team member in a project and iteration
11	The process	Project implementation format and team participation: process templates with stages, iterations, work, and documentation
12	The team	Specialists, roles, participation in projects, access to the software system and environments
13	Effort and cost planning and reporting	Iteration, team, individual evaluations, individual time, and cost reporting
14	Integration with external systems	Partner, system, version, integration card
15	Status and effectiveness	of product, project, and iteration: by-product, project, version, iteration what is the efficiency and status
16	Support	Requests and feedback from customers, monitoring of indicators; converting into tasks, customer satisfaction

Thus, the presented range of desired functionality is achieved in the model of the software system. Regarding design, we consider as essential components the activities detailing the requirements, analysis, and design of an information model. As the system is based on working with users, we think it is appropriate to use an architecturally centered model based on interaction scenarios. Therefore, a business model of the system has been developed and we adhere to the classical approach to information business modeling, based on the universal language for modeling and description of UML software systems [3, 7, 30, 32] as a recognized international standard for object-oriented modeling language.

For information business modeling purposes, we use UML with a specialization extension with an IBM RUP profile for business modeling [6, 34]. Following this approach, we can say that the main point in the design of the software system is the business scenario for interaction with the system, which reflects the goals and scope of the future software system, the interaction with users, and what services it provides. Based on it, they can effectively develop a conceptual business model - it shows how employees and objects they manage connect (statically and dynamically) to achieve the relevant business scenarios for interaction; object business model - part of the conceptual business model, reflecting only business entities (characteristics and relationships) and does not include responsibilities of business workers; and logical model - developed based on the presented business model in the concept of the software system.

4. Business scenarios for interaction with the system

In developing the model, we have limited ourselves to basic business scenarios for interaction with the system. We will distinguish individual roles using the following standard roles in software start-up companies:

- Product owner - creates the vision, development guidelines, selects the stages of development, projects characteristics.
- Marketing/business development - market analyzer which generates product requirements from the market.
- Coordinator - leads the team to comply with project processes.
- Architect - manages the structuring of the software.
- Developers - software developers - programmer, database specialist, quality assurance, and others.
- Quality assurance specialist.
- Support specialist.
- Team participant - abstract role summarizing the above.
- Client - an external person who is a client and has access to the system.

The description of the business scenarios for interaction with the system is concluded in the presented in Table 3.

Table 3. Areas describing the scope of the software system

№	Business scenarios	Description
1	Product description	The owner defines the problem, the business, and the solution as a vision, at the highest level
2	Defining a project	Owner and marketing define versions, projects, with an architect define the stages of product development
3	The market valuation of a business model	The stage of development, business model, evaluation indicators, and results are defined
4	Market test version	Marketing defines a version for a test, hypotheses, and tests, conduct, report market evaluation, results
5	Project planning	Plan of requirements, versions, iterations, distribution of tasks in iterations and the team; ranking

6	Organizing development	Coordinator defines a process by a selected template, stages, iterations; the team identifies tasks, risks, assessments, and efforts for them, allocates and tailors them to capacity
7	Execution of development	Developers perform the task in tasks and iterations; Quality assurance specialists perform tests
8	Completion of iteration	Coordinator and team report the results, make a demonstration, and record conclusions from the reflective improvement. Modifies the plan for subsequent iterations and tasks; Marketing and owner adjust hypotheses and tests
9	Implementation	Architects and quality assurance maintenance specialists ensure that the completed development is implemented with the newly developed characteristics and acceptance tests
10	Completion of a project	The coordinator reports the results, reports are made on the effectiveness and result of the project; Owner and marketing adjust business model and metrics

The product maintenance scenario could be detailed as follows:

1. Defining maintenance - owner and architects define requirements, conditions, and monitoring of maintenance.
2. Request tracking - maintenance specialist monitors and processes requests; fill in requests from a client; monitors monitoring and creates a request in case of a problem.
3. Conversion of requests - requests are converted into defects, tasks, or characteristics for product update and are appointed as a programmer.
4. Inventory of implementation - coordinator describes the implemented versions.
5. Support report - coordinators and product owners receive a support report.

The main scenarios can be further detailed in subordinate business interaction scenarios.

5. Conclusion

This article presents business scenarios for interaction as an essential stage in the modeling of a software system designed for a start-up software company. The proposed option can support the company's activities for the effective management of product development activities, its validation, and implementation of related projects. The focus of the software system is on project development in connection with product development.

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Application of Map Charts in the Context of Data Analysis of Web Publications

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Abstract. The paper presents research on data analysis in the context of web publications. Web publications today have a large amount of data that should be processed analytically. The paper focuses on the possibilities for analyzing these data from the point of view of their geographical connection. This type of analysis is useful for many organizations because it gives a visual idea of the geographical distribution of the data in web-based information systems. The paper presents a traditional approach for performing map chart analysis, as well as an approach for presenting such analysis with application of data science. In conclusion, arguments are summarized in support of the importance of map chart analysis for modern business and public organizations.

Keywords. Map chart, Internet, data analysis, web publication, data science

1. Introduction

Nowadays, there is a very large amount of data that organizations want to have in the context of their strategic management. This is true for both business and public sector organizations. The data are in various databases and information systems. A significant part of them can be found on the Internet in the form of web publications. The content of web publications is accessible through the relevant web-based information systems. Although the Internet represents a virtual world, it can be said that it is known which web-based information system belongs to which real geographical region. In this sense, a connection can be made between publications and regions. The presentation of these connections using appropriate technical means is a map chart analysis. This type of analysis is particularly suitable for presenting the relationships between the data and the region to which they relate. Such analysis is of interest to almost all large-scale business organizations, as well as to public sector organizations – especially those with a regional character. Map chart analysis are a specific type of analysis. They are usually prepared in combination with other analysis, the most popular of which is perhaps the timeline analysis, which presents the distribution of data over time. In some cases, combining these two types of analysis is particularly useful. In this way, valuable information is obtained about the distribution of data over time and the distribution of the same data according to some geographical (regional) principle. The preparation of map chart analysis depends on the regional units to be covered. In the broadest sense, map charts represent the distribution of data by country, but this type of analysis is very suitable for presenting data for smaller geographical units. This would be particularly useful for public institutions with regional functions. In any case, this type of institutions makes great efforts to improve their services [9, 10]. From a technological point of view, the analysis of data can be done through its own service or with the help of a cloud solution. The availability of alternative data storage options, as well as the application of cloud services are the basis of the modern concept of big data [1, 14]. At the same time, the need to analyze data from web publications

is very relevant in the context of the importance of unstructured data for organizations [11]. In the paper we will emphasize the possibility of using map chart analysis in the context of the need to monitor data on the Internet. The topic of application of data science in performing map chart analysis is also very relevant, so that the results can be of greater added value for organizations.

2. Use of map charts in field of data analysis

The classic map chart analysis should represent the geographical distribution of data by some criteria for some period. In the study we will use the keyword “research” as a criterion, and the period will be January 2020. Web publications that will serve as a basis for searching by this criterion for this period are publications from some of the world's most popular web-based news information systems, namely CNN Business [2], Deutsche Welle [3], The Economist [4], The Guardian [6], The Independent [7], International Business Times [8], Politico [12], Reuters [13], The Times of India [15], The Wall Street Journal [16]. The study also uses data from publications on some of the Facebook pages of these media [5]. Fig. 1 presents the relevant map chart analysis by country.

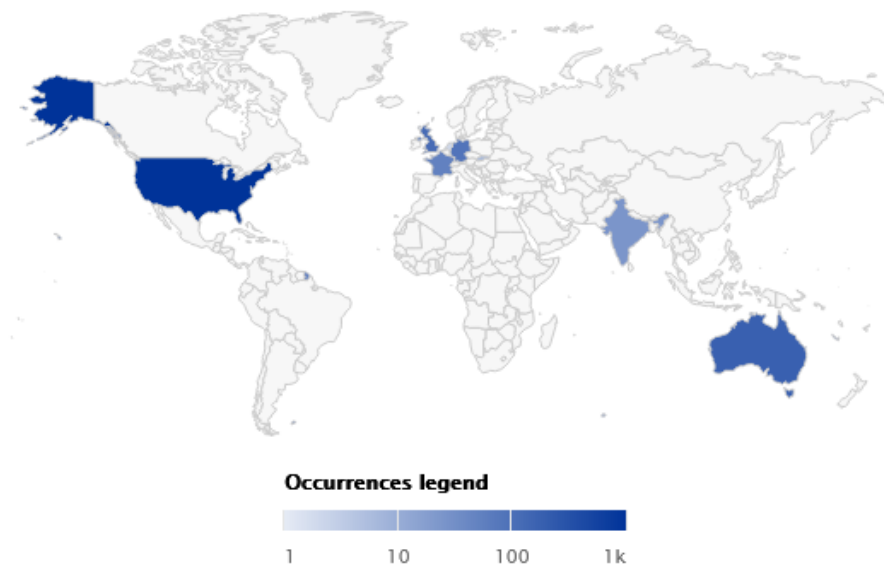


Fig. 1. Traditional map chart

From a visual point of view, map chart analysis presents the distribution of data in each region with different color saturation. The more saturated the color in the respective region of the chart is, the more posts from that region there are. In this classical approach, the association between the region and the result is made based on the geographical affiliation of the source of the publication. The presented graph shows that only a few world regions fall into the results of the analysis. Most results are in the United States, followed by Australia, India, and some of the largest countries in Europe. The reason lies in the data sources used in the study. Such research is usually relatively easy to perform from a technological and resource point of view. The reason for this is that the relationship between web publications, web-based information systems and regions is relatively clear and easy in the context of data models. Such an analysis

is useful because it becomes clear which countries' sources publish the data on the criteria, we are interested in. At the same time, it would be more interesting to understand in what regional context the criteria we are looking for is presented. For this purpose, we will explore the possibility of performing the same analysis for the same resultative publications, but with application of data science.

3. Map charts with application of data science

The application of data science for data analysis is a very current topic. With the use of data science, connections and dependencies are established between the data, which bring higher added value to the respective analysis. Modern researchers usually associate data science with artificial intelligence due to the specifics of the algorithms used. Specifically, in this study, data science can find a very good application for map chart analysis. The difference from the previous traditional map chart analysis is mainly in the fact that data science map chart analysis establishes links between publications and regions that are not known in advance. In traditional map chart analysis, the main goal is to establish the effective number of publications in a region according to given criteria, but it is known in advance which regions can be included in the analysis, because they depend on the selection of relevant sources and their affiliation. Data science map chart analysis first identifies the publications that meet the keyword and period criteria, and then analyzes these publications to understand from their content which regions they relate to. Therefore, this type of analysis is more complex from a technological and resource point of view. In any case, it is known that in general data science needs a significant resource. Fig. 2 presents the analysis performed earlier in the study, but this time with the application of data science.

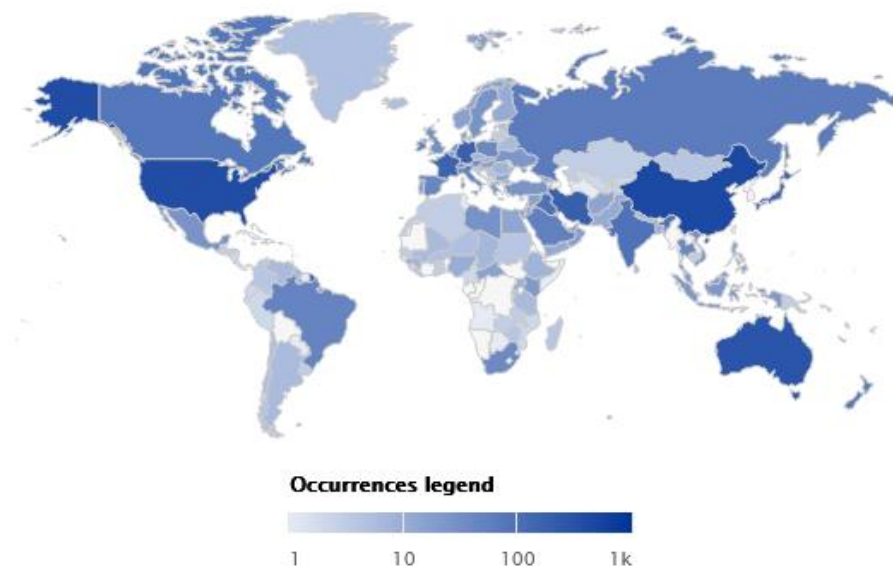


Fig. 2. Data science map chart

The presented graph shows the difference compared to the previous results. The new graphics are much more saturated. It is attended by many more countries that are relevant to the results found by the relevant criteria. In this case, there is no way to know in advance what to expect as a result. This analysis takes more resources, but the results can be very useful for public and business organizations.

4. Conclusion

In conclusion, it should be noted that map chart analysis and its variants are becoming increasingly popular. These analyses are very useful because they visually illustrate the connection between publications and regions. This type of analysis is often used in both the private and public sectors. In the study we paid attention to the traditional map chart analysis and map chart analysis with application of data science. Based on the achieved results we can make the following summaries:

- The traditional map chart analysis is useful for information on publications on the relevant criteria in a given region;
- Traditional map chart analysis requires less resources and its preparation are relatively easy from a technological point of view;
- Map chart analysis with application of data science is the next level of analysis in terms of establishing links between publications and regions;
- Data science analysis requires more resources and is more complex from a technological point of view, but the results are significantly more saturated with potentially useful information.

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Features of an Information System for Application, Evaluation and Classification of Research Projects

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Abstract. The paper presents the results of practical development on the issues of research projects. Many of these projects are implemented at university level. In this sense, it is necessary to design and develop an information system that digitizes the relevant processes. The implementation of such a system is possible only when the issues of the subject area are adequately reflected in the developed software solution. The paper presents the current level of development of an information system for research processes and the vision for its future development. In conclusion, emphasis is placed on the increasingly important role of software solutions through which modern research projects are managed.

Keywords. Information system, Web application, Research projects

1. Introduction

The development of software solutions for project management and monitoring is a very topical issue given the availability of a lot of data related to these projects. The present study focuses on the possibilities for developing software solutions at the university level. Although university research projects are much smaller than national and international projects, the data related to their management do not differ much in volume. It is also important to note that the number of these projects is significantly higher than the number of projects in the other larger categories. That is why the development of software solutions to digitize these processes is very important for the activities of universities in general. From the point of view of their life cycle, university research projects have the sequence of actions, presented at Fig. 1.

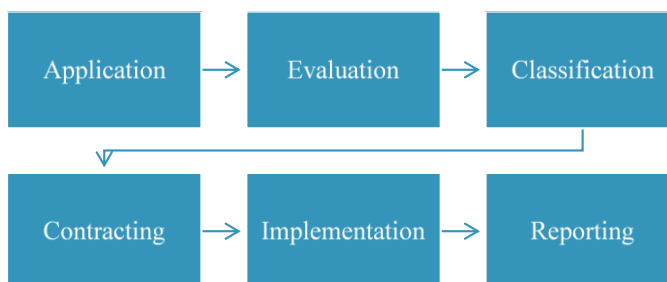


Fig. 1 Research projects lifecycle

The administrative aspects of electronic services are usually related to different user roles [1]. Internal information systems for public institutions, including those at university level, need specific data management mechanisms that are also in line with the relevant

regulations [2]. Many of these systems take advantage of some of the largest vendors of database management software, such as MS SQL Server [4, 5]. It is also possible to use other popular database systems, which have their advantages in the stage of development of the respective technological solutions. Some solutions focus on the digitalization of a specific area, such as accounting [3]. The present study focuses on the development of an information system that digitizes all aspects of the business process of managing and monitoring the implementation of university research projects.

2. Current state of development

The object of the study is the information system for research projects at UNWE [6]. Participants in this process are representatives of the university administration, university professors who may have different roles within the system, students, as well as persons external to the university. The main user roles in the system are the following:

- Administrators;
- Applicants with project proposals;
- University evaluators;
- Reviewers, including external to the university;
- Other roles that are related to the administration of projects by departments that are not directly involved in university projects.

In the current study we will consider some features of the currently developed functionalities, as well as the guidelines for the forthcoming development of the software service for digitalization of the whole process. At the time of the present study, the available functionalities in the information system for university research projects are the functionalities for application, evaluation, and classification. These functionalities, although traditional for project management systems, have some specifics that are due to the university rules for this type of project.

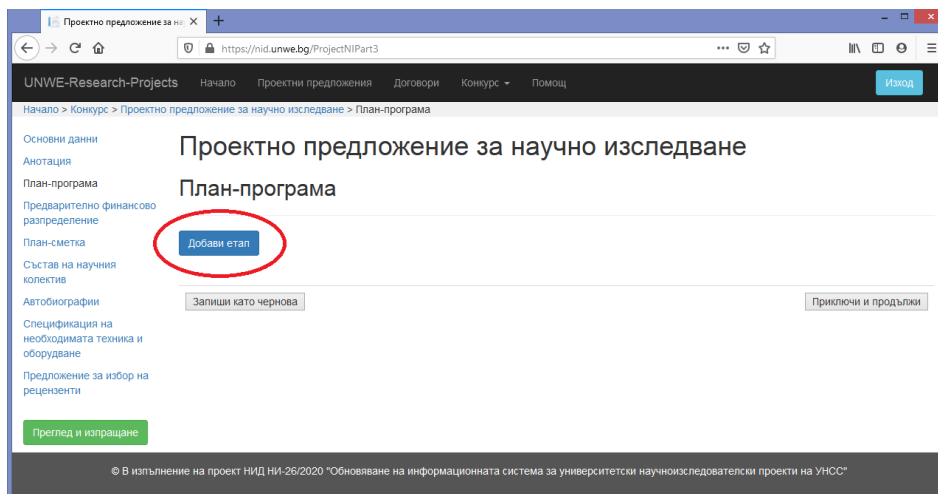


Fig. 2 Dynamically adding of content to a web page

Figure 2 presents a user interface of the information system for research projects at UNWE. Specific about this interface, as well as about other interfaces in the system, is the

need to dynamically add content to the respective interface. This is one of the features of this type of systems and the requirements for their user interface. The reason is that there are several stages in the process for which it is not known in advance what data will be available. This is the case with the project plan. There are projects for different periods of time, which implies the presence of dynamism in entering this type of data during the application with a project proposal.

Another specificity of the university research projects is presented at Fig. 3. It is related to the possibility to evaluate the project proposal entirely electronically. The evaluation of the project proposal is performed on the one hand by an evaluation committee inside the university and on the other hand by external evaluators.

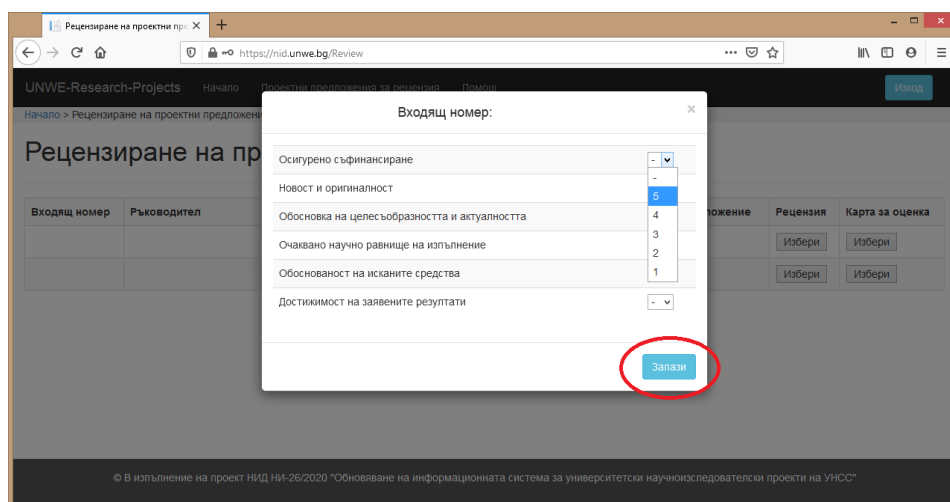


Fig. 3 Evaluation of a project in a digital way by external reviewers

The presented interface refers to external evaluators. Specific about the system is that it has a different set of evaluation indicators. Each indicator has a different weight in the formation of the final assessment. An important point in the context of software development for research projects is the possibility that these indicators and their weights can change over time. The digitalization of the process of evaluation and classification of project proposals is a prerequisite for better management of the entire business process. Unlike external evaluators, the evaluation committee of the university has an additional opportunity to leave notes on its evaluation. This possibility is presented at Fig. 4. Because of this option, there is a possibility for feedback, which is entirely electronic within the system. In general, the purpose of this type of system is in time all the connections between the individual participants in the process to be digitized and realized only through the information system. Once the evaluations from all the parts involved that have been received electronically are available in the system, or after the time allotted for the evaluation of the project proposals has elapsed, the generation of classification is started. The classification is generated automatically based on the parameters set in the system, and before its final generation it is visible only by the administrators of the information system.

Входящ номер:

Осигурено съфинансиране

Новост и оригиналност

Обосновка на целесъобразността и актуалността

Очаквано научно равнище на изпълнение

Обоснованост на исканите средства

Достижимост на заявените резултати

Препоръки

Запази

Fig. 4 Evaluation of a project with an option for leaving notes

After considering some of the main points of the current state of development of the information system for research projects at UNWE, mainly concerning application, evaluation, and classification, we must define some future tasks that are essential for the overall digitalization of this subject area. These future tasks concern contracting, implementation and reporting of research projects at UNWE.

3. Future work

The future functionalities of the information system are mainly in the direction of the management and monitoring of the implementation of the university research projects. Some of the main functionalities that should be available are:

- Generating documents through the system or working with fully electronic documents in relation to all types of contracts related to the implementation of the projects;
- Ability to reflect all changes that occur in the implementation process, including changes in the team that implements the project and financial changes;
- Maintaining a history of changes made during execution, including annexed changes;
- Ability to report the results of the project electronically;
- Ability to evaluate the intermediate and final reports electronically;
- Maintaining a complete digital dossier for each project proposal, which includes all documents accompanying it;
- Integration of the data from the information system for research projects with the system for research activity of the university.

The ability to change project data during its implementation is key in the context of digitizing the overall process. This ability is the most difficult to implement given the specifics of some of the data that should be able to be changed. This is the case with the ability to change the project budget. During the implementation of each research project there is a need to change its budget. This change is related to some of the basic data of the project. At the same time, the change cannot take place without the approval of the administrative unit, which is engaged in the research activities of the university. In this sense, the system should electrify

all aspects of this process. This means that the desired change must first be reflected in the system and then approved by the relevant system administrators. The change in the project budget also concerns other administrative units at the university. For the process to be fully electronic, these other units should also be able to influence the changes in the data in the system. Providing this access is associated with some challenges in the context of the need for a change to be coordinated with more than one user role. These additional roles should be for representatives of administrative units, such as the accounting department, the finance department, the control department, the legal department, and the human resources department. Future developments in the information system for research projects are of key importance for the digitalization of this part of the university activity.

4. Conclusion

In conclusion, it should be noted that information systems for management and monitoring of research projects are very important in the context of the overall management of university activities, because the research part is essential for all universities. The functionalities developed so far for the digitalization of the management of research projects allow us to draw the following conclusions about the peculiarities of the information system in the context of the application, evaluation, and classification of project proposals:

- Need to design and develop a large number of dynamic user interfaces in order to cover the specifics of each project proposal;
- Opportunity to evaluate project proposals entirely electronically with the possibility of feedback in the form of notes to the relevant project managers;
- Existence of classification, which is calculated automatically and maintains the possibility to determine different weights on different indicators for evaluation, including the possibility to change them according to the specifics of the respective competition session.

Acknowledgement

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Integration of Business applications via Data-driven File Import

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Abstract. The paper presents a generalized approach for design and development of an integration software module for data import that can be plugged in different types of business applications. This module is a natural extension of the General Data-Driven File Export Integration Solution previously presented. The pros and cons of data-driven implementation approach are discussed. Architecture of an Integration Module for Data-driven File Import that comprises of universal data base structures and stored procedures is proposed and developed. Promising directions for future optimizations of this Integration solution are outlined.

Keywords. Data-driven software, Integration solution, File import, Universal database structures, Heterogeneous system integration

1. Introduction

Every company has many different sources of information that vary depending on its business needs which predetermine the way, the time, the format, and the representation of similar data received from different addressees [7]. Data that is needed for core business activities or deflect to customer support, must be processed in a real time manner, thus the organization will be more flexible, it will deliver more value to customers and new business opportunities will be enabled. On the other hand, there is also data that is not needed in a real time or near real time fashion. Such information can be created as a result of some calculations and aggregations of large volumes of data, that has been processed by some other internal or external system and imported in the so-called batch window, when the core applications are not fully loaded and have free resource for synchronizing. Basically, this scenario is commonly used for ETL process into the company's data warehouse [14] and for data provided by or delivered to National or European institutions. In integration frameworks based on batch processing, a significant number of transactions are collected and then the whole bunch of data is imported or exported by a software agent during a single execution. Data integration frameworks are better applied in business scopes with batch-oriented problems, because of their lower network and processing overload and better scalability for large data volumes [6, 8]. In data integration approaches, the integration adapter or interfaces may be implemented in two different manners - to wrap directly the data repository or data-access layer of both interconnected systems [4,2], or to be encapsulated in the data repository or data-access layer of the system that has to import data from or export data to one or more other (including third party) systems. The latter approach requires development of a standalone software tier, independent on any business logic, thus no business rules must be directly involved in the processing, so it is usually applied when the main aim of the integration is synchronizing or replicating data between systems without direct access to each other's storages [18].

2. Fundamental Requirements to a File Import Integration Solution

The main purpose of an integration solution for importing data from files is to synchronize or to replicate data between third-party systems without direct access to each other's data repositories. The choice of an architecture for such an integration module is mainly determined by two groups of factors – business and technological.

Once we abstract from the information semantics, the most important business consideration remains the file format that must be processed by individual procedures for import. This requirement may be imposed by some national regulatory authorities, that supply the information, like National Credit Register of Bulgarian National Bank (NCR of BNB) [1], Nacional Revenue Agency (NRA) [16], National Security Institute (NSI), etc. In other cases, the type of files may be chosen based on some internal design considerations like estimated volume of data, future data usage, effort, time and cost of implementation, frequency of data import (periodic or on demand) etc. Commonly used file formats [18] for data exchange may be summarized as follows (see 0):

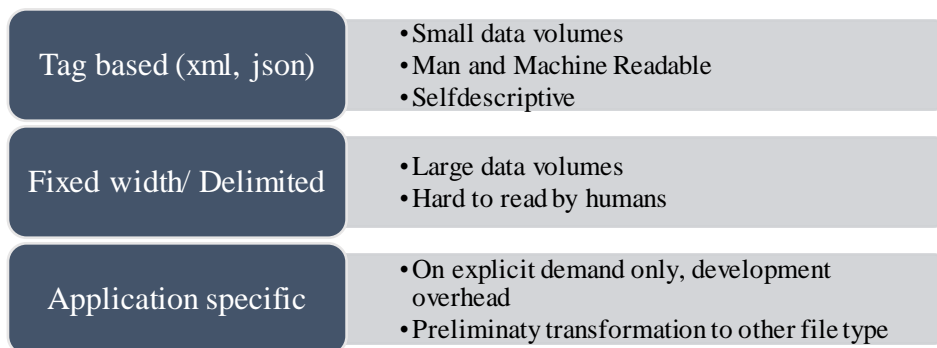


Fig. 1. Commonly used file formats for data exchange

Usage of tag-based files sounds like the most modern option. Their most significant advantage is that they are both man and machine readable, but these file types are somewhat wasteful in size (especially XML, because of duplicated tags). These characteristics make them suitable for import and/or export of a small amount of data that will be instantly visualized. Large variety of fixed width and delimited file structures are suitable when transfers of large data volumes (delimited files are smaller) are in order. These files may or may not begin with a header row, contain one or more sections that differ in structure and finish with or without a summary row, but in any case, they are easy to process, but difficult to read by humans. Basically, because of considerable development overhead, application specific file formats (e.g. rtf, doc, docx, dbf, xlsx, xls, etc.) are not directly used for general purpose data imports, and such kind of specific implementations exist more as exceptions and thus are outside of the aim and the scope of this paper. More feasible solution is to perform some preliminary transformations of application specific files to some tag based or delimited file format and proceed with standard import afterwards.

The technological requirements for the file import module aim to ensure both the smooth and trouble-free exploitation and maintenance of the system, and its agile extension:

- Flexibility – fast and easy change of data structures when a new business requirement or a legal demand occurs.

- Extensibility –high degree of reusability of data structures, software components and metadata must ensure relatively fast and easy development of new imports.
- Scalability – the ability of a system to handle a growing amount of processing procedures and volume of information by adding resources to the system.

Like the concepts of file export architecture previously proposed [18], the flexibility and extensibility of current solution may also be achieved by designing and developing abstract metadata that describe properties of each individual import, universal data structures to store this metadata and database procedures to parse and persist the imported data. Such a solution is relatively easy to implement in a traditional database, and scalability may be achieved by providing for the possibility of future migration to the cloud [8], both of its built up software components and of the database structures [4,9], persisting results of their execution.

3. Architecture of an Integration Module implementing Data-driven File Import.

All popular relational Database Management Systems provide a large set of techniques and tools for developing stored procedures including rich and high-level syntax constructs, technologies, and many utilities to deploy existing stored procedures as services. Considering that this kind procedural software component of a database is powerful enough to fully implement the necessary functionality and can easily be made available for use, it can be considered as one of the simplest and most economical possible options.

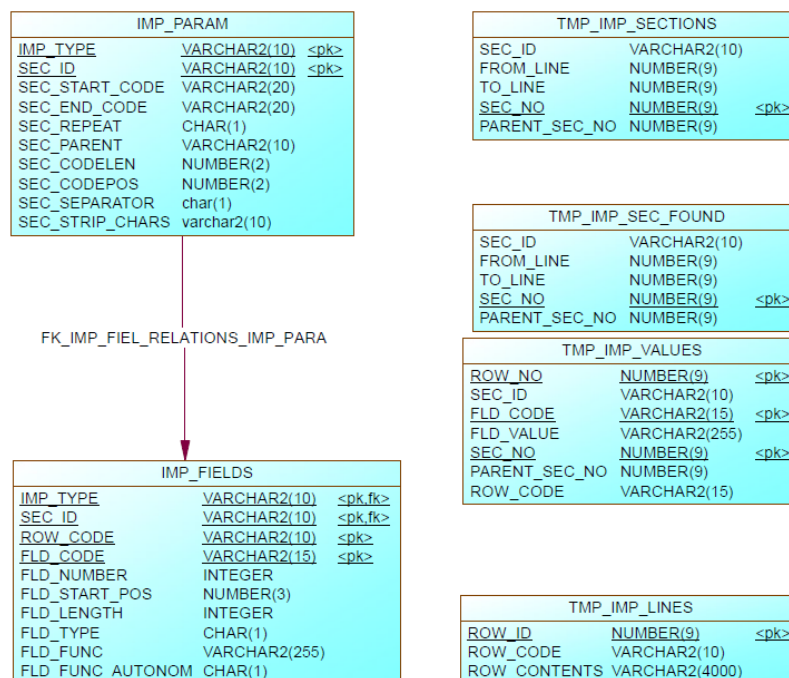


Fig. 2. Physical Model of a Abstract Data Structures for file import

Suggested approach includes two main components - database stored procedures to perform the import and abstract data structures implemented as a separate scheme within the same database (0), which:

- On one hand store metadata about the parameters of each individual import and the structure of the incoming file (sections, rows, and fields), define the processing for parsing and validating the data and the general execution flow control. These tables are placed on the left side of the model on 0.
- On the other hand, provide storage to temporary keep the rows of the file being imported, while parsing and validating its content according to metadata describing file sections, rows, and fields. Temporary storage tables are placed on the right side of the model on 0
- Database tables where imported data is persisted, are totally dependent on business logic and information semantics, so they are not a part of the solution currently discussed but are mentioned as a final step of the whole processing.

In the context of this development, the term “section” is used to define a set of lines (rows) with one and the same structure. Basically, each file that can be imported, comprises of one or more sections and even complicated master-detail relations between records in a single file may be described (0). Each section has a unique identifier (SEC_ID), a starting code (SEC_START_CODE) and a terminating code (SEC_END_CODE) used to distinguish it among other sections (together with SEC_CODEPOS and SEC_CODELEN metadata fields) and to facilitate development, tracking and logging. If needed, any section, except the first one, may be a part of some upper-level structure thus belonging to a container with all other sections with the same master (identified by SEC_PARENT) section. Each section may use with some specific separator to separate its fields if such has been defined by SEC_SEPARATOR field value. All unnecessary characters that must be removed from data during import, must be defined as a part of the string value of SEC_STRIP_CHARS field. SEC_REPEAT is used to set or unset the option for a section to be duplicated in the file.

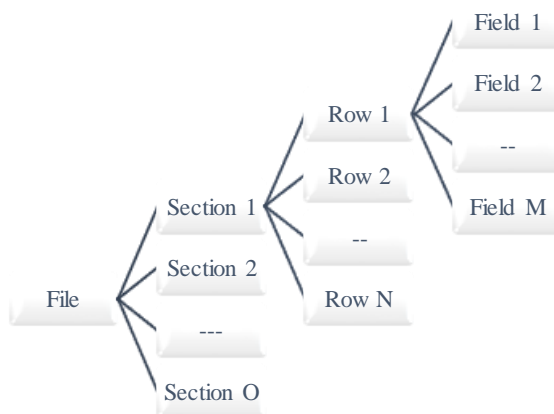


Fig. 3. General structure of a file to import

The first step of the processing (0) is to retrieve the parameters for all the sections of some file that comprise the whole data import. Each individual import may include one or more sections and each section is defined by a single record of IMP_PARAM table (0). It is identified by a composite key (unique combination of IMP_TYPE and SEC_ID) and has a

descriptive name, that is used for visualization and logging purposes. The other columns of IMP_PARAM table contain import metadata that are used as follows:

- To set the type of the file which will be imported (fixed struct, delimited or other), the separator (if any) which distinguishes each two data fields and redundant characters that must be stripped before parsing, validating, and persisting each imported value.
- To set some properties which are used to distinguish individual sections of a file like codes denoting the beginning (SEC_START_CODE) and the end of each section (SEC_END_CODE). Assuming that section fields may not be placed from the beginning of each row, properties like initial position of the section code (SEC_CODEPOS) and length of this code (SEC_CODELEN) may also be defined. General idea is that each section may be distinguished by its code value, which starts on SEC_CODEPOS position of each line and after SEC_CODELEN characters starts the first data field of this section. The simplest possible case is when the file contains a single section and in more complicated situations file sections form a complicated hierarchy which is described by metadata set as identifier of the parent section (SEC_PARENT) field and a Boolean defining if multiple instances of this section may occur in the file (SEC_REPEAT).

On this first step of the import procedure all import parameters are retrieved and parsed in order to define the fullest possible structure of the file and the relevant flow control.

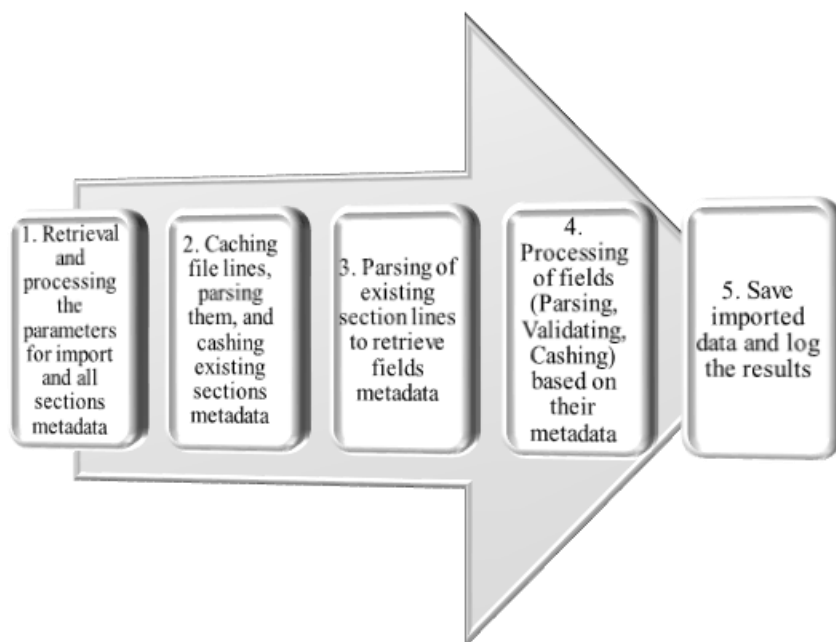


Fig. 4. Stored Procedures flow for file import implementation

In the second step of the processing flow, all file rows are cached in a temporary table (TMP_IMP_LINES in 0) and the content of imported file is analyzed. Parsing is based on the presence of SEC_ID and ROW_CODE fields values in the file contents) and aims to determine

which of all possible sections (as defined on step 1) are existent in the file. Finally, metadata describing existing sections them is temporary saved (cached) to a temporary table.

Based on metadata about actually existing sections, the third step – processing of previously cached rows belonging to each section is performed. As a result, metadata about all fields composing each line is retrieved, so to enable control of the sequence (determined by FLD_NUMBER property) and formal logic for parsing and verification of individual fields processing preformed in the next step.

The fourth step of the import procedure deals with individual fields of each line being currently processed. Each field is uniquely identified by its FLD_CODE and its content is extracted based on its position in the file. The values in delimited file fields are self-separated, while fields in fixed width files must be explicitly separated by FLD_START_POS and FLD_LENGTH properties. All field values are converted depending on the setting for their type (FLD_TYPE) as follows:

- Data types currently supported are strings, numbers, dates and datetimes. There is a single compulsive requirement (limitation) – the file separator cannot be used as a part of a date, datetime or numeric type value, but strings can contain it if the value is properly enclosed in quotes.
- The format for dates, datetimes and numbers supported by default, depend on locales of the data base management server, but the additional effort has been made to try parsing the values in many commonly used formats for long and short date, for time and datetime types. Numeric values may also be parsed using different popular combinations of decimal and thousand separators.
- All string values are trimmed from both sides.
- A user-defined pre-processing function may take place if its name is set in FLD_FUNC. Depending on FLD_FUNC_AUTONOM property, this pre-processing function may run as an autonomous transaction or as is by default, in the scope of current transaction.
- In the conversion is not possible, an exception is thrown and the whole import procedure is terminated.

In addition to this formal data type control during file content parsing, at this stage the maximum length of values is also checked. All other validations are performed in the process of persisting the data in database tables where they eventually belong.

On the final step, the results of the whole processing like file name, processing times, number of lines been successfully imported, number of lines been skipped etc. are logged. As a significant part of this final step all the data that has been imported, parsed, and validated are persisted in subject area specific data base tables. In the common scenario, this processing is strongly dependent on business logic and business rules, that have not been currently abstracted and are not a part of this implementation but can be a promising direction for future development.

4. Conclusion

The proposed integration approach comprises of interconnected import and export subsystems and with provides some significant advantages to businesses: it is a general-purpose solution that does not depend on the business process and its data structures specifics; the solution does not require substantial financial or time resources since it employs the existing IT infrastructure. The designed file-import and file-export modules are both highly efficient, flexible, and scalable. They have been operational for more than six years now without any substantial delays in the core system or the business process being registered so

far and a functionally complete bidirectional batch integration module with third party systems has been implemented. Many new file-import and file-export functionalities have been integrated in this integration module since its initial deployment, thus practically proving that suggested implementation does not impose significant functional restrictions and stays open for agile extensions.

Some options for integration of business logic plug ins are currently being explored and probated. Migrating this universal database scheme to a cloud data base is also planned.

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Comparative Analysis of E-government in the Western Balkans

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Abstract. The paper examines the state, trends, and level of development of e-government in some countries of the Western Balkans. A comparative analysis was made for Bulgaria, the Republic of Northern Macedonia, Albania, and Serbia. The comparison is based on UN data for 2020. Finally, conclusions are drawn, and recommendations are made.

Keywords. E-government, comparative analysis, public administration

1. EGDI methodology

Carrying out a comparative analysis is important for revealing the main trends in the development of e-government. One of the main methodologies applied worldwide is that of the United Nations. It is based on the development and implementation of a single complex index called the E-government Development Index. The EGDI methodology is based on the calculation of three composite indices based on a group of indicators. Each of these three indices has a specific focus on the development of telecommunications infrastructure, online services, and human capital. Fig. 1 presents the structure of the UN methodology.

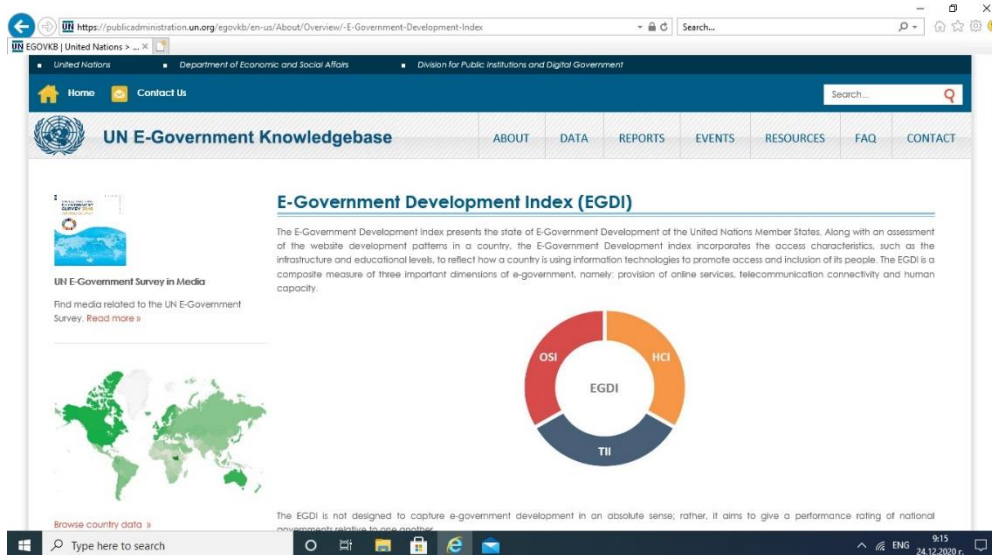


Fig. 1. E-government Development Index [3]

2. Status of e-government in the countries of the Western Balkans

Software solutions for the public sector have specific characteristics and they reflect the peculiarities of this type of organizations [2]. The state of e-government in the countries of the Western Balkans will be analyzed on the basis of several major perpetrators for Albania, Bulgaria, the Republic of Northern Macedonia and Serbia. The main indicators are:

- E-Government Rank;
- E-Government Index;
- E-Participation Index;
- Online Service Index;
- Human Capital Index;
- Telecommunication Infrastructure Index.

These 6 indicators show where the individual countries are in the EGDI world rankings. They are also indicative of the values and trends of the individual components of the general index. Summary data are presented in Table 1 [4].

Table 1 Data on individual indicators for 2020 [4]

Country Name	E-Govern ment Rank	E-Govern ment Index	E-Participatio n Index	Online Service Index	Human Capital Index	Telecommunication Infrastructure Index
Albania	59	0,7399	0,8452	0,8412	0,8001	0,5785
Bulgaria	44	0,7980	0,8929	0,7706	0,8408	0,7826
North Macedonia	72	0,7083	0,8333	0,7412	0,7395	0,6442
Serbia	58	0,7474	0,8214	0,7941	0,8280	0,6200

It can be seen from the presented data, that the best position in the ranking is Bulgaria, which is ranked 44th in the world rankings. In 58th place is Serbia, in 59th place is Albania and in 72nd place is Northern Macedonia. The EGDI values for the individual countries are as follows: for Bulgaria - 0.7980, for Serbia 0.7474, for Albania - 0.7399 and for Northern Macedonia - 0.7083.

3. Comparative analysis

In order to be able to perform a comparative analysis, it is necessary to define basic principles in advance [1]. In addition, several conditions must be met:

- Select the objects for comparison on the basis of a common feature;
- Provide up-to-date data;
- Provide data from the same source;
- Use a unified system of indicators for comparison;
- Perform the comparative analysis;
- Indicate conclusions and recommendations.

The first stage is the selection of objects for comparison. In this way, the analysis becomes horizontal. It compares data for the same period for different sites. In this case, the sites are the individual countries that are selected on a geographical basis. The sites are the following countries: Albania, Bulgaria, Northern Macedonia and Serbia. In the second and

third stages, it is important to provide reliable, up-to-date data from the same information source to be used for the purposes of the analysis. Such data in this case are provided by the UN Global Survey. It is held regularly every two years for all 193 member states. In this way, both horizontal comparative analysis and vertical time analysis can be successfully performed. The choice of indicators is a complex task. It should take into account to a large extent what data are available on the indicators. In this case, 6 indicators have been selected, and all of them have up-to-date data. This is followed by the actual comparative analysis and the formation of conclusions and recommendations. The described approach is shown graphically in Fig. 2.

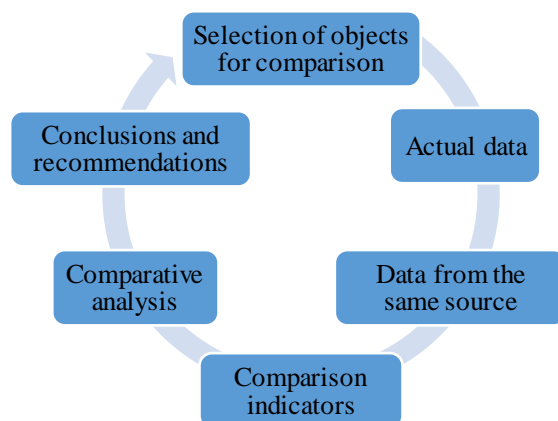


Fig. 2 Main stages in performing a comparative analysis

Figure 3 presents the original data used in performing the comparative analysis.

Country	Group	Rating Class	Rank 2020	EGDI 2020
Bulgaria	VHEGDI	V1	44	0.7980
Serbia	HEGDI	HV	58	0.7474
Albania	HEGDI	HV	59	0.7399
North Macedonia	HEGDI	HV	72	0.7083

Fig. 3 Data for performing a comparative analysis

Of interest for the analysis is the information shown in Fig. 4. It shows that 4 countries have higher values of the overall EGDI index than the world average. This shows that they are in the groups of high and very high values of the overall index.

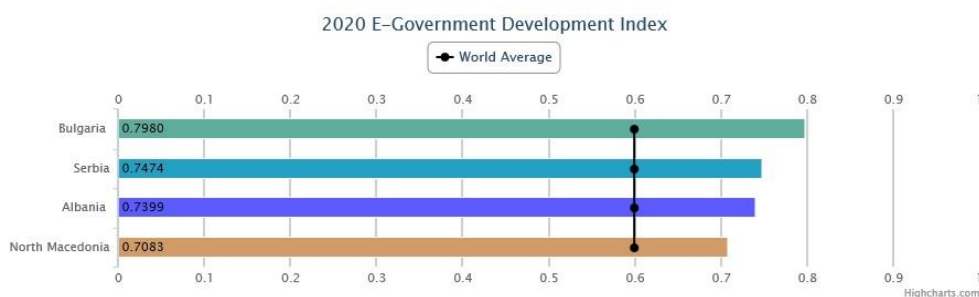


Fig. 4 Comparison of values with the world average

Figure 5 shows a comparison in the values of the individual components of the general index.

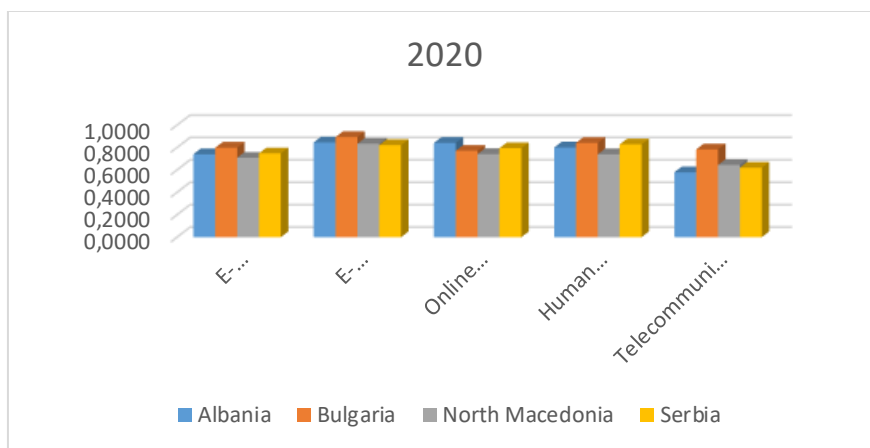


Fig. 5 Comparison of the components of the general index

The presented data show that the values of Bulgaria are leading in relation to two of the three components of the general index. From the point of view of online services, Albania and Serbia have higher values than Bulgaria. In terms of human capital, the highest values are for Bulgaria and Serbia. In the state of the telecommunication infrastructure, Bulgaria has a leading role, followed by Serbia, Northern Macedonia and Albania.

4. Conclusion

Because of the research we can draw the following conclusions:

- The data for 2020 show that Bulgaria has higher values, both of the general index and of two of its three components;
- In recent years, significant funds have been invested in telecommunications infrastructure, which leads to higher values of this component of the index;
- Benchmarking can be used to identify areas for improvement in the components of the overall index;
- Efforts for development of new online services need to continue.

Acknowledgement

This work was supported by the UNWE Research Programme (Research Grant No:NID-NI-7/2020).

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Trends in the Development of E-services in Bulgaria

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Abstract. The paper examines the problems of development, implementation and use of electronic services in Bulgaria. The analyzes are based on the data from a large-scale UN study from 2020 on the state of e-government in Bulgaria. Finally, some of the challenges are outlined, conclusions are drawn, and recommendations are made.

Keywords. E-government, Comparative analysis, Public administration

1. Methodological issues

In the Bulgarian and foreign literature there are several studies on the degree of development of electronic services. In the situation of a pandemic with COVID-19, this problem becomes especially relevant. The lack of certainty in the future regarding such health crises raises very seriously the question of readiness to deal with them. The lack of such readiness can cause enormous damage to the economy, social and cultural life of the nation. The more prepared a society is, the less damage will be in all spheres. All this requires the search for approaches for constant analysis of the main components of electronic services.

The main source of data for such analyzes is the ongoing research conducted by the UN on the level of development of e-government. From a methodological point of view, these analyzes are performed every 2 years among all 193 member states. The general index of development published by the UN is composed of three sub-indices, namely [3]:

- Online Service Index;
- Human Capital Index;
- Telecommunication Infrastructure Index.

Based on these three indices, a general index for the level of development of e-government - EGDI - is calculated. On this basis, rankings are made in the world for the order of the individual countries, forming the so-called e-government rank. From a scientific point of view, it is of interest to perform horizontal and vertical analyzes of these indices. Horizontal analyzes are comparative analyzes of individual values for the same period and for several countries. Vertical analyzes allow the comparison of the values of the total index (EGDI) and its components for the same country for a certain period of time. When studying the values of the human capital index, the peculiarities of the career development of young specialists in the economy should be taken into account [1].

This study focuses on the analysis of the values of the general index and its components for Bulgaria for the period from 2003 to 2020.

2. Indicators for Bulgaria for the period 2003 - 2020

The possibilities for presenting different types of analysis in the field of public electronic services is an actual issue [2]. The state of electronic services for Bulgaria is presented on the basis of an analysis of four main indicators:

- E-Government Index;
- Online Service Index;
- Human Capital Index;
- Telecommunication Infrastructure Index.

The data show that in 2020 the value of EGDI for Bulgaria is 0.7980. The value of the index for development of electronic services is 0.7706. The value of the index for the telecommunication infrastructure is 0.7826. The value of the human capital index is 0.8408 (Fig. 1).

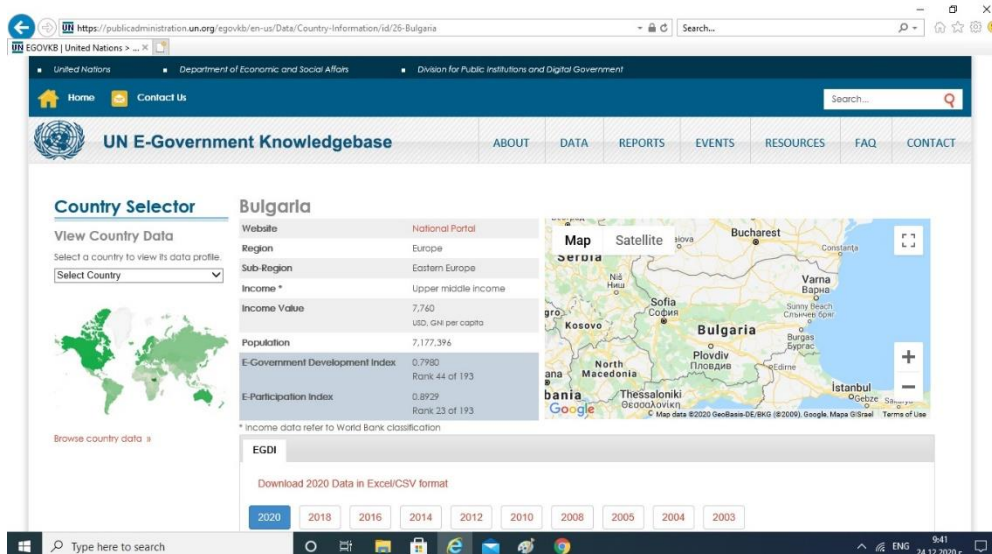


Fig. 1. E-government Development Index, Bulgaria, 2020 [4]

Of interest for the study is the analysis of data over the period 2003 - 2020. In this way, trends in individual indicators can be studied, as well as to predict to some extent future developments. The summarized data for Bulgaria are presented in Table 1 [4].

Table 1 Data on individual indicators for the period 2003 - 2020 [4]

Bulgaria	2003	2004	2005	2008	2010	2012	2014	2016	2018	2020
EGDI value	0,5480	0,5417	0,5605	0,5719	0,5590	0,6132	0,5421	0,6376	0,7177	0,7980
OSI value	0,5371	0,5058	0,5192	0,4849	0,4095	0,4902	0,2362	0,5652	0,7639	0,7706
TII value	0,2069	0,2094	0,2522	0,3071	0,3370	0,5006	0,5941	0,5602	0,5785	0,7826
HCI value	0,9000	0,9100	0,9100	0,9262	0,9350	0,8486	0,7960	0,7875	0,8106	0,8408

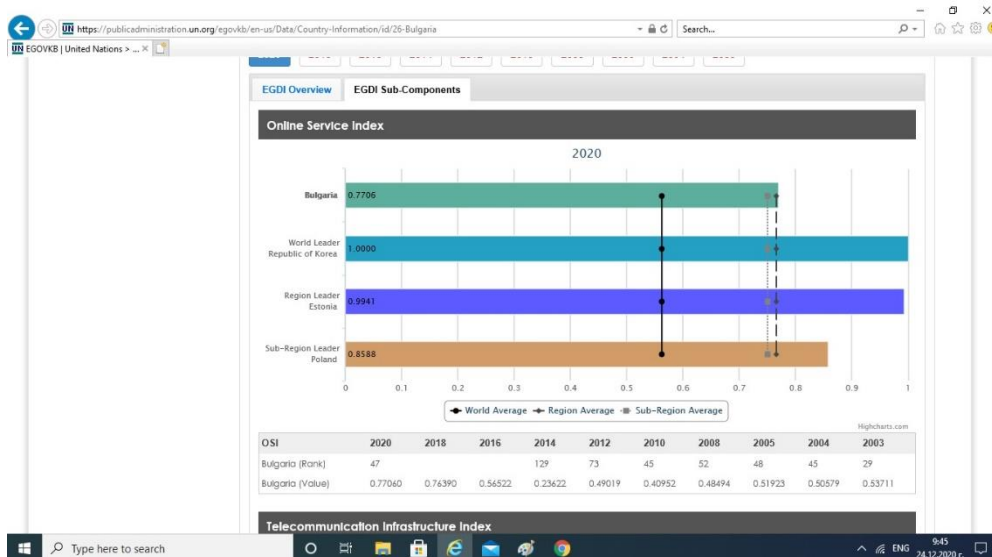


Fig. 2. Online Service Index [4]

Data from the Online Service Index show that its value for 2020 is 0.7706. This puts our country in 47th place in the world rankings. The value is much lower than that of the regional leader (Estonia) and higher than the world average. At the beginning of the study period (2003) the value of the index was 0.5371, which put Bulgaria in 29th place in the world. The data for the period 2003 - 2020 are presented graphically in Fig. 2.

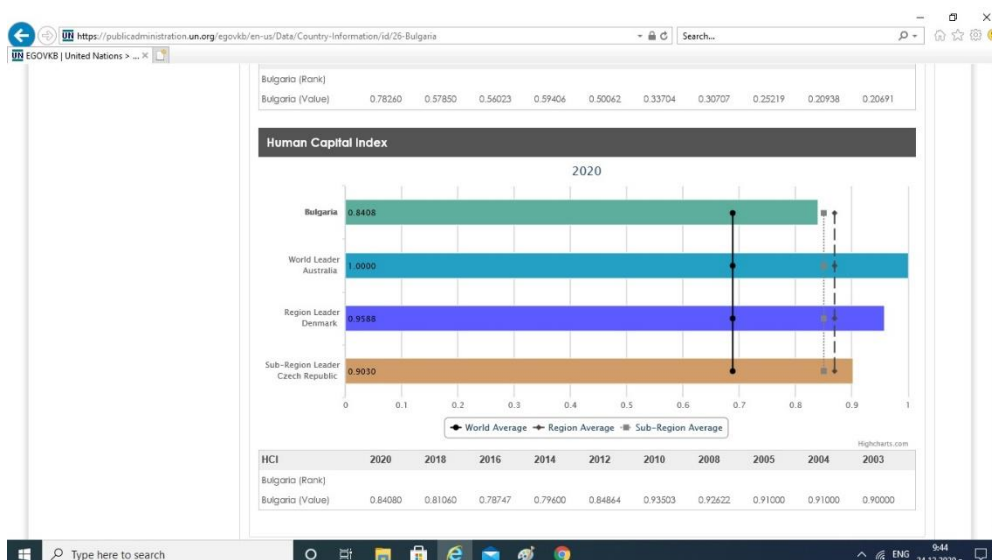


Fig. 3. Human Capital Index [4]

Data from the Human Capital Index (Fig. 3) show that its value for 2020 is 0.8408. The value is much lower than that of the regional leader (Denmark) and higher than the world average. At the beginning of the study period (2003) the value of the index was 0.9000. Data for the Telecommunication Infrastructure Index show that its value for 2020 is 0.7826. The value is much lower than that of the regional leader (Liechtenstein) and higher than the world average. At the beginning of the study period (2003) the value of the index was 0.2069. The data for the period 2003 - 2020 are presented graphically in Fig. 4.

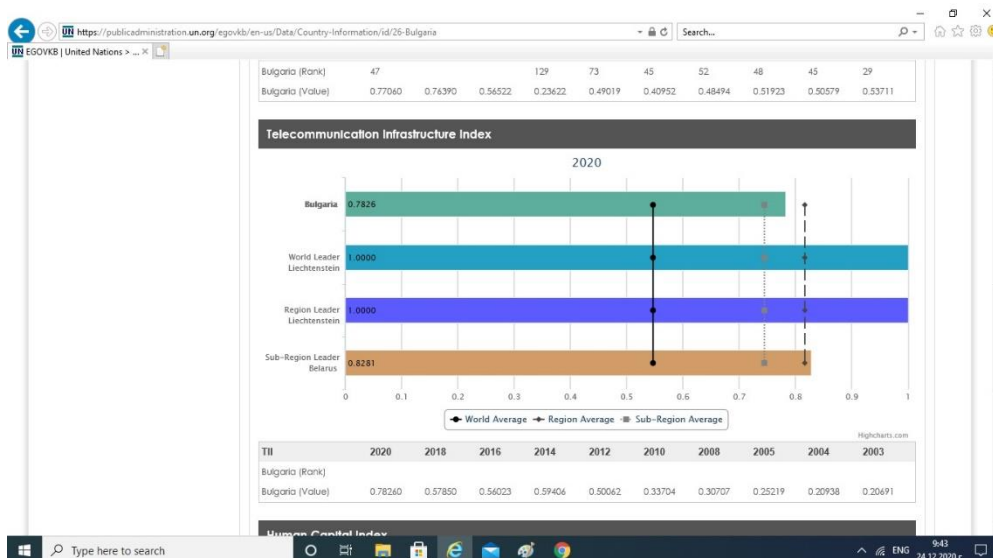


Fig. 4 Telecommunication Infrastructure Index [4]

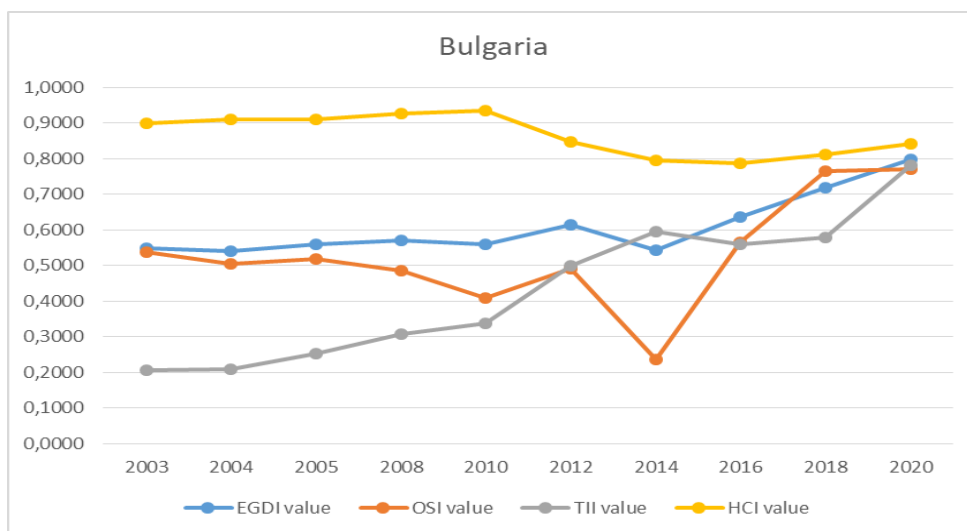


Fig. 5 EGD, OSI, HCI and TII (2003 - 2020)[4]

The summarized graphical representation of the total index and the three composite indices is given in Fig. 5. As can be seen from it, the telecommunication infrastructure in Bulgaria continues to improve in the period 2003 - 2020. This is largely due to the continuous projects and investments in network equipment and the development of mobile communications. There is an upward trend in the human capital index. Fluctuations in values over time can be due to a different set of internal and external factors. Electronic services continue to improve and expand. These trends need to be strengthened in the future.

3. Conclusion

Because of the research we can draw the following conclusions:

- In the last few years, Bulgaria has significantly improved the values of the general index for measuring the level of development of e-government;
- Electronic services have also been significantly expanded and improved. At the same time, further efforts are needed in this direction. This will allow the economy to be better prepared for future crises.

Acknowledgement

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Container Technology against Virtual Machines - Docker and Kubernetes

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Abstract. The report describes the most common characteristics of IT container technology in comparison with virtualization technology – virtual machines. The report also describes common use cases for containers and outlines the key products for container creation and container cluster orchestration – Docker and Kubernetes.

Keywords. Container technology, Virtual machines, Containers, Docker, Kubernetes.

1. Introduction

The technologies related to the term “virtualization” have great impact on the world of information technologies in present times. Virtualization from a computer perspective is most commonly described as to create a virtual version of a specific computer component that is real (physical) by nature. Some of the components that can be virtualized include hardware platforms, storage components, network components and others.

The creation and development of virtualization technologies leads to a new era in the evolution of information technology. In recent years following the development of virtualization technologies, another similar technology gains popularity and rapid development – the technology for building application containers.

Although container technology occurred more than thirty years ago (compared to the time of this report - 2020) it has developed a lot in the last fifteen years and in the recent few years containers entered the state of wide use and popularity. Container and virtualization technology (especially virtual machines) have a lot of common features as well as some key differences that are both in the scope of this report.

2. Container technology – common features and historical development

Container technology in the IT world can easily be described by using a non-IT example – freight containers. Years before a unified freight container standard was created the carrier companies had trouble transporting packages of various types, shapes and sizes. The establishment of a common standard that regulates the shape and size of the freight containers as well as other characteristics enables the creation of all the other freight transport-related elements – freight ships, cranes, container trailers for trucks, etc.

Like freight containers, IT application containers are a way to package application program code for one or more computer applications, including other dependency components into a so-called container, that can be executed on different computer platforms with almost no specific platform requirements. The goal is to isolate the application and the minimal required components for its execution into a complete packaged component – a container. Everything that is unnecessary is not included in the container and that makes it very small in

size and very fast for execution. The small container sizes make possible the reuse of a single platform environment (a workstation or a server) by many containers that share common hardware resources, operating system and other related components.

Following the freight container example, the carrier ship is the server (or workstation) that executes a large number of applications, packaged into containers. All application containers depend on the characteristics of the host (server, workstation) but can seamlessly be transferred and executed on another host with different characteristics.

Some of the key features of application containers can be summarized as follows:

- Application containers are independent elements that include everything required by a computer application to be executed;
- Containers are a form of computer virtualization but on an operation system level;
- Containers include all required sub-components – application libraries, configuration files, binary files, etc.;
- Containers provide platform and infrastructure independence of the application.

Application container technology has a long history that starts in the late 1979. Back then in version seven of the Unix operating system a new service is added – the “chroot”. This service provides a way to create a sub-environment in the operating system and execute applications and services in this isolated environment. The reason for creating the “chroot” service was to be used for testing purposes on production servers and systems. This service is the first implementation of the idea for application containers.

Twenty years later, in year 2000 the Unix-based operating system FreeBSD introduces the FreeBSD Jails components. FreeBSD Jails add additional isolated components to the already established “chroot” service, for example – users, files, network layer. This makes it possible for each “cell” to have its own IP (Internet protocol) address adding network layer logical isolation.

Four more years later (2004) the Solaris operating system introduces Solaris containers that enable the creation of “zones” that isolate applications and other related components. In 2008 the Linux operating system introduces LXC – Linux Containers, that serves as a foundation for the development of the Docker containers in 2013. After the first implementation of Docker containers, the Docker company replace the LXC with their own container library called “libcontainer”.

After the introduction of Docker containers and the growing use of containers it becomes necessary for the container technology to be standardized, so that all container implementations can be platform and infrastructure independent. This leads to the emergence of the Open Container Initiative in 2015 and the introduction of common standards for application container formats.

The standardization of the container technology enables it to outgrow Unix-based operating systems and to reach Microsoft Windows users as well. This happened in 2016 with the launch of Windows 10 and Windows Server 2016, that enable the execution of Docker containers.

3. Application containers and traditional virtualization

Containers are commonly perceived as a form of computer virtualization that in many aspects resembles the traditional virtualization. The common characteristics between the two are many, but there are some key differences as well. Figure 1 describes general pattern of traditional virtualization using virtual machines.

Traditional virtualization using virtual machines a so-called Hypervisor is installed on a physical server (or workstation) that manages the creation and control of separate virtual machines and the required hardware resources.

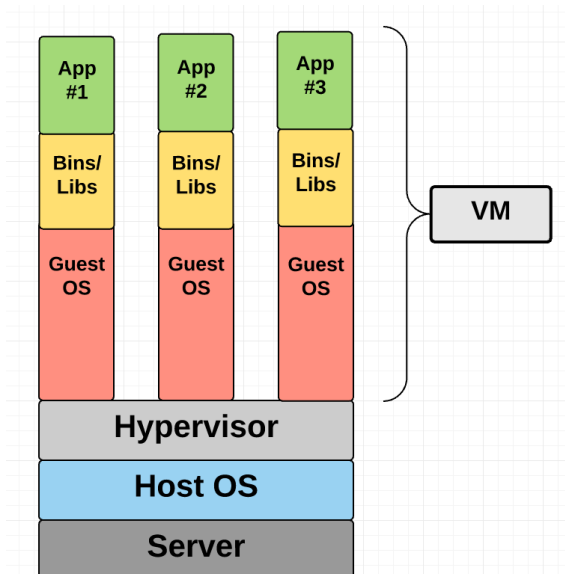


Fig. 1. Components of traditional virtualization [3]

Depending on resources, a single server can host many virtual machines (VMs). Each virtual machine has its own operating system (called Guest operating system) that can be different from the host Operating system. Each separate OS has its own layer of additional application libraries, binary files and applications. The key aspect is the presence of an Operating system and additional accompanying elements in every virtual machine.

If we follow the freight container examples, the host is a large freight ship that swims in the ocean, but instead of carrying containers, it carries small lakes that have smaller freight ships sailing in them, transporting the packages.

Figure 2 shows a basic representation of Docker containers.

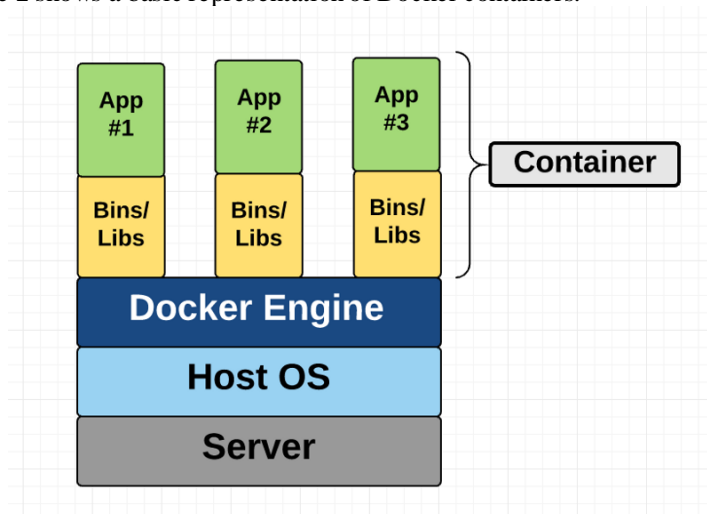


Fig. 2. Docker containers [3]

Docker container technology replace the hypervisor with the Docker engine – a software component for management and execution of application containers. Depending on the host resources many application containers can be created and executed on the host. The key difference between the two technologies is that containers eliminate the duplication of operating systems. Each container includes the application and all the required application libraries and binaries (Bins/Libs). Opposing virtual machines, the containers use the host operating system of the server (workstation). Sometimes a container can include a packaged operating system, if it is required for the execution of the packaged application.

Sharing the operating system of the host environment leads to the following points, that can be considered as advantages over traditional virtualization:

- Containers use a lot less resources;
- Containers are usually a lot smaller;
- Containers are initialized faster;
- Using containers makes it possible to implement the “microservices approach” – each function or service in an application should be packaged separately and independently from the others;
- Container infrastructure is more scalable when there is a need for increasing or decreasing physical resources;
- Containers are portable to other platforms and are platform independent;
- Container technology is based on Open source and Open standards.

The next section in the report explores two of the most common applications, related to containers.

4. Docker and Kubernetes

At many points in the report so far, the solution of the Docker company was mentioned. At the time of this report (October 2019), Docker is the most popular solution for creation and management of application containers. Docker provides a complete platform for management of containers under Linux and Microsoft Windows operating systems, as well as in a Cloud environment. Docker also provides a repository for predefined container “images” for different applications that are ready to use. This makes it very easy for users to quickly deploy an application in a container.

Some of the competitors for Docker are:

- CoreOS rkt (also known as Rocket);
- Apache Mesos;
- Red Hat Open Shift Container Platform;
- Rancher.

On the other side there is one platform that also has great popularity – Kubernetes. Kubernetes is not a platform that is a direct competitor of Docker. It is the next step in the evolution of container technology and standards – a platform that expands the Docker technology. The term that describes Kubernetes is “Container orchestration”. Kubernetes provides a way to fully automate the creation, execution, termination, maintenance and overall management of containers. Kubernetes also provides automated load balancing for a container environment. Containers under Kubernetes are deployed in “clusters” that allow the high availability and load balancing through automatic increase or decrease of the number of active containers in a cluster. Container environment in Kubernetes is described as a self-healing environment – the platform discovers problems in container execution and resolves those problems automatically, executing predefined rules and scenarios.

Kubernetes was founded under the name Borg System in 2003 as an internal solution in Google. In 2013 Borg System was expanded and renamed to Omega cluster management

system by Google. The next year (2014) Google handed the platform to the development community as an Open code platform under the name Kubernetes. In 2015 version 1.0 of Kubernetes was published. All the technological enterprises like Microsoft, IBM, Google, Oracle and other participated in the development of the platform and the standards for container orchestration. At the time of this report (November 2020) the current version of Kubernetes is 1.16.

5. Conclusion

Application container technology in IT is introduced in the end of the 1970s but their rapid expansion and gain of popularity begins in 2013, led by the development of the virtualization technology. There are many similarities between the two technologies as well as some key differences that lead to different directions in development and usage. The emergence of Docker and Kubernetes leads to the development of standards in the area of application containers. It also leads to the rise of a new term – container orchestration, a technology that brings interest in the author of this report for further research.

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Comparing Business Process Management and Case Management

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Abstract. The report strives to compare Business Process Management and Case Management solution technology, outline the main differences, and use cases where each approach is most appropriate.

Keywords. Business process management, Case management, Workflow, Automation.

1. Introduction

The hyper dynamic business environment in recent years forces the organizations to find a way to respond to all kinds of disruptions with minimum delay and almost daily. Change is now something that they must face constantly. To be able to do that, organizations undergo what is known as digital transformation. This term is closely related to digitalization but on a broader scale. A definition for digital transformation that the author considers to be accurate is the following: “organizational change at the intersection of technology, business and people” [1].

Some authors [2] place the most significant impact of digitalization on areas such as: Data analysis, data transfer, work and production, security and supply. Other authors analyze digital transformation in terms of handling big data [3], supply chain management [4] and security [5]. The author of this report highlights four key areas that he considers to be the core of digital transformation:

- Data analytics;
- Business automation;
- Digital content;
- Artificial intelligence.

The topic discussed in this report is in the field of business automation. The term business automation is very often related to business process automation, but the author considers that business automation can refer to topics that go further than automation of processes.

2. Business processes and cases

As stated above, the topic of this report is in the field of business automation and more precisely – business process management. Previous research of the author in this area resulted in selecting a definition of business process management that the author considers to be most accurate: “a discipline that includes any combination of modelling, automation, execution, control, measurement and optimization of the interconnected activities that are done in the organization for the purpose of achieving the organization’s objectives” [6]. The digital transformation in the area of business process managements is now achieved using computer

software, known as Intelligent business process management suits (iBPMS). According to Gartner [7], some of the critical capabilities of the iBPMS platforms are:

- Composition of intelligent process-centric applications;
- Continuous process improvement;
- Business transformation
- Digitalized processes;
- Citizen developer application composition;
- Case management.

In this report the author would like to highlight the key difference between the core capability of the iBPMS – process management and one of the latest additions to the list of capabilities – case management. The first step is to provide some basic definitions: According to Rosing, Scheel, & Scheer, business process is a set of actions or steps in the organization that combine people, materials, machines, systems and methods and are done in such a way that would lead to the accomplishment of specific business goals [6]. In the author's point of view, this definition is broad enough to accommodate both processes and cases. Both concepts include "a set of actions or steps" that are "done in a specific way". But what distinguishes one from another is related to their structure. While the terms "structured" and "unstructured" are mainly analyzed by researchers in the context of data [8], in this report the author examines the difference between structured and unstructured business processes.

According to IBM, as one of the leaders in Gartner's Magic Quadrant for Intelligent Business Process Management Suites [9], processes and cases have the following distinguishable characteristics [10]:

Business process scenario:

- The activities are in order and their order follows a predictable and repeatable process;
- The process determines the sequence of events;
- It is a stable process that likely remains unchanged over a long period;
- A number of the actions can be automated.

Case scenario:

- The activities are unordered because the sequence of activities is unpredictable;
- The events determine the order in which the activities in the process are followed;
- People rather than programs interact to resolve the dispute;
- External documents are needed for verification.

The first scenario describes a structured – well known and predictable flow of activities while the second scenario describes an unstructured and unpredictable process – referred to as a case.

Furthermore, IBM provide graphical examples for process and case, modelled in IBM's iBPMS solution (see Fig. 1).

Figure 1 shows very clearly the structured order of process steps, some of which are carried out by the system. The example shows a process for offering credit card products to potential customers.

Figure 2 shows an example for handling credit card complaints. The diagram shows a case – unstructured process with unclear number and flow of activities. Steps are not automated because of the diversity of the cases. The flow is determined by the users.

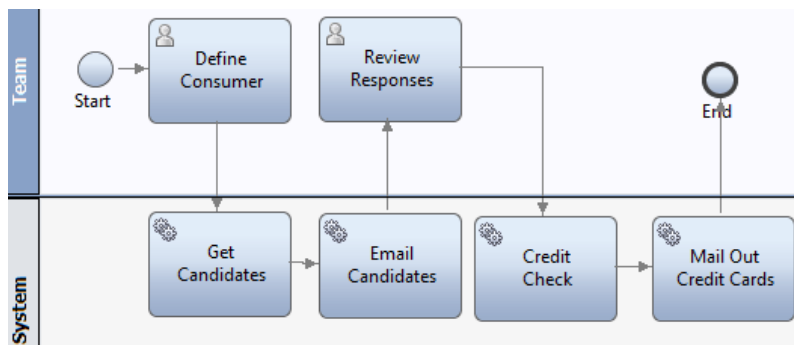


Fig. 1. Business process example [10]

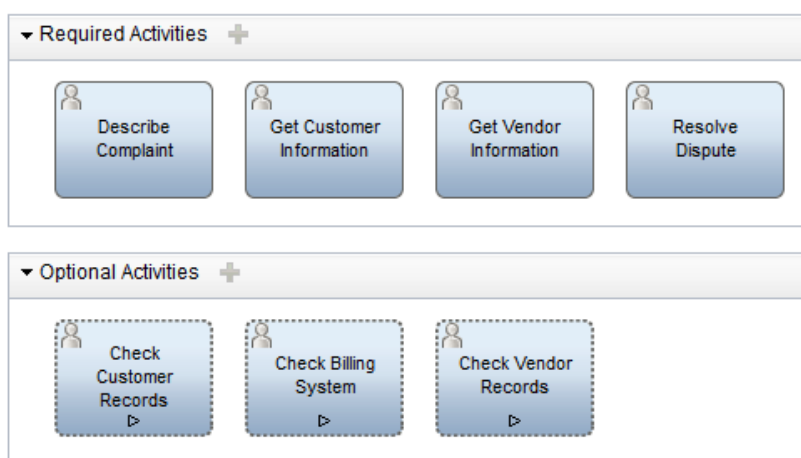


Fig. 2. Case example [10]

3. Business process management and case management

The same information source that was used above summarizes the key differences between business process management and case management [10] (see Table 1).

Table 1 shows very clearly the differences between processes (also referred to as workflows) and cases. Each of the two concepts has a very specific use case. Using the same platform tools that were used to create the examples in Figure 1 and Figure 2, the author has tried to highlight the differences further by reproducing case functionality in a process and process functionality in a case. For ease of understanding, the same two examples from Figure 1 and Figure 2 are used.

Figure 3 shows an attempt to reproduce the case in Figure 2 but using process (workflow) BPMN (Business Process Model Notation) components. There are a few customizations that are applied to achieve similar functionality:

- All Activities are in one process swim lane (that combines All Teams), because all activities can be performed by any user based on user's preference.
- The starting user should choose what activity to start with.

- At the end of each activity the user chooses what will be the next step (activity). To ensure the case is routed to the proper activity a Gateway component is used to assess the user's choice.
- The routing of each task is achieved using a Team filter service to route the task to the appropriate user or team.

Taking a single look on the modelled process clearly shows the high complexity of the implementation in comparison to the simple case solution.

Table 1. Business process management and case management differences [10]

Business process management	Case management
Ordered sequence of activities that can be completed to solve a business challenge.	An unordered set of activities that can be completed to solve a business challenge.
Stable sequence of activities and seldom changes; process is predicable and repeatable.	The activities occur in an unpredictable order.
The process determines the events. The first activity determines the first set of events, which then leads to the next activity and the next set of events. The activities are wired to one another, which determines the sequence.	The events determine the process. As events occur, a worker selects the appropriate activity. The resulting process can vary depending on the current event and the subsequent selection by the worker. Activities are not wired to one another.
The activities are often programmatic. A repeatable sequence can be automated.	People primarily determine the activities. Handling is done by a person who uses judgment to determine the best resolution of the case.
External documents are not part of the process.	External documents play a key role. For example, receipts provide a record for how the problem that must be resolved began.

On the other hand, there are ways to make activities in a case solution follow a more specific order and to behave in a more structured way – very much like processes do. Figure 4 shows a modification of the sample process that was presented in Figure 1 but modelled as a case. The case has two required activities that follow a specific execution order, similarly to a process. The first activity (Define Consumer) is modelled to start automatically with the launch of the case. The second activity (Review Responses) is configured to start automatically after the completion of the first activity. Each activity is modelled in such a way that it includes child activities that follow a specific execution order.

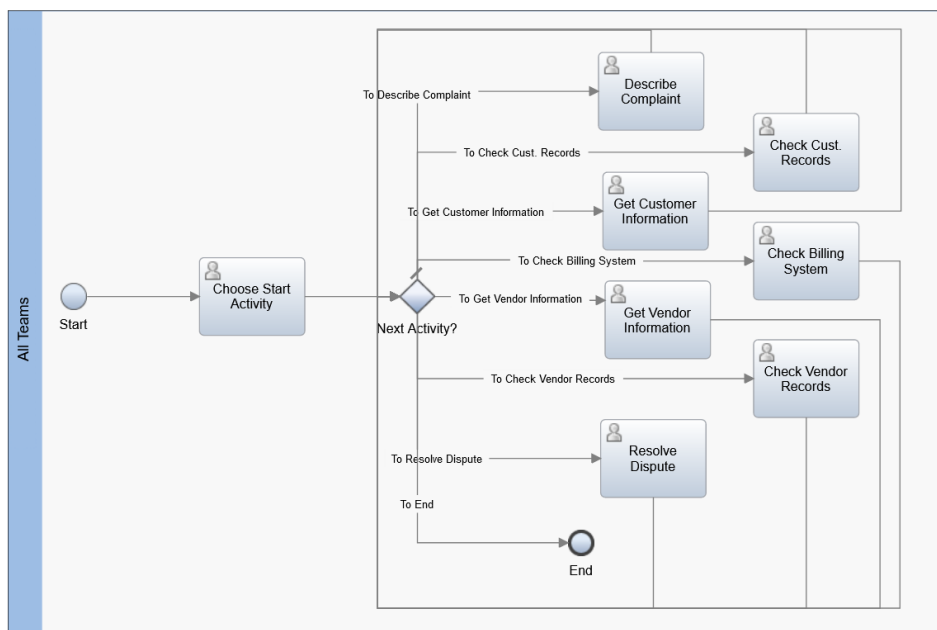


Fig. 3. Case-like process example

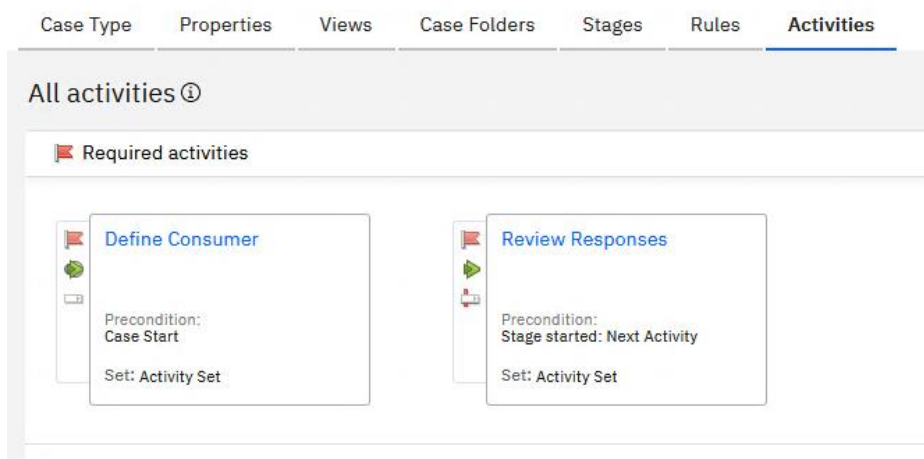


Fig. 4. Process-like case example

Figure 5 shows a detailed view of the first case activity - (Define Consumer). The activity was modelled using a specific feature of the platform to make the child steps in the activity run sequentially. This feature, however, requires much more detail to model the activity and its sub steps. The model is now realized using at least two layers – the case layer, the case activity child layer, and another implementation layer for child activity (an additional sub-layer that is not shown in the diagram).

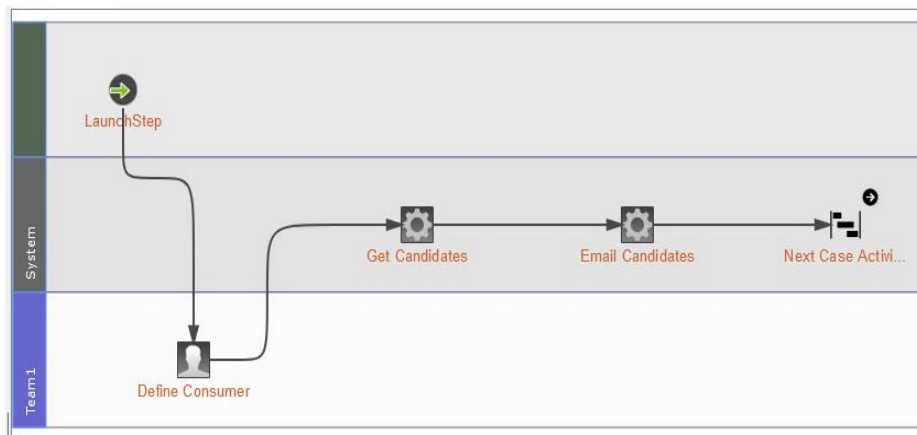


Fig. 5. Child steps for Define Customer activity

4. Summary

The report aims to highlight the different concepts for business process management and case management in the field of business automation. The difference between the two is shown clearly using some examples. Furthermore, the author creates analogy of the presented examples but modelling each example using the modelling techniques of the opposing concept. This shows how different the two scenarios are but also shows that modelling each concept using the opposing modelling techniques is possible. The same functionality can be achieved with both modelling techniques. However, doing so brings much more complexity to the implementation. All this leads to the conclusion that both the business process management concept and the case management concept should be implemented only for the specific conditions that are most appropriate for the corresponding concept.

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Challenges Faced During the Independent Financial Audit of Financial Statements of Health Insurers

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Abstract. This publication focuses on the challenges faced during the independent financial audit of health insurers' specific financial statements. It highlights some more important and specified audit procedures performed by the certified public accountants, registered auditors while carrying out independent financial audit of health insurers' financial statements, aimed at identifying a reliable basis for expressing auditor's opinion with regard to the observance of the "going concern" accounting principle. Special attention is paid to the specific business pursued by health insurers within high-risk environment, which results in the establishment of specific items of accounting, analysis and independent financial audit. The independent financial audit facilitates adequate management decision-making and achievement of good results by means of skillful planning and pursuit of insurance business, enabling insurers to survive and flourish under market economy conditions, to be financially stable, solvent and to achieve good financial performance, to properly raise, control and invest and spend funds raised by the insurance funds they manage through the contributions of insured and insuring parties. This publication may be used for carrying out different types of financial audit – internal audit carried out by the intracompany management structures of the health insurers; independent financial audit carried out by certified public accountants, registered auditors, and external audit carried out by the governmental supervisory, financial and other authorities in terms of health insurers' business taxation.

Key words: health insurers, insured persons, health insurances, independent financial audits health insurers' financial statements

1. Introduction

This publication focuses on the challenges faced during the independent financial audit of health insurers' specific financial statements. It highlights some more important and specified audit procedures performed by the certified public accountants, registered auditors while carrying out independent financial audit of health insurers' financial statements, aimed at identifying a reliable basis for expressing auditor's opinion with regard to the observance of the "going concern" accounting principle. Special attention is paid to the specific business pursued by health insurers within high-risk environment, which results in the establishment of specific items of accounting, analysis and independent financial audit.

The independent financial audit facilitates adequate management decision-making and achievement of good results by means of skillful planning and pursuit of insurance business, enabling insurers to survive and flourish under market economy conditions, to be financially stable, solvent and to achieve good financial performance, to properly raise, control and invest and spend funds raised by the insurance funds they manage through the contributions of insured and insuring parties.

This publication may be used for carrying out different types of financial audit – internal audit carried out by the intracompany management structures of the health insurers;

independent financial audit carried out by certified public accountants, registered auditors, and external audit carried out by the governmental supervisory, financial and other authorities in terms of health insurers' business taxation.

2. Description of Health Insurance Business

Health insurance business is extremely important for the society. This business refers to raising, investing, managing and spending the cash raised by the health insurance funds from health insurance contributions paid by the health-insured persons or by the insuring parties to cover any additional healthcare activities and medical goods and services used, which are out of the scope of the compulsory healthcare activities as set out in the Health Insurance Act or the National Framework Agreement. Health insurance provides insurance cover of medical risks expressed in raising, spending and management of assets in which collected health insurance contributions are invested for the purposes of providing healthcare activities, medical goods and services, subscription healthcare service and other amounts upon occurrence of the health insurance risk, events or conditions as set out in the health insurance contract. Making a health insurance is intended to provide prevention against occurred medical conditions and diseases and ensures higher quality of used medical services and quicker administrative service.

The insurance amount under the health insurance is determined by the insured person, and the health insurer may fix its minimum value only. The contribution depends on the insurance amount, on the type and term of validity of the insurance and on the medical condition of the health-insured person. Health insurance contract is concluded with an insured person after conducted medical examinations for identifying his/her medical condition by an independent examining doctor of the health insurer. The health insurance contract is concluded against covered risks related to the health of the health-insured person. It is made on the basis of a medical document certifying the medical condition, the profession and the activity pursued by the health-insured person, as well as other evidence necessary for the assessment of the health insurance risk. When concluding the contract, the health-insured person is obliged to disclose the existing facts that he/she is aware of and that are relevant to his/her medical condition. Upon failure to disclose, misrepresentation or concealment of material facts or newly occurred circumstances with regard to the medical condition of the health-insured person, the contract is subject to amendment or termination in accordance with the terms and conditions of the Code of Insurance. By concluding the health insurance contract, the health insurer undertakes, in return of received insurance premium, to pay the health-insured person any compensation or amount fixed in the contract upon occurrence of an insurance event within the frames of the covered risk. The risks covered by the health insurance are compensated by the health insurer. It reimburses the expenses incurred by the health-insured person for used medical goods and services, which are a direct and immediate consequence of the occurrence of an accident or disease for him/her, which are not due to any exceptions from the insurance cover, and are within the limit of the insurance liability. The occurrence of disease of the health-insured person means occurrence of the health insurance risk. Disease means a set of complaints and clinical manifestations diagnosed by a licensed healthcare establishment and registered in an official medical document. The date of diagnosing the disease is considered the date of its occurrence.

The limit of liability of the health insurer is the maximum amount of payments to one health-insured person or a group of persons during the term of validity of the health insurance for one or more medical goods and services covered by it. The insurance amount is equal to the limit of liability. With regard to specific medical goods and services, the health insurance contract may set specific sub-limits of liability of the health insurer. Expenses for treatment

that exceed the insurance amount or the agreed sub-limits for the respective medical goods and services are borne by the health-insured person. Upon concluding the health insurance contract, a deductible of the health-insured person may be agreed upon as a percentage or specific amount of the amounts that are subject to reimbursement by the health insurer. The deductible is that portion of each payment for medical goods and services that is borne by the health-insured person. Within the frames of the agreed limits, the health-insured persons choose the way in which they want to use any outpatient, inpatient, laboratory, dental, prevention or another healthcare service. Therefore, the medical goods and services may be used by the health-insured persons in two ways:

1) Principle of reimbursement of incurred medical expenses – it is applied when the health-insured person visits healthcare establishments that are not on the list of the health insurer, by presenting properly issued primary accounting documents with enclosed copies of medical documents for medical examinations, laboratory tests and other healthcare services in accordance with the applicable contractual conditions of the health insurance.

2) Principle of subscription healthcare service – it may be applied only with regard to the healthcare establishments the health insurer has entered into agreements with. In the case of the subscription healthcare service, the health-insured person contacts a coordinating doctor who directs the treatment and drafts the necessary medical and insurance documents. The health insurer provides a list of coordinators' names upon entering into the health insurance contract, together with the list of healthcare establishments it has entered into subscription healthcare service agreement with. Health-insured persons provide the coordinating doctor a valid medical card on the basis of which the health insurer pays the healthcare providers it has entered into subscription healthcare service agreement with, for the medical goods and services used by the health-insured persons.

3. Description of Specific Objects of Health Insurers' Business that are Subject to Independent Financial Audit

The independent financial audit gives an opinion about the authenticity, trueness and fairness of health insurers' financial statements. Thus, the users of these statements – health-insured persons, shareholders, government and supervisory authorities, may make important decisions or undertake adequate managerial, supervising or taxation actions. This is how the independent financial audit contributes to the normal functioning of the health insurers on the medical insurance market through increasing the trust in the authenticity and fairness of their financial statements.

The main challenges that health insurers face are due to the changes that have occurred in their insurance business under the conditions of global health crisis giving rise to specific insurance operations and insurance relationships with the health-insured persons, the insuring parties and the beneficiaries of health insurances. As an object of accounting and management, the health insurance business is a set of specific type of economic operations that are differentiated by content, time periods for performance, method and technology of implementation. Its features are determined by the existing specific reporting items, which are typical for this business only, and which, in their turn, are specific objects of the independent financial audit. These are:

1) *Expenses for administration of health insurances* – these are the health insurers' expenses comprising:

- amounts reimbursed to health-insured persons, which they have paid for the medical goods and services they have used;

- amounts paid for subscription healthcare service to healthcare establishments – healthcare providers, such as preventive examinations, laboratory tests and radiology investigations, physiotherapeutic procedures, sanatorium treatment, etc., in accordance with the terms and conditions of the voluntary health insurance agreement;
- amounts paid for settlement of occurred health insurance events and for fees to insurance brokers;
- allocated health insurance (technical) provisions;
- other expenses paid for protective medical events, such as purchase of flu vaccines, advertising of healthcare packages, etc.

2) *Revenue from health insurances* – they comprise:

a) *Revenue from collected health insurance premiums* – these are the health insurance premiums received from health-insured persons, from insuring parties, or those collected from the health insurance brokers under concluded voluntary health insurance agreements.

b) *Revenue from released health insurance (technical provisions)* – these are revenue from released health insurance (technical) provisions during the current reporting period, which have been allocated during the previous insurance period as a guarantee for payment of health insurance compensations upon occurrence of the health insurance risk;

c) *Other revenue from health insurance business* – these are other amounts that health insurers receive from health-insured persons by virtue of the health insurances made between them.

3) *Specific accounts of health insurances* – these are customer accounts (insuring parties and health-insured persons) who initiate the issue of the health insurances; insurance broker accounts occurring upon entering into, maintaining, performing and terminating the insurance contracts; accounts with independent examining doctors and expert witnesses with regard to the conclusion, administration and settlement of occurred health insurance events as a result of occurrence of the health insurance risk.

4) *Specific technical provisions for health insurances* – these are specific obligations of health insurers to health-insured persons and are intended to cover possible occurrence of the health insurance risk. The technical provisions refer to decrease of the health insurer's resources with regard to the fulfilment of its existing obligation to the insured persons as at the date of the statement of financial position. These are specific liabilities that are not always required due to the probability of non-occurrence of the insurance risk or the insurance event, respectively. This fact refers to the process of their release, which results in their recognition as health insurer's current revenue generated from health insurance. They represent the main part of health insurer's liabilities – the biggest balance sheet item in the liability section of its statement of financial position (balance sheet)." [1, p.310]

Health insurers allocate technical provisions for the purposes of covering health insurance risk. Their sufficient amount ensures the health insurers' ability to cover all payments under concluded health insurances to health-insured persons in future reporting periods. The allocation of sufficient technical provisions calculated by the health insurer's actuary results in their recognition as health insurance expense in the current reporting period, and their release during the next reporting period results in generation of health insurance revenue.

5) *Specific assets (covers of technical provisions under health insurances)* – these are the investments of health insurers in financial assets and financial instruments. They need to be properly classified, recognised and measures. Reliable measurement of health insurers' assets must further comprise evaluation of the nature and degree of risks that occur from the

financial assets and financial instruments themselves and the effective management of those risks. Each category financial assets and financial instruments should be disclosed truly and fairly in the statement of financial position (balance sheet) of the health insurers. The nature of the assets; the possible risks and benefits of the ownership that health insurers are exposed to; the carrying amounts of recognised assets and their related liabilities need to be properly disclosed in the financial statements too.

6) *Revenue from investing of specific assets (covers of technical provisions for health insurances) and own funds of health insurers* – these are financial revenue generated from profitable transactions with financial assets and financial instruments performed on primary markets and transactions performed on the real estate market by investing the specific assets (covers of technical provisions for health insurances) the own funds of the health insurers.

7) *Specific financial statements of health insurers*

Health insurers grant licenses to insurance companies to assume risks related to providing funds for specific medical goods and services in return of receiving health insurance premiums from health-insured persons under concluded health insurances. Health insurance companies are joint stock companies. The management bodies of these companies are required to prepare and present specific financial statements in accordance with the International Accounting Standards [2]. Their form and content are provided for in IAS 1 *Presentation of Financial Statements* and in IAS 7 *Statement of Cash Flows*. [3]

“Financial statements are prepared on the basis of the assumption that the entity is going concern and will continue as going concern in foreseeable future. It is assumed that the entity neither intends nor needs to liquidate or significantly shrink its operations.” [4]

The annual financial statements comprise: statement of financial position, statement of profit and loss and other comprehensive income, statement of cash flows, statement of changes in equity and health insurance provisions and annex. The annex to the annual financial statements is prepared in accordance with the requirements of IFRS/ IAS and provides information about the applied accounting policy, the status and changes in assets, liabilities, equity, revenue, expenses and cash flows, disclosure of risk management policy, disclosure of the effective interest rate and revaluation of financial assets and financial liabilities, and other disclosures about the health insurers’ operation. Health insurers further prepare management report that presents information about their operations during the current reporting year and their future development; events after the reporting date; their investments in financial assets and financial instruments; their financial risk management objectives and policy, including their policy to hedge each main type of hedged item to which hedging account applies; the exposure of health insurers to price, credit and liquidity risk and cash flow risk; the analysis of development and their performance; the financial indicators relevant to the respective operation, and other information from the management. The managing bodies of health insurers are responsible for the preparation, content, presentation and publication of their financial statements. They are required to prepare the financial statements in strict observance of the *going concern* principle of accounting.

The annual financial statement of health insurers that hold license to pursue non-life insurance business issued by the Insurance Supervision Division at the Financial Supervision Commission are audited and certified by two independent certified public accountants – registered auditors or by a specialized audit company domiciled in the country and elected by the general meeting of the joint stock company of the health insurer.

4. Main guidelines for Carrying out Independent Financial Audit of the Health Insurer's Financial Statements

While carrying out independent financial audit [5] of health insurer's financial statements, certified public accountants – registered auditors have to pay special attention to:

- verification if the determined health insurance premiums under concluded health insurances are sufficient to fund the operations of the health insurers;
- verification of the total amount of the gross premium revenue and the total amount of reimbursed premiums and derecognized receivables under health insurance contracts that are terminated earlier, as recorded in the accounting books of the health insurers;
- verification of compensations paid and amounts reimbursed by health insurers to health-insured persons for the costs the latter have incurred for used healthcare activities, medical goods and services, as set out in the annual actuarial report, by making review of the authorization of paid claims, review of primary documents for paid claims, comparison of paid claims and those recorded in the accounting book where they are entered by the health insurer;
- verification of amounts paid to healthcare providers the health insurer has entered into subscription healthcare service agreement with for the medical goods and services used there by the health-insured persons;
- verification of large compensations paid by the health insurer to the health-insured persons upon sudden occurrence of obligations for payment and reimbursement of amounts for used healthcare activities, medical goods and services due to occurrence of the health insurance risk on large scale;
- verification of the calculation of allocated technical provisions for the next reporting year and released technical provisions allocated during the previous reporting year made by the health insurer's actuary;
- verification of the actuarial report in terms of the sufficiency of the technical provisions allocated by the health insurers;
- making substantive tests in terms of the tests performed by the health insurers with regard to the sufficiency of their technical provisions in accordance with IFRS 4 *Insurance Contracts*, in order to ensure the payment and reimbursement of expected amounts for used healthcare activities, medical goods and services to the health-insured persons or to the beneficiaries of concluded health insurances in foreseeable future, in accordance with the requirements of the government insurance supervision authority;
- verification of the total amounts of the technical provisions by type, the deferred acquisition expenses and the charged impairment of overdue receivables under health insurance contracts and from health insurance brokers as set out in the actuarial report in comparison with the accounting books of the health insurers;
- verification of the financial assets and financial instruments held by the health insurers as covers of the health insurance (technical) provisions, by means of different types of tests and/or alternative procedures. In case of changes, the registered auditor should use the reports of the rating agencies and the report of the health insurer's actuary in order to make a comparison between the prices and rates of health products offered by the health insurers and to compare them with those of an equivalent competitor on the market of health insurances;
- verification of the assessments of assets used as covers of the health insurance provisions, the assessment of the technical provisions of the health insurers and the

opportunity to establish a Reserve Fund that covers the threat of large-scale occurrence of the health insurance risk;

- verification of the sufficiency of cash and cash equivalents, bank deposits, investments in financial assets and financial instruments, loans and receivables, investments in properties for the purposes of ensuring sufficient liquidity of the health insurers;
- analytical review of investments, deposits, management transactions, sales of investments – gains and losses thereof, review of the amortised value recalculation of securities held to maturity and accumulated interest for investments that may be quickly disposed of and converted into cash upon large-scale occurrence of the health insurance risk;
- analytical review and assessment of the opportunities to exercise ex-ante, ongoing and ex-post control at the entry and exit point of the health insurer's accounting system;
- analytical review and assessment of the opportunities for maintaining an open information system with view of enabling the addition of new objects that have occurred in the course of the health insurers' business, such as the new liabilities under the concluded health insurance undertaken with regard to the protection of COVID 19 virus infection, and namely – to implement preventive health events, such as vaccination with flu vaccines;
- analytical review and assessment of the information about the health insurer's financial position disclosed in the Annex to its financial statements and in its annual management report in terms of its objectiveness, completeness, timeliness, reliability, fairness, correctness, logic, in order to enable its use for making effective management decisions;
- analytical review and recalculation of the solvency capital requirements and the indicators for rate of return, ability to cover deferred tax losses, assumptions about the technical provisions and other techniques for mitigation of the health insurance risk and management of such risk by the health insurers;
- assessment of the requirements to corporate culture, fitness and propriety of staff working in the insurance company that provides health insurances and assisting the health-insured persons.
- expressing auditor's opinion on the observance of the *going concern* basis of accounting.

5. Main Challenges of Carrying out Independent Financial Audit of the Health Insurers' Financial Statements

For the purposes of improving the efficiency and quality of the independent financial audit, certified public accountants – registered auditors should:

- ensure transparent methodology for the independent financial audit carried out in terms of health insurers' financial statements;
- effectively use their audit tools by updating and modernizing them;
- further improve the reliability of the audit procedures they carry out during the audit of the health insurers' financial statements;
- train, develop and strengthen the human resources responsible for the independent financial audit of health insurers' financial statements;
- give specific and meaningful recommendations after the completion of the independent financial audit of the financial statements in order to improve the internal

- control and the specific operations of health insurers for the purposes of maintaining their solvency and protecting them against bankruptcy and liquidation;
- encourage the publication of the stress test results carried out by health insurers;
- cooperate with the government insurance supervision authority and other government institutions for eliminating systemic weaknesses of the control and supervision over the business of health insurers.

6. Conclusion

Health insurance in Bulgaria meets the requirements of the European Commission Directives. [6] The main goal of the European Commission is to create a common market of non-life and life insurance within the European Union in order to enable the users of health insurances to have a wider choice of health insurance operations and to increase the competition among non-life insurers.

Health insurers accumulate and manage cash in voluntary health insurance funds with the care of good trader [7] and prudent investor by observing the principles of reliability, liquidity, return and diversification in the interest of health-insured persons. They face a serious threat under the conditions of a global health crisis due to the announced COVID 19 pandemic. As a result of this pandemic, they assume additional liabilities under the concluded health insurances that cover health insurance risks related to diseases caused by the COVID 19 virus. There is a large-scale occurrence of the assumed health insurance risk under the conditions of global health crisis, which gives rise to an urgent need of sufficient liquid funds for payment of large-scale compensations for the healthcare activities, medical goods and services and subscription healthcare service used by the health-insured persons and by the beneficiaries to the health insurances.

Health insurers should commit themselves to decrease the occurrence rate of the health insurance risk in order to mitigate the occurred insurance events and to be able to meet their obligations to the health-insured persons and the beneficiaries without any troubles in terms of liquidity.

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Driving Discussions in Online and Hybrid Classes – Putting Live Cohort of Students Together to Lead the Conversation

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Abstract. The paper reviews the power of discussions to serve as a leverage for conversation in online and hybrid classes. The general concept considered is designing a virtual course that allows students to engage – synchronously and asynchronously – and thrive for learning by discussion. It addresses the issue of leading the conversation reciprocally when the teacher facilitates and the student partakes in simulcasting theory and practice. An interesting perspective is revealed by applying Cohort Analysis to understand student contributive engagement with discussions *at a time* analyzing student overall retention rate.

Keywords. Online and hybrid classes, Discussion, Cohort analysis, Flipped classroom, Student centricity.

1. Introduction

The purpose of the paper is to examine certain clusters of students who *are capable* of gaining and sharing learning experience in online and hybrid classes. They perform homogeneity and retention to drive the procedural *knowing to do* paradigm through online and hybrid course design. Cohort Analysis need to be applied to help faculty identify “granular” clusters by analyzing the student dynamics in synchronous and asynchronous learning environments such as MS Teams. The Undergraduate class under consideration is to be researched during the Fall term of the academic 2020/2021 year at a Marketing and Entrepreneurship College in Bulgaria. Observing how various student groups behave over the term, insights are to be obtained into what evolution pattern emerge when designing online and hybrid courses to put live cohort of students together to lead the conversation.

2. Designing an Online and Hybrid Course

Designing an Online Course

Designing an online course [2, 3, 4, 6, 12, 13] proves to establish a frame where both the faculty and the students are reciprocally placed in “driver mode” to lead the conversation. To interchange hosting responsibilities of the meeting platform to set in hands-on type of experience – screen sharing – is the most valuable part of teaching online.

Putting together an asynchronous, mostly self-led course – when students watch videos, do the assessments, watch the material, do the reading – is different than synchronous live sessions and having a conversation, a discussion with people simultaneously. Just recognizing the sheer difference and richness of the medium and knowing that online doesn’t only mean one single thing is really important. One recognizes that designing online and hybrid courses it’s almost like a different set of skills, considering certain types of capabilities or engagement. The faculty has to choose which parts of the conversation and the content to deliver online

following the pedagogical process: asynchronous discussion and synchronous, or individual, work. [4]

Live discussions are powerful online, but the conversation online could be slower paced than it is in the classroom. According to Grushka-Cockayne [4] one of the keys to success in online courses is be thoughtful about the teaching objectives and the teaching plan, not being overwhelmed with trying to accomplish too much per session. She comes up with a *modal* design, embracing a motto of humbleness, “keep practicing”. It is about making students more comfortable with online classes and adhering to their sensitivities about them. Using team-based communication environments help students communicate on a regular basis, and having online forums give faculty another avenue to reach out to students.

Faculty needs “to change the beaten path”, being thoughtful and creative in a way that opens opportunities to break some of the habits brought up in the physical classroom. Thinking about schedules is useful to let students work in teams on assignments or to let them do some work asynchronously, in different time. It is going to give faculty some more “flexibility to cater to students’ comforts”.

Online teaching is advantageous in terms of learning that enables students to join the class and not miss anything. Sessions are recorded and documented and students become appreciative for such an opportunity to acquire knowledge. It is easier to keep log. The teacher can annotate an online conversation very quickly and go back to his/her notes. He/she can have breakout rooms in very creative ways and have students discuss among smaller groups. The technology is tremendously rich and allows faculty to do things that were not naturally doing in the classroom, such as screen sharing, e-learning exercises, simulations; or to make the class more interactive.

Still there are things faculty needs to relearn in a sense when they go online. [5] The whole notion of lecturing is very different online. Attention span has been shown to be short. Then the lecturing online is being chunk up into small bits and recorded in short instances. By having it saved in a recording format, everybody becomes a little bit more conscientious. Yet, the teacher’s sense of being natural, fumbling his/her words, and doing another take and breaking it into smaller chunks is important in online delivery. These are things that don’t work online and both faculty and students lean on in person, in the classroom. [4]

There are plenty of teaching approaches that work well online. The key is “to make it useful for all” participants in the online course. Videos and links out to the web and being spontaneous work in synchronous classes, especially in discussion formats.

Breakout rooms are beneficial for the online space because they break up the class and give a different dimension. It allows smaller groups to talk amongst themselves and everybody gets a voice. [1, 4, 6, 12, 13]

The biggest difference between online synchronous sessions and in class discussions, is the chat feature. It can be distracting because the teacher is doing a couple of things at once. Nonetheless, having the chat window there and having students debate and discuss and post ideas becomes a powerful tool for engagement. Typically, the comments are more additive to the class than distracting. People post things that contribute to the main conversation. The chat feature enables production of “a narrative that complements the class as a side conversation” [4]. It is also a place where some students, who don’t immediately raise their hand or speak up, prefer to chat.

The faculty role in designing and teaching in online and hybrid classes is to push students to become „leaders of the conversation“ [4]. And if they know in advance that they’re going to do that, then they can practice and get ready, without being surprised, but getting comfortable with it.

Designing a Hybrid Course

As teachers begin to design their hybrid curriculum, they draw from various approaches at the broader course level. It is a mix of in-person and online students following the flipped classroom model—and at the individual session level—it will be a synchronous, or asynchronous, student-led class. It wraps up the point that the teacher thinks in terms of what students are going to do or deal with on any given session, ensuring it varies the student experience [3].

A clear and a prescriptive picture of defining and designing a hybrid curriculum is made by Grushka-Cockayne. She explicitly delineates a few different definitions of hybrid class design. They are based on determining what to apply to the specific teaching circumstance, which impacts *what* material is to be included in the course, and *how*.

The hybrid format typically includes a combination of *online* learners and people in a physical room, *in person*. Furthermore, it is broken down, as each distinction has an impact on the teaching plan for the moment, the pedagogy in general, and the curriculum overall. That impacts teacher's choices around team projects and group work in general, thinking through how all types of activities that require interaction between students – breakout, discussion groups – are to be arranged.

Planning *synchronously* for a live online session is very different from thinking about content that is going to be delivered *asynchronously*. When a course involves live online meetings, an online simultaneous participation occurs, with learners all logging in at the same time. Faculty then preferably uses the synchronous time together to foster interaction and engage students as a group. Synchronous learning time could be useful to debrief a simulation or to make connections between a few different assignments that show a larger learning arc. [13] Additionally, a teacher has got discussions, polls, Q&As, debates, breakout rooms, and other kinds of tools at disposal. And that variety *should* be part of the course design. The live cohort of students experiences unique interaction together, and which is different from students who watch the recording later. Conversely, material taught asynchronously is to be through videos, assessments, quizzes, or competitions, typically chunked much smaller. [3, 4] Leaning heavily on asynchronous learning means that teacher requires hard and clear deadlines for certain things (such as discussion board participation), but ultimately it can be a great tool for the faculty and the students. Individual discussion pastures require longer blocks of time than face-to-face teaching does, depending on the frequency with which students will log in to the system. In an asynchronous course, teacher can reread the case, do research, consult colleagues, taking actions in a discussion. [13]

A hybrid class can be focused on the distinction between theory and practice—when to teach theoretical concepts versus exercises and putting things into practice with a hands-on component. A *traditional classroom* does theory together, while students explore practice on their own. And in a *flipped classroom*, students learn the theory by themselves and then come to the classroom to practice together. [3]

A central point in a hybrid course design is to answer the question who is leading the conversation – the teacher or your students. Knowing whether they will be *lecture-* or *student-centered* discussions will make a difference for your ultimate curriculum and for the delivery mode chosen.

In designing an effective hybrid course, experts [3, 12] advise “to mix it up” – the course should vary the student experience by breaking down the course design into smaller individual components (Table 1).

Table 1. Designing effective hybrid course. Source: Grushka-Cocaine (2020)

HYBRID COURSE DESIGN COMPONENTS	WHO IS LEADING THE CONVERSATION	
	<i>Teacher</i>	<i>Students</i>
Videos for asynchronous learning	<ul style="list-style-type: none"> • Takes material out of the classroom leaving synchronous sessions for discussion. • Rather than relying too heavily on textbooks and requiring too much reading, mixes it up with short videos. 	<ul style="list-style-type: none"> • Have access to videos using the learning management system (LMS) of the HE institution. • Get most of the theory. • Approach it asynchronously on their own. • Can watch over and over.
Labs for synchronous leaning	<ul style="list-style-type: none"> • Designs it in a self-paced mode as a live session with students working independently. • Pops in breakout rooms – virtually or in person – to check how students are doing and to answer their questions. • Pops out breakout groups for debriefing to solidify lessons learned on their own. 	<ul style="list-style-type: none"> • Learn independently, together; • Work through an assignment given during a synchronous session. • Learn at their own pace while fostering a sense of community. • Share their solutions with the rest of the class. • Have resolution at the end of the lab sessions, driven from their own.
Case studies	<ul style="list-style-type: none"> • Drives class discussion. • Weave in practice and theory: videos for the theory, case studies for the practice. • Eventually creates networks of voting students that would often agree or disagree. • Starts forming conversations around agreeing and disagreeing groups. 	<ul style="list-style-type: none"> • Express opinions related to a case study. • Think about how persuasive are. • Vote opinions up or down by agreeing or not with the critical decisions
Dojo exercise to explore practice	<ul style="list-style-type: none"> • Designs it as student-led approach to allow them understand their capabilities in a constructive environment. • Supplies the guidelines to the exercise in advance. 	<ul style="list-style-type: none"> • Prepare all before class: go through the exercise and come ready to engage in a conversation. • Develop dojo mindset, inspired by martial arts. • Have an immersive experience • One or two people are “in the dojo,” debating, discussing, and trying things out. • The others are watching, providing input, supporting, and encouraging.

Bringing leaders of conversation up with discussion boards and group work

Teacher has a wide range of options when it comes to structuring asynchronous discussions using Discussion Board. He/she can keep all discussion of a case within a single thread, a series of sequential threads, or multiple parallel threads. He/she can allow students to start new threads themselves, which can increase students’ ownership of the discussions. Allowing parallel threads leads to powerful, simultaneous, focused discussions and makes it easier to follow conversations. An important role of an online teacher is to make students aware of redundant discussions and explicitly point them to the appropriate place by establishing strong norms and being explicit about student behaviors within. [13]

A discussion can last from a few minutes to weeks, which makes it a powerful conversational tool in a synchronous and an asynchronous environment. It materializes the insight that “a primary reason for teaching online is to enable asynchronous elements”.

Students participation can vary from student contributions once or twice to a discussion, to sustained conversations with communications back and forth. [13]

Online team-building activities can help your students come together. There are many tools available, with which each participant contributes one short sentence and, together, the group prepares a summary of the lecture that anybody can then use for studying and revision. It is often harder for digital communities to perceive common goals, so using these tools also helps create communities that strengthen the group's shared purpose, vision, and goals. [6]

With online courses, the teacher has the opportunity to be more or less involved in the groups. This makes it critical to set clear boundaries around his/her role there. Unless the course is intended to teach students how to work effectively in groups, he/she has to think about how to limit the extent of his/her role in students' group work, but to facilitate how to bring the leader of the conversation up for in there. [13]

3. Identifying *leaders of conversation* by managing retention

Finding pedagogically meaningful ways to transform learning experience when designing online and in hybrid courses is essential. To adopt particular techniques of student-teacher interaction not only to "to keep students from tuning out" [12] but to reveal "leaders of the conversation" [4] is crucial. Listening to the student auditoria dynamics with Cohort Analysis [10] can help faculty to identify "granular" [10] clusters of students who *become capable* to distribute interactive experience within a group/ team work. They perform homogeneity and retention to drive the procedural *knowing to do* [9] paradigm, as a constitutive aspect of competence building up.

Such a hypothesis is being proved by analyzing attendance and engagement data from MS Teams, collected for an undergraduate class at a Business College in Bulgaria during the Fall term of the academic 2020/2021 year. Examining how various student groups behave over the term, since they have joined the course, insights are obtained into what evolution pattern is driven. The types of the dynamic student examination are considered by the Cohort Analysis [10]

The cohort, which is investigated there, is a group of students enrolled under an alternative end week-weekend form of education. The meeting they joined are modularized in bulks of five academic hours per a scheduled week. Hence, the acquisition period as the primary grouping criteria is a determined meeting block called here *a module* per a scheduled week. By demographics the cohort shares the common characteristics of being actively employed, which affects the infrequency they attend at the synchronous sessions. It also presents the student *lifecycle* – from the course election to final assessment – that embodies their relationship with the educational service, and with the course under consideration, in particular.

The examined class consisted in 57 students who had enrolled for the term. The course length includes 4-module meetings per scheduled four weeks: Module 1 design includes synchronous front-session discussion on fundamental theoretical issues; Module 2 – work on cases in breakout rooms for group work and further case discussion; Module 3 – Lab on applying methods for analysis with final screen sharing, discussion and peer-to-peer assessment; and Module 4 – End session with assignment accomplishment with further discussion. Fig. 1 represents the dynamics in the peer "acquisition" for the purposes of the synchronous teacher-student interactions. The tracking history from the LMS reports that 27 students (47%) of 57 enrolled joined the 4-module course. The overall student retention synchronously joined the course gradually running up from 33% at the begging to 56% at the end of the course. That automatically reflects on the consequence that 20 students joined the course asynchronously. i.e. their learning experience is being built asynchronously.

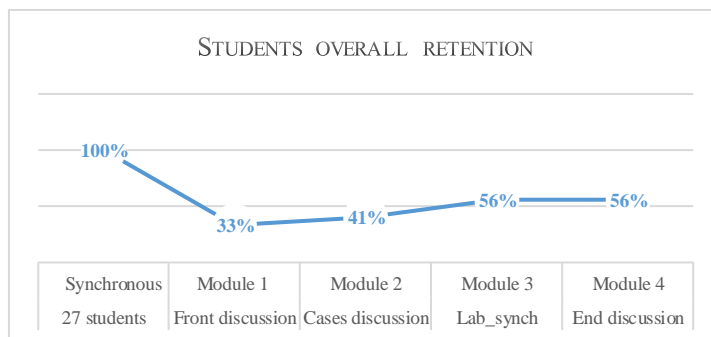


Fig. 1. Overall retention of students synchronously joined for 4-day modular course – Fall term 2020/21.

The Retention rate of student synchronous attendance, accepted here as *customized rate*, appears to be low, although it raises slightly from 33% (13 students) to 56% (19 students) of people joined per Module. Following the numbers in Fig. 2 there is an evidence that only 13 of those 27 students present synchronous loyalty. They could be defined as a live cohort of students who could interact synchronously as leaders of conversation. They performed to a be a live core of whole the class enrolled for the term, who could be the front line of involvement and reflection in both synchronous, and asynchronous learning experience. Moreover, those loyal students, retained for the purposes of the online synchronous education, develop capabilities to gain, share and distribute conceptual, procedural, and attitudinal knowledge [8] within and out of the class.

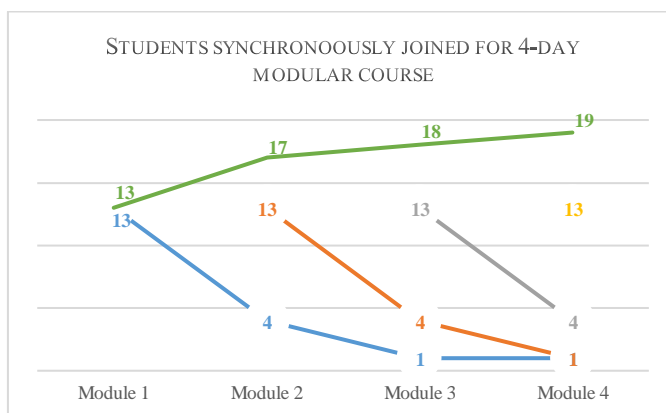


Fig. 2. Number of students synchronously joined for 4-day modular course – Fall term 2020/21.

Furthermore, the Cohort Analysis helps to identify a fluid group of people who joined single synchronous Module of the course – typically the front discussion session – and convert into asynchronous participants. There are 12 students (of those 27 *active* folks, but different from those 13 *loyals*) or 21% of the course who called for attention in the hypothesis discussion of the research. They present excellent outcomes in turning in the assignments commonly set and they also perform above average to excellent on the final examination. Those migrated students could be profiled as a cohort of asynchronous leaders of the conversation. It gives the

faculty a bold experiential signal that those asynchronous students need to be addressed and to respond to a hybrid course design.

There is another cohort of 20 students left who disjointed neither of the Modules – neither synchronously, nor asynchronously. They are eligible to participate in the course but they are clustered around their explicit requirement their learning experience with the course to be self-led. Apropos, the value proposition of the educational service addresses that student segment to be independently involved in the service. They watch the videos, they do the assessments, they watch the material, they do the reading, and remain *casual*, with no expectation of ongoing engagements. They are oriented towards course completion. Labeled with the modern market language, they could be defined as acquired folks, subscribed to a course, who need to experience a sequential standardized – not reciprocal – educational service design. Their disposition to participate is high, but their diversity of demands is low. They need self-led engagement with the course, and they have differential sensitivity [10] to its attributes: content, price, engagement, teacher-student interaction, peer-to-peer learning, course design (Table 2).

ATTRIBUTE	COHORT		
	“LOYALS” 23%	“ASYNCHRONALS” 42%	“CASUALS” 35%
Content	Full	"Productized" [11] component of the course	Massive
Engagement	Leader of Conversation	Social contagious	Self-led
Teaching	Interactive	Experiential	Instructional
Price	Premium	Differential	Low
Course Design	Blended	Hybrid	Online
Service Design	Reciprocal	Sequential Customized [7]	Sequential Standardized [7]

The “Asynchronals” also demand high level of diversity of course features and content. They are familiar with the synchronous participation, but peer-to-peer learning is not a preference for them with the online sessions. Their priorities could go aside and before the educational service itself. They are pretty dependent on the personality of the teacher and the *service* he/she could deliver. Moreover, they are populated much more in scale, and they contribute with lower marginal costs of the educational servuction [7]. They could pay an additional fee for a content if it “productized” to provide “sprint” [11] learning experience and to retain them as skill beneficiaries.

4. Conclusion

Student Management with Cohort Analysis gave the perspective that Leaders of Conversation are those students in online or blended education who behave synchronously. They partake in any discussion and group work that make them proactive to drive the educational service itself. They join synchronous sessions and demand the highest level of diversity of the course features and content. In the teacher-student interaction they follow the *knowing to do* pattern to develop practical skills at a high level of knowledge. As a cohort of “Loyals” they are pretty concentrated in scale and want more value added by in-person sessions.

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Increasing Cybersecurity in the Process of Digitization in Higher Education Institutions in Bulgaria

Digitization of Higher Education Institutions in Bulgaria: Cybersecurity Aspects

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Abstract. The aim of the article is to explore cybersecurity aspects of digitization of Bulgarian higher education institutions. The digitization is a complex area and a process of transition because of the complex and multidisciplinary nature of the universities. The complexity has been reported in many scientific studies. In the times of digitization, issues related to the change in the organizational culture, the lack of information security strategy, costs for current investments, people training, and sustainable data management can be faced. In order to identify in advance these problems from a cybersecurity perspective, the study analyzes the digitization of main areas and suggests metrics for measuring the level of the security thereof. The data for the research are gathered from two organizations - a large Bulgarian university and from one of its departments. Aim is to compare the state of cybersecurity of a large and of a small organization in order to consider how the size and complexity of the organisation are related to the management of cybersecurity. Each organization uses its own platform (Microsoft Office 365 and Google's G Suite). The two systems are implemented and managed independently. The comparison of the level of cybersecurity of the two organizations can show the critical areas on which the management should be focused during the digitization. The results of the study show that the established indicators can be used to measure and to analyze the aspects of digitization related to cybersecurity. It was found that the initial level of cybersecurity is unsatisfactory in both organizations. The main weakness is the relatively low priority of cybersecurity and the absence of documents regulating organizations' cybersecurity domains.

Key words: digitization, higher education, digital transformation, cybersecurity, information security.

1. Digitization

The widespread use of new technologies has changed the way of teaching, the generating of new knowledge and management processes in universities and this has created a need for their management. The management of information technology (IT) in higher education institutions and research organizations is related to defining the roles and responsibilities for decision-making, the organizational structure and the processes that ensure the connection between the goals of the university and its policy. Taken together, they all predetermine success. The introduction of IT in education leads to the use of digital technologies, united under the term digitization. Digitization in higher education creates new opportunities - virtual lectures, discussions, exams, libraries, various types of services, exchange of research papers and information, three-dimensional laboratories and more.

Universities derive value from data by using the information they collect as a way to make decisions, planning and supporting the delivery of new services. This approach must be linked to cybersecurity, as part of digitalisation, needs assessment, investment, data management and information and organizational security review. Effective security can be achieved through training of the interested parties, new technologies, daily monitoring and analysis of the university network and services, and a clear idea of which privacy standards govern the institution. That is why increasing cybersecurity in digitalization processes is one of the main priorities.

The strategy for development of higher education in the Republic of Bulgaria outlines key priorities, but not specific methods and approaches for digitization. Universities have developed and adopted mandated development programs, a small part of which is related to cybersecurity. Among the commitments of the IT departments the most priority areas are: administration and maintenance of various databases, university mail, existing applications, management of online learning systems, updating the university website, network connectivity, end-user support activities and more. There are no clear algorithms for emergency response, information security policies and the good practices are often violated. Bulgarian higher education is part of the European higher education and it must adapt to new trends and requirements.

EDUCAUSE defines the digital transformation as "a series of profound and coordinated changes in culture, workforce and technology that enable new educational and operational models and transform the business model, strategic guidelines and value proposition of the institution" [1]. It requires innovative leadership and coordination between departments. Providing new services, adapting to specific needs and interests and providing a competitive advantage through new technologies are the priorities of the management. This use of technology is described as a digital transformation. Many higher education institutions are more focused on digitalisation, which helps to lay the necessary foundations for digital transformation, than on real digital transformation. Currently, most of them are either in the initial phase of digitizing information, or are now moving to digitizing processes.

Digital technologies [3] in the field of education are changing the functioning and organization of universities. Following global trends and technologies in higher education is extremely important and is part of the strategies of leading universities around the world. Some of the most important and popular software architectures and applications include the use of:

- Artificial intelligence for scientific research, student and administrative services.
- Mobility Management (people, data, resources) as finding the balance between access and control is important.
- Software-defined networks that allow system administrators and network engineers to respond quickly to ever-changing network requirements and optimize their resources.
- Science networks with a demilitarized zone (Science DMZ) for highly efficient scientific applications and transmission of large research data.
- Cloud security services used in combination with local services and tools to improve information security.
- Data loss prevention (DLP), dynamic application of security policy based on data content.
- Security of Information and Event Management (SIEM) tools

2. Information security and cybersecurity

Cybersecurity and digitalization involve many structures and processes. The structures are responsible for defining roles and responsibilities. Processes include planning and strategic decision-making based on practices, IT policies and standards, and information security risk

management. The balance between them is difficult and the problems are related both to their application, and to the structure of the university, its tradition, culture and values. Despite the growing importance and need for a model for digitalization and management of IT, the level of its acceptance and implementation in Bulgarian higher education institutions is relatively low. Each university maintains various information technologies, applications and services that contain important information for the whole institution. Most have a central technology unit that provides basic information services. Information security breaches can occur due to unauthorized access, improperly configured software, human error, missing procedures, and an overall security strategy. The reliability of the network and information systems is a key for the smooth functioning of all platforms and university sites, the conduct of students' admission campaigns, electronic exams, enrollment, training and more. It is necessary to maintain security standards and policies which include a list of resources to be protected, potential threats and risk assessment. In the report "Getting Ready for Digital Transformation: Change Your Culture, Workforce, and Technology" [4], the following are listed as main difficulties: change in organizational culture, lack of information security strategy, understanding of the potential benefits of digital transformation, costs of ongoing investment and training, sustainable data management and confidentiality.

3. Indicators of the level of digitalization in universities

The following 5 indicators were identified and analyzed in the study for determining the current level of digitalization:

- User accounts (number and activity): this indicator shows the activity of users, the speed of communication within and outside the organization, organizational culture, effectiveness of policies to administer the university mail.
- IT administrators (number and roles): size of the organization and types of administration systems, digital competence, continuity of processes
- Group security policies: rules for access to sensitive information and the number of people who have access to it.
- Cyber threats (type and frequency): how valuable the information is, types of threats and frequency
- Monitoring systems: threats and challenges in security systems

4. User accounts

Higher education institutions use Office 365 of Microsoft, which is built into the operating system of Windows 10 (and previous versions). The platform includes: Outlook, OneDrive, Word, Excel, PowerPoint, One Note, Skype. Nearly 20,000 students' study in the university every year. The total number of user accounts exceeds 100,000, of which the official accounts of teachers and employees are 3874.

The department administers its own domain through G Suite. The platform is powered by Google and includes Gmail, Drive Cloud Storage for file storage and management, Google Docs, spreadsheets, slides, Calendar, Keep, Hangouts, and other applications for mobile devices, tablets or desktops. Its users are 1135 in number, divided into six groups: management, teaching personnel, staff, students, PhD students and partners.

Both Office 365 and G Suite support software licenses, installations, cloud storage and sharing, and the creation of organizational email accounts. According to statistics from the university system, the space used in OneDrive is currently close to 1 TB. University mail is 50 GB for all accounts, and OneDrive space is 15 GB for students and 100 GB for teachers. This, together with the activity of the mail accounts and the space used in them,

shows good communication and a satisfactory level of digitalization.

Security is one of the main concerns when using cloud platforms. G Suite uses the same levels of security as Google, which includes automatic detection of suspicious activity, phishing attempts, detection of spam, viruses and malware, and more. The administrator can set different rules to prevent unauthorized access to user accounts, as well as the use of two-factor authentication to all users. Office 365 enables multi-factor authentication for all user passwords and uses Microsoft spam, virus, and malware detection tools to scan all documents, names, and attachments.

Table 1 shows data on the number of active users in the various platforms of Microsoft Office 365. In October 2020, 249 meetings were held through Teams in which 5906 people participated. This high activity is related to the pandemic and online university education. Teachers and students mainly use SharePoint Online, Microsoft Teams, Stream.

Table 1. User statistics and activity for October 2020 in the various platforms of Microsoft Office 365

	University Users	University Activity
Office 365	6917	390
Exchange	2371	82514
One Drive	659	449
Teams	5906	249
Share Point	2503	263
Skype for Business	9	2

The importance of university mail and the benefits it includes as licensed products and storage space is not understood by everyone. Some of the resources that Microsoft offers in A 1 Pluse are underused and the main reason for this is the lack of awareness and training among the interested people. Examples of such products are: Azure Information Protection, Identity Service, Intune, Kaizala, Power Automate, StaffHub, Planner, Skype for Business, Project Online, School Data Sync, Sway, Yammer Enterprise.

An analysis of the activity in the university emails shows that the received emails exceed in times the ones sent. Figure 1 shows the days with the lowest and highest activity in October 2020.

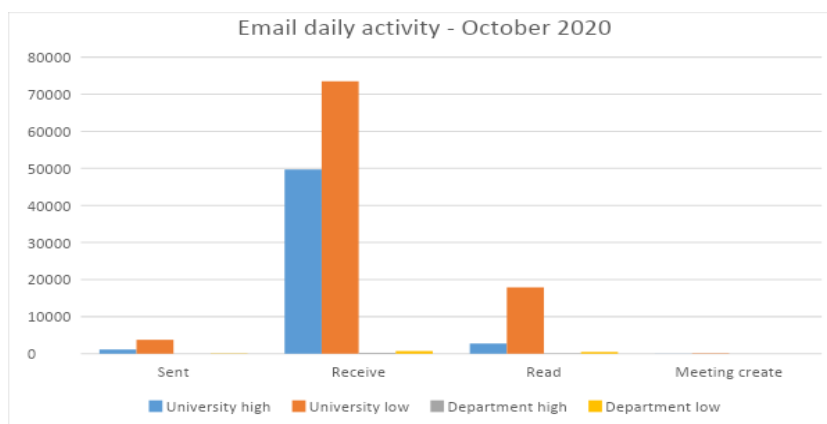


Fig. 1. Days with the lowest and highest activity in October 2020

The number of emails received varies from 49696 to 73491 for the whole university and from 260 to 715 for the department. Marked as read are from 2745 to 17920 for the university and 140-480 for the department. The large differences between emails received and read show an alarming number of spam attacks.

5. IT administrators

The university has 15 administrators performing different roles. The largest number of administrators is dealing with user and mail accounts, licenses and Teams support specialist/ service admin. The combining of several roles by one person is a normal practice and is associated with the in-depth knowledge and experience in the field of IT, access rights and responsibilities. Microsoft website [6] describes the IT roles and recommendations for their competencies. The number of administrators depends on many factors - monitoring systems, network connectivity architecture, number of users and cybersecurity strategy. For comparison, the department has 4 global administrators who cover all these roles, but for much fewer users.

Table 2. Comparison of the number of administrators in the university and the department, divided by administrative roles and categories.

Admin Role Name	Category	University admins	Department admins
Global admin		5	4
User, Helpdesk	Teachers, Employes	5	3
MTTeams Helpdesk	Students, Teachers	8	1
Exchange admin - License, Password, Group mails	Students, Teachers, Employes	5	1
Network admin	Teachers, Employes	3	2
System and Authentication (digital signature)	Teachers	1	2
Security group domain	Students, Teachers, Employes	7	2

The administration of Skype for Business, Power Platform, Hybrid Identity, Office apps, Kaizala, Azure is performed by global administrators, but this is relatively rare. Security group domain administrates: accounting, student system users, desktop admins, server admins, hyper V admins, hyper V servers, SQL student admins, TSQL, VPN access.

6. Cyber threats, malware and monitoring systems

Data is the most valuable commodity of higher education institutions [8] and digitalization processes are directly related to information systems. The value of data is increasing, as are the risks to information security and privacy concerns. A balance needs to be found between protecting the privacy of data stored by the university and ensuring easy and fast access to data across multiple systems, interested parties and digitization processes. Developing a risk-based information security strategy that effectively detects, responds to and prevents security threats and challenges in universities is crucial. According to a Microsoft report 61% (nearly 4.8 million) of the malware attacks reported last month, targeted the educational sector, making it the most affected industry in the world [5]. In Great Britain, universities are the target of nearly a thousand attacks a year. The British National

Cybersecurity Centre said there was an increased risk of cyber-attacks on educational institutions this year. These are mostly ransomware incidents that block access to computer systems. Paul Chichester, NCSC's director of operations, says such attacks are "reprehensible" and could have a "devastating impact" on universities.

Malware blocks users indefinitely, disabling access to online services, websites and telephone networks. Any such incident can have huge reputational, operational and legal consequences for the institution, and it is impossible to rely on the responsible behavior of well-informed end users using fully protected systems, devices and networks.

The table below shows the number of detected spam attacks per day in October 2020, divided into categories of filtered content, blocked addresses, malware and phishing.

Table 3. University spam detections daily report- Security & Compliance

Spam detections report	Total	8349
	Spam content filtered	964
	Spam IP block	7253
	Spam DBEB filter	132
Sent and received email report	Total	36323
	Good mail	27971
	Malware	3
	Spam detections	8349
Threat protection status	Total	396
	Email malware	25
	Email phish	331

The Threat Protection Status report is a single view that brings together information about malicious email message and content found and blocked by various layers of protection offered by Office 365 Security (Fig.2).

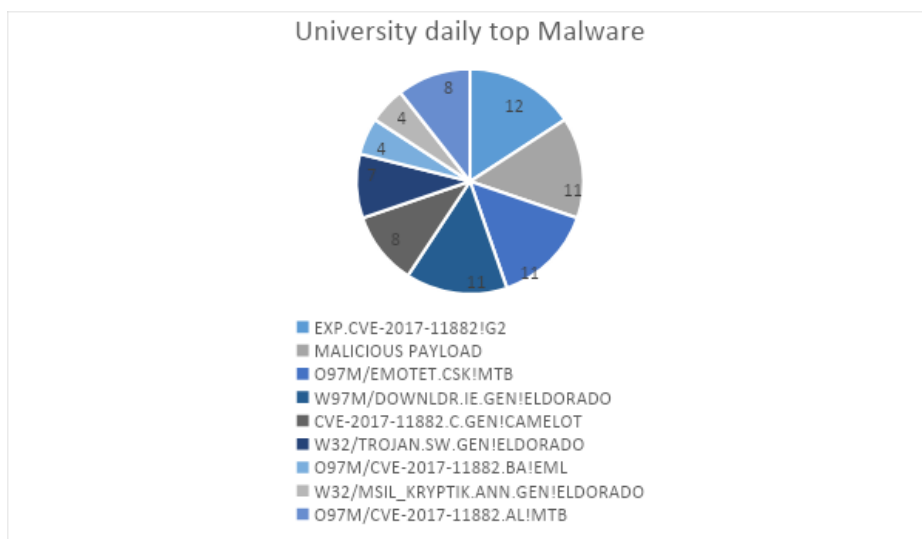


Fig. 2. Top Malware

Administering network connectivity is impossible without proper software to monitor all servers, firewalls, databases, manageable switches, and other network devices. The university's network has about 1,500 personal computers and peripherals, 162 Internet devices (switches and routers), which are monitored through the open-source platforms Cacti and Observium.

Cacti [2] is open-source network monitoring tool that can be installed on Linux or Windows OS. It is connected to RRDTool, which allows us to generate graphs related to relevant network data. It works with SNMP and presents the network statistics in the form of easy to understand figures. Cacti require MySQL, Apache, or IIS that support PHP.

Features: Unlimited graph items can be defined for each graph optionally utilizing CDEF or data sources from within Cacti, Auto padding support for graphs, Supports RRD (Round-Robin Database) files with more than one data source and can also use an RRD file stored anywhere on the local file system, User-based management and security, Custom data gathering scripts.

Observium [7] is a low-maintenance auto-discovering network monitoring platform supporting a wide range of device types, platforms and operating systems including Cisco, Windows, Linux, HP, Juniper, Dell, FreeBSD, Brocade, NetScaler, NetApp and many more. Observium focuses on providing a beautiful and powerful yet simple and intuitive interface to the health and status of your network.

Finding a balance between the use of innovation, research and application of security processes and methods is a particular challenge for higher education. Security requirements are often among the last considerations when new systems are added, and they are usually seen as a barrier to innovation. The costs of cybersecurity can easily hinder institutions, and often the information security strategy is discussed only after there is a breakthrough in the system. This means a lack of clear objectives, identified powers and responsibilities for information security.

7. Conclusion

Higher education in Bulgaria must continue the processes of digitalization without compromising security and must create digital resources so that data can be managed and create new sources of value. Technology solutions typically have an expiration date that requires an IT strategy focused on priorities and consistent with technology investments. Part of things, which must be done include:

1. Use DLP rules to scan emails for sensitive information and create an Anti - malware policy to reduce the quantity of spam in university accounts.
2. Partnerships between higher education institutions and adoption of common cybersecurity standards.
3. Development of an IT strategic plan that balances digitalisation processes and opportunities for continuous provision of basic institutional services in line with the growing risks of cyber-attacks.
4. Focusing on technology as an investment in support of teachers and researchers to improve learning - use of APIs, mixed data centers, security analysis, monitoring and management of network devices, inclusion of mobile devices in learning, open educational resources.

The ability of higher education to use standards is still very low. Investments in analysis, process management and information security are too expensive and complex to justify many individual initiatives. Integrated applications and data require an information and technical architecture. Data management is difficult. Roles, responsibilities and policies need to be clear, including classification and cybersecurity standards.

The results of the study show that the established indicators can be used to analyze the aspects of digitalization related to cybersecurity. It was found that the initial level of cybersecurity is unsatisfactory in both large and small organizations. In both organizations, the main weakness is the relatively low priority of cybersecurity and the absence of some basic documents. From this point of view, it can be argued that the process of digitalization is still in its infancy and it cannot be established how the complexity of the organization affects this process.

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Security Challenges for Big Data Platforms

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Abstract. The paper looks at some challenges in the field of security for big data. They are examined in terms of difficulties for developers and business itself, from both theoretical and practical point of view. The paper also presents current and future trends in dealing with security for big data tools and platforms, strategies, good practices and technologies.

Keywords. Big Data, Security, Big Data Security Challenges, Hadoop, Cloudera, Data protection.

1. Introduction

Since the advent of digital transformation in almost every area of human activity, data has become one of the main assets in gaining competitive advantage for any business.

In all systems, to name a few - health, financial, social, etc. huge amounts of data and information is constantly collected. Data is about markets, customers, competitors, and the various processes that take place around us. Much of the collected data describes business events such as sales, production, and on-site transactions. Thanks to this data, people get information, analyze it and receive knowledge. With it companies manage to identify what is most important for them and what actions they must take, or change, so that they can achieve the goals set for their success.

As the amount of data that is collected increases, so do the problems. Data can be of different types, but probably the most worrying aspect is related to ensuring the security of stored data. The reason is clear - the larger the data, the more complex the structures are collected and analyzed, and the more sensitive information is. By sensitive we mean personal information about customers, employees, business, privacy, etc. Leaking such information would be damaging to the business, so most big businesses focus on preserving the integrity and privacy of data collected [1].

2. Big data

There are many definitions of big data. To put it in simple terms, such data is larger, more complex, and often from new data sources. Data that is generated by modern digital systems and sources is huge. It also becomes difficult to measure it, as data is constantly growing. According to a study by Micro Focus, 840 new users are being added every minute on social media. On Facebook, for example, the "Like" button is being pressed more than 4 million times per minute [2]. Traditional data processing software cannot store and manage it. But these massive volumes of data can be used to deal with business problems that have previously failed.

Big data can be best represented and understood with the six Vs: volume, velocity, variety, veracity, value, and variability.

Using the term "big data" usually means that large volumes of unstructured data will have to be processed. This can be data of unknown value, such as clicks on a web page or a mobile application or sensor-supporting equipment. For some organizations, this can be hundreds of terabytes of data. For others, it could be tens, hundreds, or even millions time more, one day reaching peta-, exa-, or even yottabytes.

The value of big data can be the greatest asset for a business, if obtained, saved, and analyzed. For example, storing data that has no value (such as customer names) would not be useful for analysis. However, if additional fields such as age, gender, place of residence, etc. can be added to the names. Thus, benefiting a particular business.

Velocity is an important characteristic of big data, as it measures their time value. The faster data is being processed and analyzed; the faster timely knowledge will be obtained to meet business challenges. If the data is not processed in time, it may lose its value.

The veracity of the data comes from their sources. If the sources were a kind of tabloids, the data would certainly have no value or reliability. Veracity of data are those sources that have been verified by the organization or that are of importance for a company, or business.

The establishment of the data flow can be considered from two points of view: as a regular data flow and as a data flow that has arisen in conditions of extreme unpredictability. Variability is characterized by the fact that it is the main determinant of the need to obtain significant data, considering all possible circumstances.

All smart products work with Internet in real time or almost in real time and will require evaluation and action in real time. Variety refers to the many types of data available. Traditional data types are structured and fit well into a relational databases. As big data continue to get bigger, data start appearing in new, unstructured data types. Unstructured and semi-structured data types, such as text, audio, and video, require additional pre-processing to make sense and be properly used [3].

2.1. Big data platforms

The volumes of data collected by businesses and organizations are not only growing exponentially, but are increasingly spreading across local, cloud, hybrid, and multi-cloud systems. This increases the complexity of managing, accessing, and using data. We need big data platforms to do all this. "The big data platform is a type of IT solution that combines the features and capabilities of several big data applications and utilities within one solution." [4].

Big data platforms are designed for the convenience of anyone involved in big data learning and knowledge extraction, as they cover all processes from data collection to data analysis, combined into a single solution. They provide tools for easier and faster data analysis and are increasingly used to find patterns and relationships in very large volumes of data [5].

The using of these platforms facilitates the use of big data. Thanks to them, it is much easier to process data streams in real time, for example in media, meteorological models, banking sector, etc. They also help to detect different types of fraud - in the insurance sector, on the Internet and much more.

An interesting study of consumer sentiment on big data platforms has been conducted, which points out the top 4 platforms – Hadoop, Domo, Cloudera and Hortonworks [6]. The study comes out of 337 polls. These platforms have been presented with a comparison between them.

It is important to note that the Apache Hadoop is used by Cloudera and Hortonworks but can also be used on its own and often is presented as a separate platform.

All four platforms are suitable for any type of business and can be used on Linux, Windows operating systems, and MacOS (the latter is a problem only for Hortonworks).

Domo is a cloud-based platform. The other three are open-source platforms. Open-source platforms have a greater advantage over others, due to the fact that organizations can modify them to their needs.

Table 1. Big data platforms comparison.

	Hadoop	Domo	Hortonworks	Cloudera
User Sentiment	86%	86%	79%	76%
Size of company	Small, medium, large	Small, medium, large	Small, medium, large	Small, medium, large
OS	Windows, Linux, MacOS	Windows, Linux, MacOS	Windows, Linux	Windows, Linux, MacOS
License	Open Source	Proprietary	Open Source	Open Source

Each of the presented platforms has its own specifications, but they also have common ones that unite them. One is that they are for work with big data. Hortonworks, for example, offers an option to track progress on initially set goals and the achievement of instrumentation, as well as an overview of the data so that it covers all possible cases and can be downloaded free of charge. Domo uses easy tools to create views and combines a lot of data from different sources into a single view and has the option to automatically update the created dashboards. It also uses a mobile version and thus makes it easier to extract knowledge from anywhere in real time. For Cloudera, real-time analysis is paramount. It allows real-time transfer of workflow data from a local machine to the cloud and vice versa. Recent updates in Cloudera offer the use of artificial intelligence to make processes more repeatable and predictable, significantly reducing the time of data processing and analysis. The cloud also develops the inclusion of data from IoT (Internet of Things) devices [6].

Of interest is the fact that “Cloudera has its own management software Cloudera Manager, SQL interface for processing Impala queries, as well as Cloudera Search for easy real-time access to products. Hortonworks has no software of its own, using Ambari for management and Stinger for query processing and Apache Solr for data retrieval” [7].

Apache Hadoop can easily perform distributed big data processing using software models. It is sufficient to diagnose and deal with all errors and malfunctions of the application layer. If one node in the cluster fails, the processing tasks are redistributed among the other nodes in the cluster, and multiple copies of the data are stored in the Hadoop cluster. Hadoop is important and widely used for many big data analytics applications; it integrates easily into several trading platforms such as Google Analytics and others [6, 8].

2.2. Security

Big data security is concerned with the protection of data and the analysis processes, both in the cloud and at site. This includes all kind of factors that could compromise issues like privacy, availability, integrity, and confidentiality.

Big data security is a general term that includes all security measures and tools applied to data analysis and processes. Such are attacks on big data systems, theft of information, DDoS attacks and any other malicious activities. Like other forms of cybersecurity, the big data security deals with attacks that originate in the online or offline realms. For companies working in the cloud, the challenges to big data security are multifaceted.

With the recent disclosure, we already know that the NSA (National Security Administration) routinely collects and analyzes vast amounts of personal data obtained from heterogeneous data sources such as telecommunications, the Internet and consumer databases

of large businesses [9]. This includes sources like Microsoft, Yahoo, Google, Facebook, PalTalk, YouTube, Skype, AOL, and Apple.

Protecting big data is critical to success in a corporate environment. Each implementation is different, and each use case requires a specific security program that ensures administrative management and compliance with regulatory requirements. As the main priority is to offer speed (and often responses in real time) for processing large amounts of data, security should not be the last element to consider. The integration of different technologies introduces new security challenges [9].

3. Risks and challenges

With the introduction each new technology or paradigm, come challenges that people do not initially know how to deal with. Such is the risks to the security of people's personal data. The same thing is happening now with big data, used by more and more organizations. They should control and deal with it in the best possible way [10].

Big data is a gold mine for hackers. The reality for business is that there is always pressured to make quick business decisions, which in turn can lead to gaps in key decisions or, worse, gaps in data security.

Proponents of big data systems argue that, while combining multiple sensitive data from multiple sources in a multi-client environment poses some additional risks, it is much easier to maintain control and monitoring of access for a single system instead of managing secure data. Data can be stored in many different repositories in an organization with different levels of controls that at many cases are not documented or well understood [11].

Big data challenges are not limited to local platforms. They also affect the cloud. The list below provides an overview of some of the most common on-site and cloud big data challenges. Most businesses that migrate big data to the cloud are concerned about security. These concerns include the availability, integrity, and confidentiality of information, which are the key aspects of information security.

Any enterprise that uses big data platforms must deal with security risks at three levels. The first level is the physical and network security of the data centers, which is essential. The security of data centers and their access to the network directly affects big data platforms. The second level is system security, which consists of security subsystems within the platform itself. Security subsystems ensure its integrity by working together. The third level is the protection of data applications. They can be divided into different data protection modules [12].

Most big data platforms are cluster-based, which introduces multiple vulnerabilities across multiple hosts and servers. Several studies identify some of the risks for the big data systems [12-15].

- a. *Lack of designed security.* Big data provides huge opportunities for businesses to take advantage of it. Despite the useful information, which is at the application, so called high level, such is not the case with security. Security, according to many scientists, is expressed in security policies, risk management, encryption, and more. However, these things are additionally applied for the systems. At the same time, the reality shows that most people neglect the problem until it becomes a danger. Timely measures can prevent some of the risks.
- b. *Distributed frames.* Most big data systems distribute excessive amounts of data for processing in different sub-systems for faster processing and analysis. There are systems, like Hadoop, that are open source and initially lacked security. On distributed processing systems, the downside is that there are more points where

security breaches can occur, although the processing is faster as each system has less processing data.

- c. *Access control*. One of the most important things in a system is the user access. Defining the roles and access rights for each user group can severely limit abuses. Nowadays, hackers take advantage of poorly secured systems, mostly by taking control of the profiles of the employees in companies.
- d. *Input validation and filtering*. Big data is collected from a variety of sources, so the validation of the data entry condition is very important. This validation involves identifying the type of data and separating the unreliable from them. It also cares about the identification of unreliable data sources, which is used to avoid the vulnerability in generating false data. If a company works with more diverse sources and uses more diverse data, it means that more work is needed to protect them.
- e. *Data breaches* are common for some time. Sony's recent hack is another example, with experts estimating up to 100 terabytes of stolen or leaked data. Data breaches are unlikely to go away for the near future.
- f. *Data mining*. At the highest level of decision-making is data mining, which can also be defined as the heart of many big data environments. Data extraction aims to highlight models and find even more knowledge in unstructured data. The problem that arises here is that the data very often contains personal and financial information. For this reason, companies need to add additional layers to their protection to protect themselves from external and internal threats.

4. Good practices

Every business strives to gather data about its customers and products, employees and even competitors. Such kind of information must be made accessible to the people in the business, who need it. While analyzing and extracting knowledge about management decisions, it is extremely important that the security of the platforms and the organization does not have security weaknesses [16].

All the risks presented above, as well as other challenges, can be mitigated with the right procedures, good practices, and technologies to help reduce or even avoid by creating and employing [17][18]:

- a. *Physical security*. Physical security is strongly recommended when implementing a big data platform. Some experts advocate for making a mandatory check about the security of the service provider that will be used. Physical security systems can deny access to the data center to strangers or employees who do not have access to so-called "sensitive" areas. Video surveillance and keeping archives of it when entering and using the system is also a very good solution.
- b. Building a *firewall* is another useful tool for protecting big data. Firewalls are effective at filtering outbound and outbound traffic. Organizations can prevent attacks before they happen by creating powerful filters that avoid third parties or unknown data sources.
- c. *Intrusion detection and prevention*. The distributed architecture of big data platforms is an advantage for intrusion attempts. The Intrusion Prevention System (IPS) enables security teams to protect big data platforms from

vulnerabilities by examining network traffic. IPS often sits directly behind the firewall and isolates the intrusion before causing actual damage.

- d. *User access control.* In order for a consumer control policy to be called reliable, it must be based on automated settings, initially defined by the system administrator, as well as on role-based policies. Policy-driven access control protects big data platforms by automatically managing complex levels of user control in the organization.
- e. *Encryption* technology for data protection is widely available. Encryption of data is generally done to secure sensitive data, and different types of data. It can be user-generated or machine-generated. Encryption involves protecting information with cryptography via encrypting algorithms. Only people with the proper key can read and use data.
- f. *Activity logs and data backups.* Logs are an important component that helps to identify problems and who caused them. Each system designer must create a log option, where every important, for data security, action is recorded, together with the person/system, who did it. In addition to the log, it is a good practice to make an automated process for data backup. This can resolve a possible user access problem and with proper backups, it will be possible to restore the system that has experienced data loss.

5. Conclusion

Big data is great advantage in today's high-tech and knowledge-based competitive market. It has the power to facilitate companies turning their approach in improving their products and marketing strategies to best meet the needs of customers, as well as successfully deal with market competition. At the same time, collecting large data from different sources requires a very well organized environment. When data is properly organized, a protected environment with limited access to malicious threats is created - a secure big data environment.

As shown above, the big data security challenges are diverse for companies working in, or out of the cloud. The main purpose of big data security is to provide good protection against malicious activities that can harm the new gold - big data [1, 2, 3].

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Disruptive Education Technologies: Threats and Opportunities

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Abstract. Technological changes and economic challenges in the early 21st century led to the beginning of the fourth industrial revolution. Areas of human knowledge that did not exist a decade ago continuously emerge. The effects of the rapid introduction of new technologies in all the sectors of the global economy as well as in people's everyday life create a growing need for new skills and expertise. The world faces the key challenge to deal with the growing need for educated and trained labor in engineering and science, as well as to prepare the global population for the upcoming technological changes, the disappearance of many traditional professions, and the emergence of new ones. As a natural response to this key issue, new technological solutions in education have been emerging continuously. This report focuses on the dimensions, perspectives, and challenges related to the group of innovative educational technologies called EDTECH. The paper is structured into several essential parts. The first one describes the theoretical framework, genesis, and evolution of EDTECH. The authors dwell on the preconditions that led to the emergence and development of this technological phenomenon in the field of education. The second part of the report is related to the continuously developing market of innovative educational technologies, its structure, and key participants. A comparative analysis measures its advancement in the already established main geographical regions and their characteristics. The third part of the study presents the perspectives for the further expansion of technologies in education and the key trends. As a conclusion, the authors define several outcomes that could clarify the picture of the global EDTECH market and outline a number of good practices in entering and operating on it.

Keywords. Education, Technology, Innovation, Global and regional markets

1. Introduction

The topic of global education is often included in the agenda of international institutions and governments. Today, primary education is compulsory in most countries. It is seen not only as a right, but also as a civic obligation [11]. Besides, a wide range of policies is in place to promote secondary education. Global economic and technological development is the main factor in the growing number of higher education students. New universities continuously emerge. The efficiency, comprehensiveness and the quality of the education systems, together with the creation of new teaching approaches and methodologies are closely connected with the competitiveness of each country in the modern technological world and its place on the geopolitical map.

It was not always the case. The most concepts, related to modern education date back to the mid-19th century. At that time, industrialization and the need for a skilled labour forced governments to develop a more extensive and efficient primary education system. But first unbalanced education policies and financing across regions and countries created many

inequalities. The second half of the 20th century was marked by the global "expansion" of education and could be described as a historical phenomenon. By the 1990's the proportional share of education expenses in budgets of developing and in the developed countries is often comparable. As a result, the period 1960-2010 is marked by a continuous reduction in inequality in education on a global scale. Recent UNESCO (The United Nations Educational, Scientific and Cultural Organization) studies show that countries continue to increase spending on education. However, there is still heterogeneity between different countries. For example, in lower-income countries, higher education can often be free, but the funds spent by households for primary and secondary education are a significant part of their budget. In high-income countries, the trend is different. In this group of countries, households' expenditures for higher education are continuously on the rise.

After the adoption of the Millennium Development Goals at the beginning of the 21st century, international financial flows related to global education have been intensified and become more concentrated. These processes develop more flexible funding of education, tailored to specific regional and national needs. For example, while there has been a relative reduction in state aid for education to developing countries since 2010, there has been an increase in the venture funding related to teacher training, the development of new curricula and creation of new teaching approaches. The share of funds allocated by households for education is also increasing on the long run. There is also a significant development in the governmental and NPO's programs aimed to fight different issues as the short time young people spend for learning, early school leaving. There is a global rise in such forms of support as grants, scholarships, etc. funded by the wide range of institutions and public organizations.

2. The rise in global population and the challenges modern education faces

The global population is growing and this long-term trend poses mankind with many challenges – humanitarian, economic, environmental, political, military. To these aspects can certainly be added the question concerning education.

By 2030 there will be 1 billion more people on our planet. Every day 200,000 humans are born. Students in different educational levels will reach 2 billion. In 2050 they will be approximately 2.5 billion. At least 100 million teachers will be needed, 50% employed in secondary education. All national education systems globally will face a huge challenge to remain stable in order to secure long run scalability [10].

According to a series of studies by the International Institute for Applied Systems Analysis, Luxembourg (IIASA), due to the cumulative effects of various factors, people without education will continue to decline on a global scale. In coming next few years their number in Asia will be 90 million and in Latin America 10 million less. In different regions of the world, this trend has slightly different characteristics.

In recent years, the sharpest increase in university graduates will be observed in Africa. As an example, in Nigeria, their number will double. However, the population with no education will continue to rise as well, but at a slower pace. The trend in Oceania is similar. In North America, there is also an expectation of a sharp increase in the number of students in higher education, but without a significant change concerning other levels of education. In South and Central America, the decades-long increase of people with high school education will continue. There will also be more post-secondary graduates in forthcoming years at the expense of population with primary grade or without education. In Asia, the same processes have their characteristics. While more and more people will acquire secondary education, the number of university graduates will not increase significantly. An illustration is India,

population with secondary grade will soon outnumber all other groups. A similar trend is observed in Southeast Asia. In Indonesia, one of the most populated countries in the region, the uneducated population is falling sharply and we can see an increase in the number of high school diploma holders. The number of university students in this region is also steadily increasing. The big exception is the People's Republic of China (PRC). For the first time in decades, the uneducated population is expected to disappear. However, unlike other regions, the absolute number of students will decrease by various reasons. Europe will remain the continent with a steady decline of the population with primary education, keeping the growth in the number of university graduates.

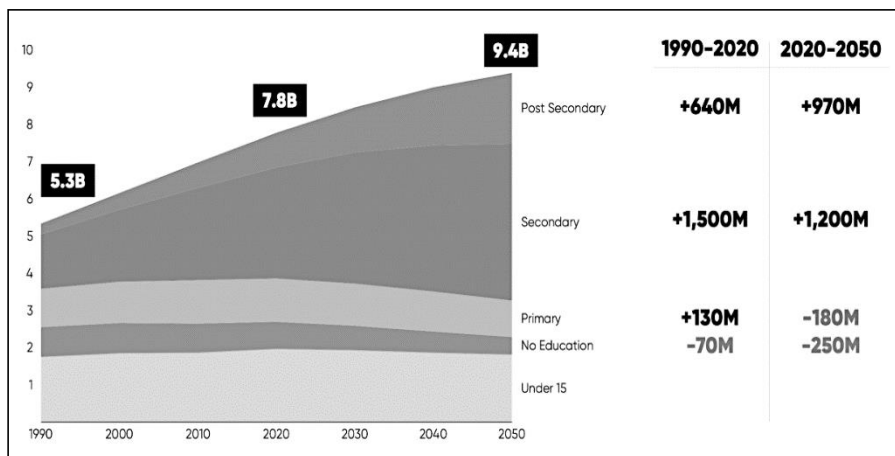


Fig. 1. Global Population by Educational Attainment (1990 – 2050)
(Source: Wittgenstein Center of Demography and Global Human Capital)

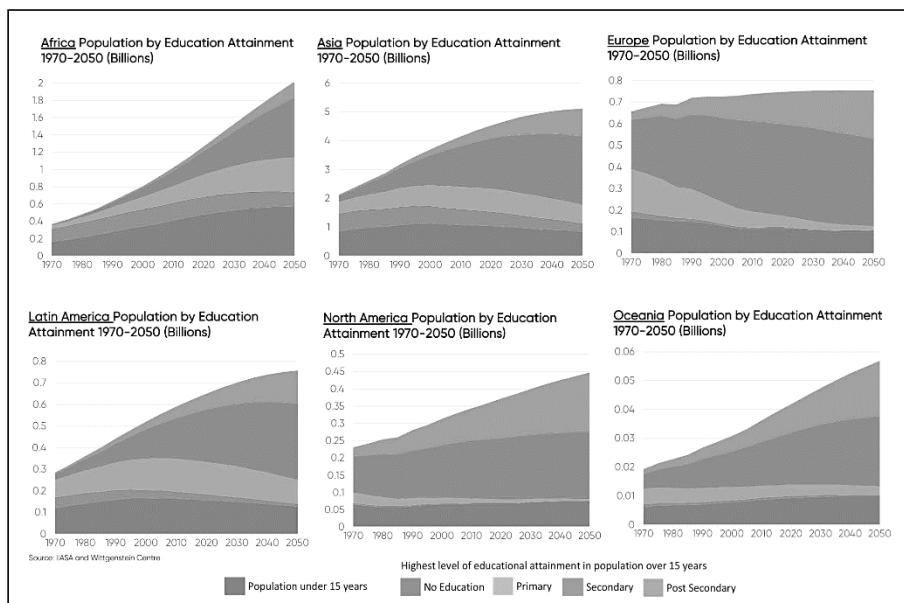


Fig. 2. The trends in secondary and post-secondary graduates by region (Source: IIASA)

The illustrated trends arise many challenges in front of all education systems across the globe. But the question of how to provide knowledge for more and more people is not the only one that governments and international organizations have to answer.

Global technological transformation in the recent decades have been also changing the set of abilities and skills that any individual must possess in order to succeed in the sharply competitive labour market and be part of a competitive economy.

3. Labour market transformation and global key education strategies

A crucial problem appears and will become more relevant in forthcoming decades—many professions soon will be replaced by new ones or will disappear thanks to introduction of new technologies in the global economy. According to the Organization for Economic Co-operation and Development (OECD), this process has already begun and it will continue in three main stages. In the years after 2020, about 5% of all employees will lose their jobs globally, regardless of their education - primary, secondary or higher [5]. Their jobs will lose those people who perform simple tasks according to a predetermined algorithm. This could be clerks, bank and insurance officers, staff from lower levels in companies. At the end of this decade, this process will intensify significantly and many more people will be forced to change their specialization or to be retrained. Respectively, 20% of the labour with primary education and about 25% with the secondary degree- those who perform routine and repetitive tasks. Some delay in this process will be caused by the large number of workers who carry out this type of activity and the scale of investment in technology and infrastructure to replace them. In this case, only 10% of higher education diploma holders will be affected by technological change. This social group remain relatively protected even after this period, but those with primary education who will have to retrain as a result of losing their jobs and the disappearance of their profession will exceed 45%, and people with secondary education - 35%. After this period labour in various areas of the economy which performs tasks connected to complex problems in real-time will face the need to be retrained or relocated.

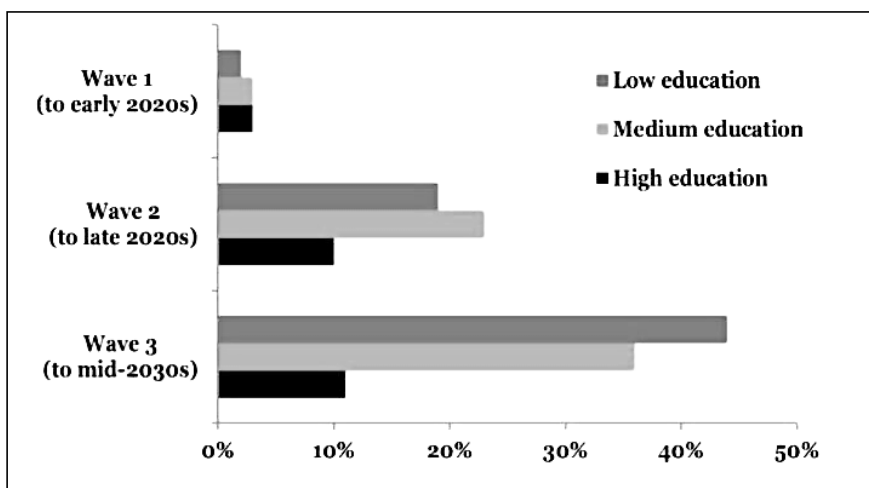


Fig. 3. The three waves of potential job automation by education levels
(Source: PwC, UNCTAD IPAAC data)

This process is unpredictable in many aspects because there is no clearness how exactly new technologies will change the global economy, how fast and what new professions will emerge. Almost 80% of students in primary schools today have been preparing for professions which will not exist at the time of their high school graduation. They will be forced to retrain and adapt to an economy based on new, not existing today technologies.

With the development of the Fourth Industrial Revolution and the rapid entry of new, hitherto unknown technologies in all social spheres, as well as in the economy, educational institutions and governments must find answers to two questions:

How the global education will guarantee that the trained people will have the skills, abilities and knowledge needed in the conditions of rapid technological changes?

How to scale primary, secondary and post-secondary education to match the growing number of learners?

Addressing these issues is in the sights of almost all governments across the world and such institutions like the United Nations Conference on Trade and Development (UNCTAD), the OECD, the World Bank and many other international organizations and NGOs. The strategies to solve global education problems may be classified into five groups.

Education as usual- Traditional educational institutions (schools, universities) funded by their governments will continue to enjoy the high trust. They will continue to offer efficient training and good realization for their graduates.

Regional co-operation- Different kinds of co-operation between all types of educational institutions will dominate at the regional level and could train a significant part of the population. They can also count on the support of both local and international political and economic organizations.

Global Giants- The global economy environment and the free market encourages the emergence of large, recognizable organizations that, working on a large scale, would achieve significant efficiency and inclusiveness in learning.

Technology and innovations- New technologies as robotics, artificial intelligence, big data, etc. will redefine how the educational process can be conducted, including curriculum development, the application process, assessment, generating learning content.

Peer-to-peer- Modern ways of communication could be successfully applied for peer-to-peer education. Online teaching with the use of rich and personalized content will dominate the educational approaches for schools, universities and professionals training. New technologies as blockchain will solve some essential problems of the distant forms of education, such as intellectual property protection and secure testing process.

4. EDTECH- technologies in education

From the mentioned above, it is clear that many questions related to the scale of global education and its adaptation to the world of technology could be solved with the application of the technologies themselves.

In the last 3 decades, together with the computerization, development of Internet and telecommunication, a long process of the technology implementation in education has begun and the term "Edtech" appeared [3]. It was introduced by the Association for Educational Communications and Technology (AECT). According to its definition, "edtech" generally includes theory and practice related to the design, development, use, management and evaluation of learning processes and resources. Edtech can be used for the application of science approach, hardware equipment and software in the educational process.

The role of edtech in global education is growing, now many problems can be solved, which in the recent past required more effort, more resources and more costs [7].

Reducing the cost of education- Edtech significantly reduces the cost of tuition, which is essential for students from developing countries or those without enough funds for costly elite schools and universities. Through platforms such as Coursera, EdX and etc. students from around the world have opportunity to attend free lectures and courses at the most recognizable universities on the planet. Also, for an affordable fee, they can specialize in a selected field and receive a diploma after taking the necessary tests.

Introduction to technology- Over the past two decades, many edtech solutions have been developed, allowing students and pre-schoolers to learn and study such subjects as robotics, physics, mathematics, programming through specialized learning technologies such as Lego Mindstorms, VEX, Arduino, Rasberry Pi, Microbit. Adapted programming languages such as Scratch are rapidly entering schools. Numerous training programs related to 3D printing have also been developed.

Makes learning interesting- Gamification in education (learning by play) is also an important approach, often applied with the help of edtech. Students can participate in games and stories created with the help of augmented and virtual reality, which allows them to be not only observers but also participants in scientific experiments, even historical events and related to games.

Makes teaching easier- Through edtech, even teachers in the most distant corners of the world can access state-of-the-art educational resources and use online platforms, including video, audio and textual content in their courses. The experience of Cambridge University Press, Pearson Publishing and others in the field of English language teaching could be given as an example.

Encourages collaboration- Today, through edtech, it is possible the teacher-student connection be continuous even over long distances. Also, a team of teachers can work from different parts of the world on one course or create common learning content. Students from different countries can share experiences, study materials or work together remotely on common projects.

Encouraging individual learning- Online platforms and remote access to educational content allow anyone to take a specialized course and study in a desired field. This can be done at any time and with individualized duration. This learning approach is often suitable for employees who want to expand their professional expertise or for retraining even without the help of teacher.

Lessons can be accessed at any time of any day- Through the Internet and the means of communication, students can use paid or free learning resources from around the world.

Monitoring the learning process and assessment. Individualization- With edtech solutions, teachers can easily create a variety of exams without repetition and track the results achieved by their students. Depending on the progress or lag in different areas of training, individual curricula can be developed for each participant in a given course.

5. The global edtech market and investments

Technologies with application in education are increasingly entering the official curricula in almost all countries around the world, as well as in households. This is an occasion for continuous increase of investments in the field of education. According to the education research center HIQ, the total cost of education globally will reach 7.3 trillion. am. dollars or almost a triple increase compared to 2000 [1].

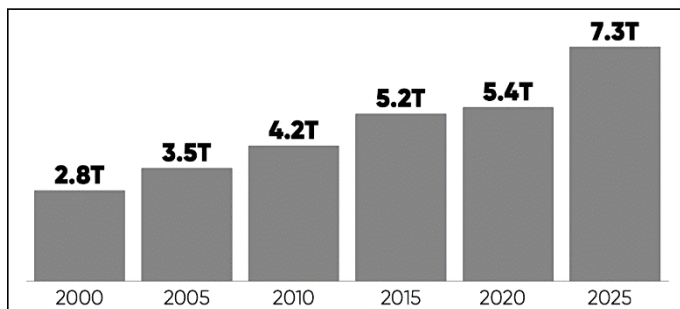


Fig. 4. Global education and training expenditure (Source: HIQ)

These figures include the cost of teaching work, school furniture and equipment, teaching materials, construction, overhead costs. The share of edtech by 2020 is relatively small - 227 billion US dollars, or about 3.6%.

The demographic and economic processes taking place in the world (Dutta 2020)[4] will change this ratio and the share of expenditure for technological training in the total will reach 5.2% and will exceed 404 billion US dollars by 2025. The pandemic of the Covid-19 virus, which started in 2019, adds a certain accelerating effect [2]. The faster entry of online learning will add a total of \$ 63 billion over the period, despite the fact that a significant portion of distance learning services are offered free of charge.

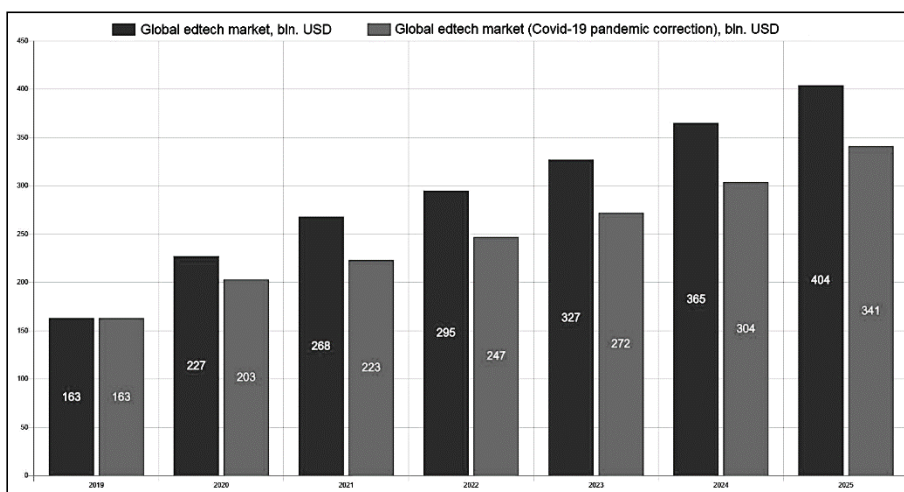


Fig. 5. Edtech market (2019 – 2025) (Source: PwC, HIQ)

The fastest growing educational technologies are virtual and augmented reality, artificial intelligence, robotics and blockchain, together forming an annual growth of 12.3%.

The rise in education expenditures and the increase in edtech's share over the last decade have also attracted the attention of risky investors [6]. As a total of 48.1 billion US dollars have been invested in edtech in the period of 2010-2020 [8]. China has the largest share in this amount - 26.8 billion. am. dollars, followed by the United States - 13 billion US dollars. dollars, India - 4 billion US dollars. dollars, Europe - 2.6 billion US dollars [12].

Table 1. The fastest developing edtech

	2018r. (bln.USD)	2025r. (bln.USD)
VR/AR	1,8	12,6
AI,	0,8	6,1
Robotics	1,3	3,1
Blockchain	0,1	0,6

Source: PwC, HIQ

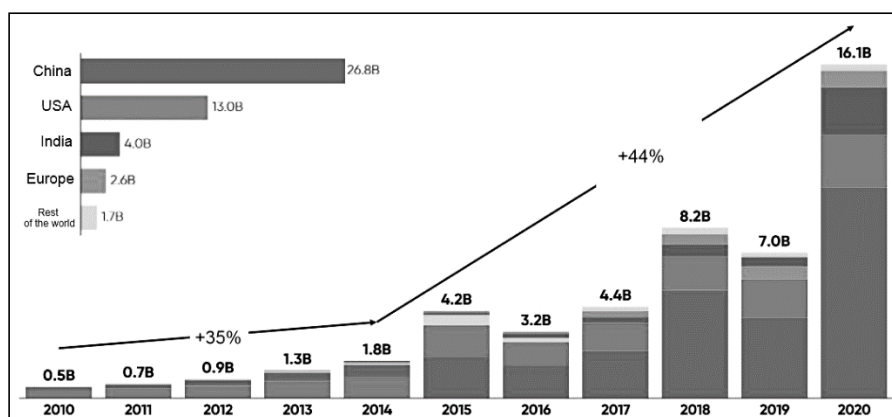


Fig. 6. Global edtech venture capital in 2020
(Source: SIPA, School of economic and public Affairs, Columbia)

6. Conclusion

The world is facing historical challenges arising from global population growth, technological changes in all spheres of public life and the economy, geopolitical rivalry, climate warming, migration. More and more people around the world need to be trained and retrained to adapt to global changes such as the emergence of new professions, the disappearance of old ones and the relocation of jobs. Traditional educational institutions are forced to modernize by introducing new methods and approaches in education (Renz, A. et al., 2020)[9]. Educational technologies, collectively called "edtech" emerged to find answers to these questions. Edtech provides continuous remote access to learning content, training without the intervention of a teacher, introduces the learners to new technologies and prepares them for work, offers an opportunity to exchange an experience and communication between the participants in the learning process.

Traditional educational institutions will not disappear, but they have to adapt to implement new methods and approaches in the teaching process, as well as to seek cooperation and collaboration with manufacturers and suppliers of technological equipment and software and to adopt or develop their online learning platforms.

The market for education technology is still relatively small. However, the need for more effective education on a growing scale is constantly pushing governments and

households to increase the expenditures for education, which increasingly attracts the attention of venture investors.

All this will inevitably lead to the acceleration of the process of modernization of global education and to the emergence of even newer technologies, which will change the way humanity learns and accumulates knowledge forever.

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Architectural Features of Technological Solutions for Structuring of Data in Web-based Information Systems

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Abstract. The paper examines the architectural features of modern software solutions for structuring of data in web-based information systems. This topic is relevant because much of the data today is in an unstructured form within web publications on the Internet. The paper explores the possibilities of some of the most used tools for structuring of web data. In conclusion, some important aspects in the term of architectural features for web data structuring are highlighted.

Keywords. Web, Unstructured data, html

1. Introduction

The aim of the research is to study the existing technological solutions for structuring data in web-based information systems. For this purpose, popular software tools for structuring data from web-based information systems are analyzed. Structuring data is topic usually associated with publications on the Internet. Structuring methods should be applied to their content to separate the main fragments that make up the data from these publications. Such data are web addresses and section names, web addresses from publication lists to detailed pages, title, date, publication text, etc. Different modern tools use different working techniques. In this sense, technological solutions for structuring data in web-based information systems also apply a different set of techniques to achieve their goals. The purpose of the report is to identify some similarities from an architectural point of view and to summarize the principles of operation of this type of software solutions. Many of the issues related to text categorization have been studied by the authors in this field [8]. It is clear, as well as from the research of other authors, that public organizations also use different types of data for the performance of their services [3, 4]. The two most common techniques for analyzing and retrieving information from the Internet are text retrieval and natural language processing. Some authors also explore the possibilities for evaluating information systems in this area [5]. In this regard, we will consider tools that implement appropriate approaches to structuring data in web-based information systems.

2. Architectural features in terms of structuring of web data

It is logical to assume that from a technological point of view, software solutions for structuring data in web-based information systems have many commonalities. The study of the most popular solutions in this field will help us to summarize the architectural features of this type of software tools. It is expected that such technological solutions have some minimalist user interface for configuring the data structuring process. The purpose of using specialized tools lies precisely in the fact that only some parts of the relevant web pages are of interest from the point of view of the data they contain.

For the purposes of the study, we will look at some of the most popular modern data structuring tools. According to reliable sources who are engaged in research in this field, some of the most used technological solutions for structuring data in web-based information systems are [1]:

- Web Scrapper;
- Import.io;
- Octoparse;
- Scrappy.

Web Scraper can extract data from sites with multiple levels of navigation. It can navigate a website on all levels [9]. This software solution makes it possible to tailor data extraction to different site structures using configurations as it is shown in Fig. 1. After a web scrapping process is completed, data can be exported in different file formats.

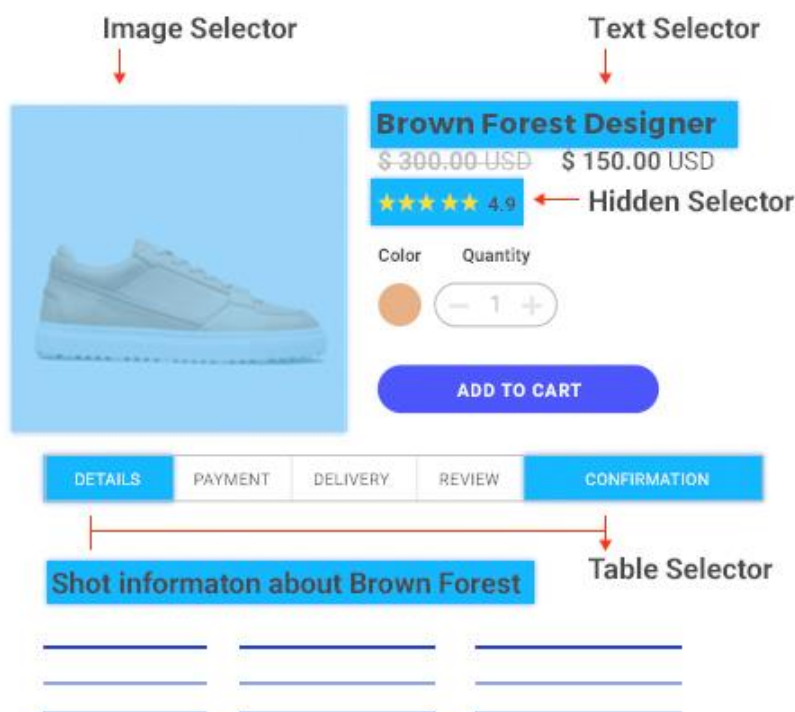


Fig. 1. Web Scrapper selector system

Import.io can extract data from websites, documents, and different data formats. It can capture screenshots at extract time, download files, images, and the source HTML for re-extraction later [2]. The screen of extractors config is presented at Fig. 2.

Octoparse is a technological solution that extracts web data in three steps [6], which are identifying the web page to be extracted, selecting the target data, and running the extraction process. This process is presented at Fig. 3. Advanced mode of this tool enables schedule tasks for scrapping at specific time or process-based scrapping on regular basis.

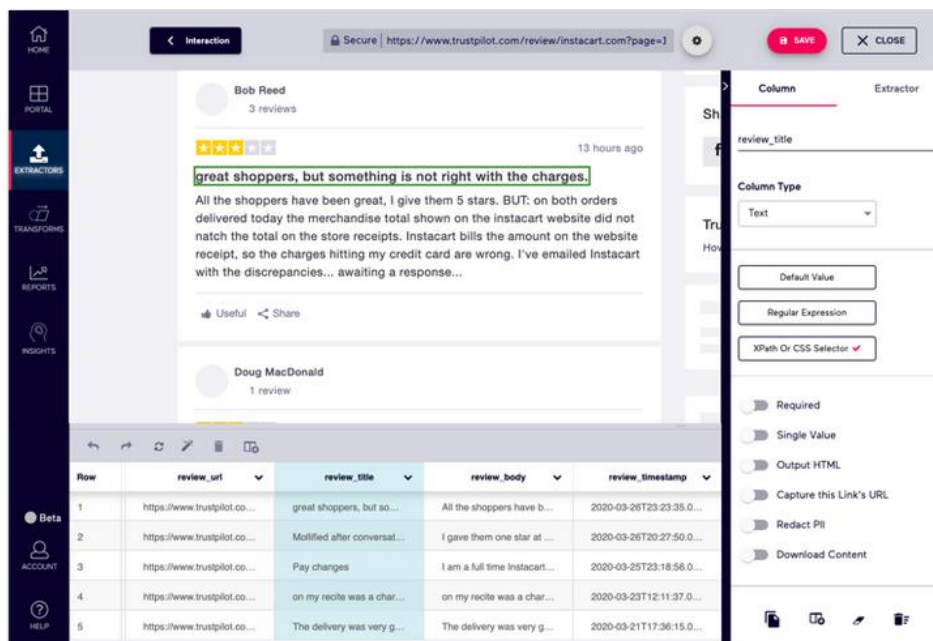


Fig. 2 Import.io extractors config

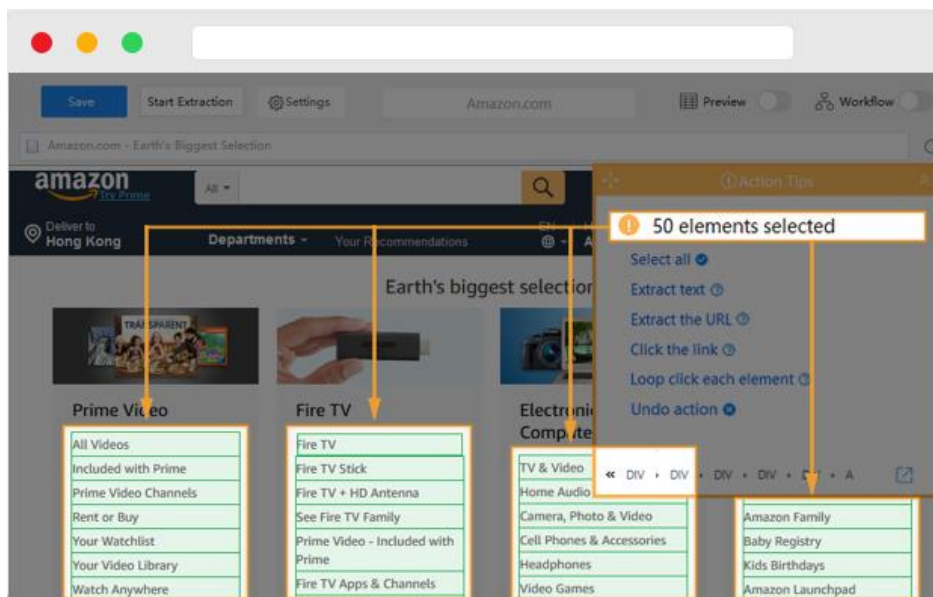


Fig. 3 Octoparse process

Scrapy is an open source and collaborative framework for extracting data from websites [7]. An architecture overview of this solution is shown in Fig. 4. It presents the data flow, that contains initial requesting, request scheduling, web data downloading, response processing, etc.

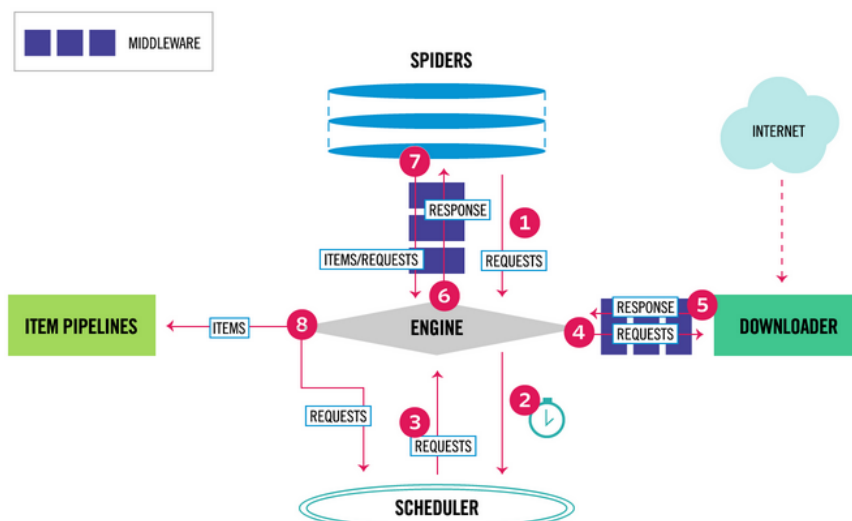


Fig. 4 Scrapy architecture overview

The technological solutions explored in the report are of interest to researchers in this field. They have their differences, but it can be said that they have some common architectural part. Structuring data in web-based information systems is a multifaceted task but clarifying the architecture of this type of solution is essential.

3. Conclusion

In conclusion, some established features of technological solutions for structuring data in web-based information systems can be summarized, namely:

- Ability to configure the individual elements of the web page using a visual (web-based) tool;
- Ability to export data in popular formats such as json, comma separated values, excel and more;
- Ability to simulate real user behavior, including solving captcha;
- Ability to export additional resources from web pages, such as photos and videos.

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Conceptual Model of Software Solution for Structuring of Data in Web-based Information Systems

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Abstract. The paper explores the possibilities for applying a software approach to structuring data in web-based information systems. This issue is very relevant in the context of the variety of websites and data in them. The paper examines the possibilities for presenting a conceptual model in several phases, which cover the individual stages of the process of structuring data in web-based information systems. In conclusion, some important aspects in the term of the presented conceptual model are highlighted.

Keywords. Conceptual model, Unstructured data, html

1. Introduction

Business data today is available in various forms. It is essential for organizations to make decisions based on as much data as possible. Some of this data is found in web-based information systems. This leads to the need to develop software solutions to provide access to this data. This access means structuring the data using some approach. This approach should have a specific architecture from a software point of view. This architecture usually includes specific components that are specific to structuring data in web-based information systems. Many of these architectures are also used in the public sector, where working with a lot of data is also crucial for the quality of services that institutions can offer [1, 2]. The software architecture consists of many software components and connections between them. In the paper we will consider the possibility of applying a specific conceptual model for structuring data in web-based information systems. A similar conceptual model was presented by Milev in his study of web scraping [3]. Some of the elements in his study are detailed in the model presented in the paper. Data from web-based information systems as external to organizations data is particularly valuable for analysis at senior management level [4]. In this sense, the topic of structuring data in web-based information systems is very relevant. We will consider a conceptual model for such structuring, which was developed for the purposes of the study.

2. Conceptual model for structuring of web data

To reach the conceptual model, we should consider steps that are the basis for structuring of data in web-based information systems. The first step should be to identify the target data. If we look at the structuring of web data as a whole process, then there should be various web-based sources that are of interest from the point of view of the data they contain. In this sense, we need to have some form of configuration of these web-based systems. Fig. 1 presents an interface that contains information about the configuration of the web-based information systems to be accessed.

In the study, the individual unit within the conceptual model, which is engaged in structuring of data in web-based information systems, will be called a grabber. The conceptual

model includes many grabbers. The reason for this is that the target data is located within more than one web-based information system. Due to the specifics of each system, it is necessary to have one grabber (with the appropriate configuration) for each system. In this sense, each grabber has its own configuration, shown in Fig. 2.

Схема	#	Граббер	Ид. Id	Домейн и начален адрес	Статус	Тип		
				economic.bg	787	https://www.economic.bg/ https://www.economic.bg/bg/a/all_news	Фикс	Стандартни
				hardwaremania.org	196	www.hardwaremania.org/	Фикс	
				mobilenews.bg	239	www.mobilenews.bg/	Фикс	
				kaldata.com	200	https://www.kaldata.com/ https://www.kaldata.com/	Фикс	
				segabg.com	8	https://segabg.com/ https://segabg.com/	Фикс	Стандартни
				bgarmy.eu	13	www.bgarmy.eu/	Фикс	
				moitepari.bg	388	https://www.moitepari.bg/ https://www.moitepari.bg/spravochnik/	Фикс	
				snews.bg	282	www.snews.bg/ http://www.snews.bg/	Фикс	
				ogosta.com	225	ogosta.com/ http://ogosta.com/	Фикс	
				hotnews.bg	58	www.hotnews.bg/ http://www.hotnews.bg/	Фикс	
				topnews.bg	354	www.topnews.bg/ http://www.topnews.bg/	Фикс	
				focus-sport.net	33	www.focus-sport.net/ http://focus-sport.net/news/Today/	Фикс	
				bnr.bg.sofia	427	https://bnr.bg/sofia	Фикс	
				pia-news.com	442	https://pia-news.com/ https://pia-news.com/	Фикс	
				standartnews.com	7	https://www.standartnews.com/ https://www.standartnews.com/	Фикс	
				barometer.net	87	www.barometer.net/ http://www.barometer.net/	Фикс	
				broker.bg	175	www.broker.bg/	Фикс	
				tehnizona.bg	210	www.tehnizona.bg/	Фикс	

Fig. 1. List of grabbers

Table 1 Grabber config

# Конфигурация граббер [Новинка] таб.1 таб.2			
1	Име	19min.bg	10 intervalrequestMax 0
2	Тип	news в проект prinfo.bg	11 intervalrequest 0
3	Домейн	https://19min.bg/	12 startingTimeMinutes 10
4	Поддиректория		13 intervalstartingMin 30
5	ID на източника	12	14 intervalstartingMax 120
6	Начален адрес	https://19min.bg/	15 intervalstarting 30
7	Описание		16 Времена
8	Режим на стартиране	normal	17
9	intervalrequestMin 0		18 Форуми наличност Има форуми
19	Формати	global 26 Януари 2011 07:54	news 26 Януари 2011 07:54
	компоненти	дата и час	
	Списък	Стандартни	Статус на граббера Готов
		Запис	Отказ

The configuration includes various attributes required to access the relevant target data, such as name, domain of the information system, home page, request interval, etc.

An important point in connection with the structuring of data in web-based information systems is the processing of the response by the respective system. Very often the data of interest are surrounded by other data that are redundant. In this sense, the conceptual model must include the appropriate means to identify this redundant data so that they are not present in the result. A way to identify redundant data is shown in Fig. 2.

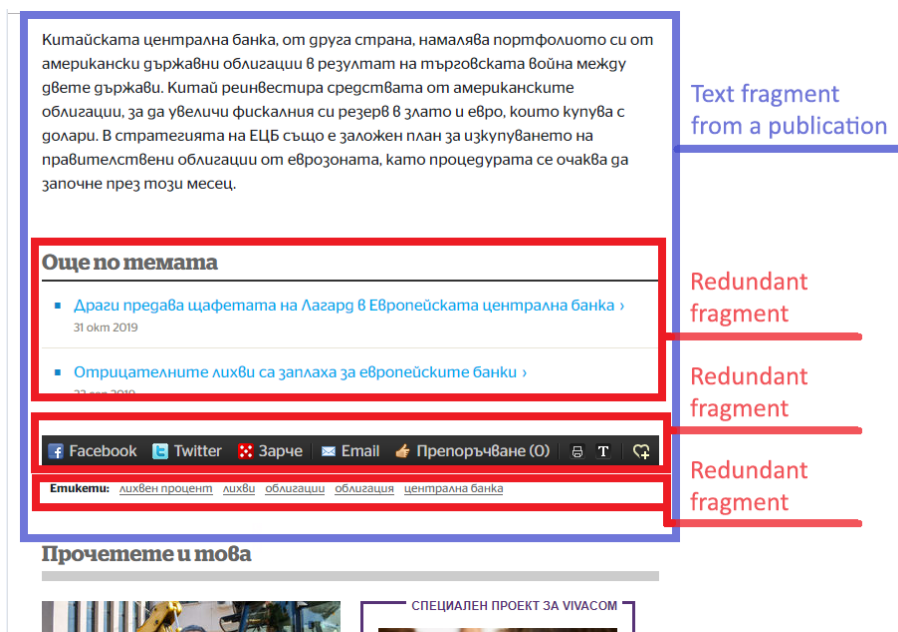


Fig. 2 Identification of redundant data

We can divide the tasks of structuring data into web-based information systems into five main stages. These stages will be the basis for the development of the conceptual model, namely:

- Identification of target data in web-based information systems;
- Configuring grabbers for relevant web-based information systems;
- Maintaining a database with the appropriate configurations;
- Performing a corresponding process according to the available configurations;
- Maintaining a database with structured data for subsequent operations (connections to other systems).

For the implementation of these steps and in the context of the research, the conceptual model, that has been developed, is presented at Fig. 3. It includes each of the considered elements, further expanding them in the context of structuring data in web-based information systems. The target data can be websites, web-based applications, social networks, and other web-based information systems in Internet. The configuration contains basic settings, content filters, and a source schema. Configurations are stored in a database, where metadata for the data is also available. The structuring process is at the heart of the conceptual model. It includes several important points, namely:

- HTTP request to the respective web-based information system;
- Response processing;
- Operations on the DOM structure of the respective response;
- Extraction of various HTML elements;
- Removal of redundant data.

The data obtained because of the applied conceptual model are stored in a database. This database can be used by data analysis applications in their current state or after appropriate intermediate processing.

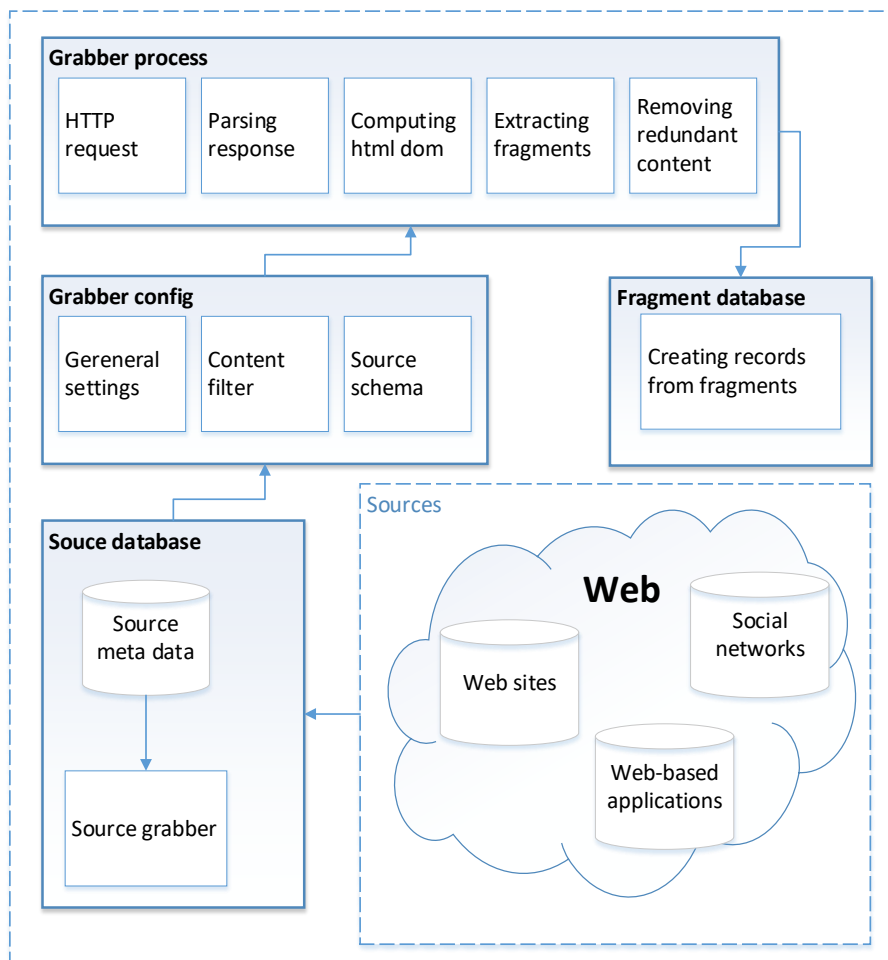


Fig. 3 Conceptual model

3. Conclusion

In conclusion, it can be summarized that the structuring of data in web-based information systems requires the application of appropriate approaches. The conceptual model presented in the paper has the characteristic architectural features of a similar type of solutions. This model can serve as a basis for the development of technological software tools for structuring of data in web-based information systems.

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Introduction and Basic Concepts in DXP - Digital Experience Platform

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Abstract. The paper reviews current trends in Digital Experience Platform concept (DXP). It traces the emergence and development of the DXP. The general notion of DXP is briefly introduced combined with the vision of the author. Basic DXP ideas and concepts are tracked. Promising directions for future research are outlined.

Keywords. DXP, Digital experience platform, Digital experience, Digital transformation, Heritage DXPs.

1. Introduction

In the last few years, a relatively new concept, the **Digital Experience Platform**, or **DXP** for short, has become more common in business and technology. This concept is the intersection between the world of Customer Experience, Digital Experience, Digital Transformation, Content Management System (CMS), Web Portal Platforms, E-commerce platforms and others. DXP has a connection with all of the above and aims to unite and upgrade them, so that organizations can provide better services to their customers. It is difficult to find a clear and uniform definition of the term DXP in the scientific literature. DXP is already a fact and is part of business and technology life. This raises the need for its definition and more detailed study of its roots, evolution and description of the current state of development of DXP.

In this paper, the concepts that are the basis of DXP and have a direct connection with it are considered. Its historical development and specifics are also considered. Some of the most common modern definitions of DXP are given, presenting the author's point of view. The essence of DXP is shown and additional information is given on a conceptual and practical level.

2. Digital Experience concept - a brief introduction

A digital experience is **an interaction between a user (customer, partner or employee) and an organization** that is **possible only because of digital technologies**. [1]

Digital experiences are that portion of technology that allows companies to go beyond digitizing paper processes in order to create services that are possible only because of the internet and other modern technologies [1]

They have two key components: **they use digital technologies** and **they provide some kind of interaction between a single user and an organization**, usually a company. Mobile apps, websites and smart devices all provide digital experiences to the customers, partners or employees that are using them to interact with companies [1].

Technology on its own doesn't make something a digital experience. Reading a scan of a paper document, for example, isn't a useful interaction to include within the scope of this

definition because it doesn't offer anything experientially different than reading a physical copy would. Companies should think of digital experiences as processes that do what a physical process cannot. A scanned document can convey written information as well as a piece of paper, whereas a digitally enhanced pdf can include cross-references to other documents, right-click definitions, online collaborations, auto-translations and digital signatures. As another example, event registration software that allows you to download a list of registrants and their information is digitizing the manual process of checking them in (i.e., instead of searching for names on a printed roster, you're searching a spreadsheet on your computer in order to confirm registration). Contrast that against a system in which you can enter a registrant's name and view their registration status, process pending payments, confirm room information and check them in from a single dashboard. This takes separate physical processes and unites them with one digital solution to save time. Digital experience is a broad category that encompasses the many digital channels that businesses need to manage today. However, digital experience is not the same thing as digital customer experience. Digital experiences are single interactions, whereas digital customer experience is the sum of all digital interactions that a person has with an organization. When companies discuss improving digital customer experience, they are concerned with improving user interface, mobile responsiveness and design, communication methods, delivering real time data, etc. across all interactions, rather than individual touchpoints. The distinction between digital experience and digital customer experience is generally only a concern to companies themselves. Customers have shown that they don't care about the idea of an "experience". They are simply focused on getting what they want in the most convenient way available. When businesses are speaking about digital customer experience, they're usually also making an effort to put themselves into the shoes of the customer, and trying to understand the impact and importance of digital channels from that viewpoint. [1]

3. Digital Transformation concept - a brief introduction

Digital transformation is what's happening to organizations as they adopt new and innovative ways to do business based on technological advances. It's the process of fundamentally changing something using digital tools and describes adopting technology and—potentially—cultural changes to improve or replace whatever existed before. Digital transformation isn't a product or solution to be purchased, but it affects everything IT touches in every industry. [2]

Some examples:

- Products, like paper-based records in file cabinets, have become bits and bytes in containers on a cloud; even the file cabinet itself is abstracted and software-defined.
- Services like hotel experiences and rental cars have been replaced with spare rooms (more on that later) and drivers are summoned by your smartphone.
- Processes like waterfall workflows have evolved into DevOps practices where teams work iteratively. [2]

Digital transformation marks a radical rethinking of how an organization uses technology, people and processes to fundamentally change business performance, says George Westerman, MIT principal research scientist and author of *Leading Digital: Turning Technology Into Business Transformation*. Ideally led by the CEO, in partnership with CIOs, CHROs and other senior leaders, digital transformation requires cross-departmental collaboration in pairing business-focused philosophies with rapid application development models. Such sweeping changes are typically undertaken in pursuit of new business models

and new revenue streams, driven by changes in customer expectations around products and services. [3]

There are four types of digital transformation:

- business process
- business model
- domain
- cultural/organizational [3].

Process Transformation: A significant focus of corporate activity has been in business processes. Data, analytics, APIs, machine learning and other technologies offer corporations valuable new ways to reinvent processes throughout the corporation—with the goal of lowering costs, reducing cycle times, or increasing quality. We see process transformation on the shop floor where companies like Airbus have engaged heads-up display glasses to improve the quality of human inspection of airplanes. We also see process transformations in customer experience, where companies like Domino's Pizza have completely re-imagined the food ordering process; Dominos' AnyWare lets customers order from any device. This innovation increased customer convenience so much that it helped push the company to overtake Pizza Hut in sales. And we see companies implementing technologies like robotic process automation to streamline back office processes like accounting and legal, for example. Process transformation can create significant value and adopting technology in these areas is fast becoming table-stakes. Because these transformations tend to be focused efforts around specific areas of the business, they are often successfully led by a CIO or CDO [3].

Business Model Transformation: Some companies are pursuing digital technologies to transform traditional business models. Whereas process transformation focuses on finite areas of the business, business model transformations are aimed at the fundamental building blocks of how value is delivered in the industry. Examples of this kind of innovation are well-known, from Netflix' reinvention of video distribution, to Apple's reinvention of music delivery (i-Tunes), to Uber's reinvention of the taxi industry. But this kind of transformation is occurring elsewhere. Insurance companies like Allstate and Metromile are using data and analytics to un-bundle insurance contracts and charge customers by-the-mile—a wholesale change to the auto insurance business model. And, though not yet a reality, there are numerous efforts underway to transform the business of mining to a wholly robotic exercise, where no humans travel below the surface. The complex and strategic nature of these opportunities require involvement and leadership by Strategy and/or Business Units and they are often launched as separate initiatives while continuing to operate the traditional business. By changing the fundamental building blocks of value, corporations that achieve business model transformation open significant new opportunities for growth. More companies should pursue this path [3].

Domain Transformation: An area where we see surprisingly little focus—but enormous opportunity—is the area of domain transformation. New technologies are redefining products and services, blurring industry boundaries and creating entirely new sets of non-traditional competitors. What many executives don't appreciate is the very real opportunity for these new technologies to unlock wholly new businesses for their companies beyond currently served markets. And often, it is this type of transformation that offers the greatest opportunities to create new value. A clear example how domain transformation works may be the online retailer, Amazon. Amazon expanded into a new market domain with the launch of Amazon Web Services (AWS), now the largest cloud computing/infrastructure service, in a domain formerly owned by the IT giants like Microsoft and IBM. What made Amazon's entry into this domain possible was a combination of the strong digital capabilities it had built in

storage, computing databases to support its core retail business coupled with an installed base of thousands of relationships with young, growing companies that increasingly needed computing services to grow. AWS is not a mere adjacency or business extension for Amazon, but a wholly different business in a fundamentally different market space. The AWS business now represents nearly 60% of Amazon's annual profit. It may be tempting for Executives of non-tech businesses to view the experience of Amazon or other digitally-native companies (such as Apple or Google that have also expanded into new domains) as special; their ability to acquire and leverage technology may be greater than other companies. But in today's digital world, technology gaps are no longer a barrier. Any company can access and acquire the new technologies needed to unlock new growth—and do so cheaply and efficiently. The building block technologies that are unlocking new business domains (artificial intelligence, machine learning, internet of things (IOT), augmented reality, etc.) can be sourced today not only from the traditional IT supply-base like Microsoft or IBM but also from a growing startup ecosystem, where we see the greatest innovation taking place. Corporations that know how to reach and leverage this innovation efficiently, particularly from new sources, are reaping the benefits of new growth. We see (and have helped) numerous industrial companies that have undergone domain transformations. ThyssenKrupp, a diversified industrial engineering company, broadened its offerings to introduce a lucrative new digital business alongside its traditional business. The company leveraged a strong industrial market position and Internet of Things (IOT) capabilities to help clients manage the maintenance of elevators with asset health and predictive maintenance offerings—creating a significant new source of revenue beyond the core. In another example, a major equipment manufacturer is moving beyond its core machine offerings to introduce a digital platform of solutions for its client sites: job-site activity coordination, remote equipment tracking, situational awareness, and supply chain optimization. The company is moving to become no longer merely a heavy equipment provider, but also a digital solutions company. The lesson is to recognize the new domain opportunities afforded by new technologies and understand they can be captured—even by traditional incumbents. Because these opportunities involve re-defining business boundaries, pursuing these opportunities often involves Strategy and the CEO [3].

Cultural/Organizational Transformation: Full, long-term digital transformation requires redefining organizational mindsets, processes, and talent & capabilities for the digital world. Best-in-class corporations recognize digital requires agile workflows, a bias toward testing and learning, decentralized decision-making, and a greater reliance on business ecosystems. And they take active steps to bring change to their organizations. Experian, the consumer credit agency and one of the most successful digital transformations, changed its organization by embedding agile development and collaboration into its workflows and by driving a fundamental shift in employee focus from equipment to data, company-wide. Similarly, Pitney Bowes, the 100-year old postage equipment company, made the successful transition to become a “technology company” by promoting a “culture of innovation,” according to its head of innovation, and by shifting company values to focus on customer-centricity. [3]

4. Digital Experience Platform (DXP) concept - a brief introduction

A digital experience platform (DXP) is an integrated set of core technologies that support the composition, management, delivery and optimization of contextualized digital experiences. [5]

Digital experience platform (DXP) is defined by Gartner.com as an integrated set of technologies, based on a common platform that provides a broad range of audiences with

consistent, secure and personalized access to information and applications across many digital touch points. Organizations use DXPs to build, deploy and continually improve websites, portals, mobile and other digital experiences. DXPs manage the presentation layer based on the role, security privileges and preferences of an individual. They combine and coordinate applications, including content management, search and navigation, personalization, integration and aggregation, collaboration, workflow, analytics, mobile and multichannel support. [4]

Digital Experience Platform (DXP) is an emerging category of enterprise software seeking to meet the needs of companies undergoing digital transformation, with the ultimate goal of providing better customer experiences. DXPs can be a single product, but are often a suite of products that work together. DXPs provide architecture for companies to digitize business operations, deliver connected customer experiences, and gather actionable customer insight. [7]

A confluence of factors has led many companies to start radically reengineering their business practices to be extremely customer-oriented:

- Digital channels (web, mobile, and social media) have become the dominant ways customers interact with companies.
- Those customers expect great experiences like Google, Apple, and Facebook.
- Social media in particular provides unstructured ways for customers to engage with and influence public sentiment for companies.
- Mobile devices provide location and immediacy, giving companies more ways to keep in touch with customers. A confluence of factors has led many companies to start radically reengineering their business practices to be extremely customer-oriented:
- Data insight is making it possible to target an audience segment of one person with a highly personalized experience.
- Digital technology makes it possible for upstarts to disrupt traditional industries: WealthFront for wealth management, LendingClub for financial products, and the oft-cited Uber and Airbnb in transportation and lodging—and all deliver a much better customer experience. [7]

Digital Experience Platforms (DXP) allow users to control and optimize their customers' digital experiences across all potential touch points. Typically, vendors in this space offer a portfolio of integrable products, or (less commonly) one suite solution to manage digital experiences. DXPs collect and aggregate customer data across a range of digital channels. This enables companies to build, maintain, and personalize the content available to its customers. [6]

Many products in this category are functionally very different, even though they may all contribute to managing digital experience. For example, a DXP may include individual e-commerce, business intelligence, marketing, data analytics and management, content management, and customer experience products. These functionally specific products are also included in this category. Additionally, DXP suites from different vendors do not always contain the same components. This can make it difficult to directly compare these products with one another, even though they each address a part of digital customer experience. For enterprises, it may be convenient to categorize and compare products with functionally different components within the context of a DXP. This can help companies integrate their digital experience management strategy. [6]

DXP Benefits - One key benefit of DXPs is the ability to access and coordinate different products across multiple interaction channels through one unified interface. These channels can include websites, customer portals, e-commerce systems, and mobile apps. [6]

The core functions of digital experience platforms include:

- Granting individuals personalized access to information based on their user credentials
- Streamlining customer interactions across channels to provide a consistent experience
- Coordinating and collecting customer data across all touch points using APIs
- Conducting web-based analytics on customer data
- Securing and storing customer data collected across multiple digital channels [6]

These platforms are similar to and may have overlapping capabilities with a few other software categories. These include: customer experience management (CXM), enterprise content management (ECM) products, and more advanced content management systems (CMS). However, the goal of CXM products is to improve customers' experience using feedback and customer data. In contrast, DXP products aim to streamline, coordinate, and personalize the presentation of content to users across multiple interaction channels. CXMs may also involve serving personalized content and experiences, but for the purpose of customer satisfaction and retention. DXPs are more focused on integration, presenting a unified brand face to customers, and giving marketers more strategic control over personalization. ECM software is focused on maintaining the internal company ecosystem by capturing, storing, and managing structured and unstructured data and content. In a similar vein, DXP products also aim to streamline processes. However, they manage external-facing digital experiences (i.e. customer' and prospects') rather than employees'. DXP use cases expand beyond optimizing internal functions, site development, and data management to include providing a better customer-interface. [6]

Digital Experience Platforms Features & Capabilities - These are some of the common capabilities offered by many DXP products. However, this is not an exhaustive list and may not be standard for all vendors in this space: [6]

- Content management
- Content personalization and A/B testing
- Content classification
- Content search and discovery
- Collaboration
- Social media
- Integrations (e.g. CRM, HR management, marketing automation, third-party CMS applications, e-commerce systems, and social media platforms)
- Content aggregation
- Customer/user data management
- Analytics and optimization
- Security administration
- Cloud enablement [6]

A checklist for choosing a DXP

A digital experience platform (DXP) approaches customer experience in a streamlined fashion, bringing together various components, such as a content management system (CMS), digital asset management (DAM) and analytics, onto a shared platform, which is then managed according to security preferences. [8]

Thanks to DXPs, organizations can now centralize the sharing of all their digital assets, collect data on customer journeys and learn about customer preferences, enabling them to hyper-personalize services and deliver unique digital experiences to all touch points. [8]

There are not many DXPs available on the market today and choosing one that is right for an organisation is not an easy task. Below you will find five tips that will guide people through the phase of selecting of digital experience platform: [8]

- **Assessing readiness for change** - Does your organization communicate with a diverse audience across a variety of different touch points? Would your users, employees and customers, benefit from a fully connected experience? And do you have board-level sponsorship? Answering these three very basic questions will help you determine how ready you are for a DXP and increase the likelihood of the project's success. [8]

- **Identifying business goal** - Very often, organizations do not look beyond their internal goals when investing in technology and their investments end up costing them a lot of money, while failing to meet business goals. However, by starting with an understanding of what your customer or end user really needs, both in the short-term and further down the line, you will be in a better position to determine what the business outcome of your DXP should be. [8]

- **Thinking in terms of the user journey** - It is important to understand how users interact with your organization's different touch points, as this will enable you to improve the overall user experience. By examining what users are looking for, which device they are using to look for it and how they interact with the various touch points, you will be able to choose the right set of technologies for a range of different use cases. [8]

- **Getting to grips with the technology** - Before making the move into a new tech environment, it is important to understand what your current technology can do, who it does it for and why. This is where a user journey map comes in handy, as it enables you to identify gaps in your technology that prevent you from providing great user experiences. Once you understand where you are in terms of your own technology, you will be able to understand whether it is compatible with a DXP technology. [8]

- **Putting together a roadmap** - When choosing a DXP, it is important to put together a roadmap. This involves asking yourself where you want to be in, say, five years, then working back. You will then be able to establish goals, key milestones and tasks for each stage of the project, in a way that is realistic and relevant to your business. Furthermore, it is crucial to align your roadmap with the user journey that you establish at the beginning of the project, in order to ensure you deliver the enhanced user experience desired. [8]

5. Digital Experience Platforms (DXPs) – origins, history and evolution

The Most products being positioned as DXPs have their roots in one of three categories:

- Content Management Systems
- Portal Servers
- Commerce Servers [7]

These roots give each set of offerings a particular orientation:

CMS-heritage DXPs – They focus on the needs of marketing departments and creative agencies. Customer data they collect tend to be anonymous and generalized into audience segments. Most business problems solved by these products are related to the acquisition of

customers: generating awareness and interest, targeting offers, and accelerating purchases. They do particularly well in B2C (retail, fashion) scenarios where the sales cycle is short and transactional, and audiences are large. The leading CMS-heritage DXPs have strong offerings for web-based analytics, user segmentation, advertising campaigns, and email campaigns. These are often provided by products in the platform suite, but because they are separate (and likely acquired from other vendors) they may be less or more well integrated with each other. Some CMS-heritage DXPs have tried to add portal-like features like logged-in experiences, and some include commerce capabilities; the latter are often the result of an acquisition or partnership. [7]

Most marketing and advertising agencies that support B2C initiatives cannot accelerate sales because they are limited by their current Content Management Systems (CMS). The CMS DXP offers a wide variety of functions based on several customer-facing experiences to accelerate moving leads down the funnel to support sales. [9]

Features include:

- Demand generation
- Customer acquisition
- Personalized content delivery [9]

Portal-heritage DXPs - Given their background in providing customer portals, are particularly suited for nurturing long-term customer relationships after the sale. Customer data is specific to each individual and is handled securely. These DXPs help companies understand the factors that lead to customer loyalty, retention and renewal. They may help calculate well-known metrics like Net Promoter Score. They can often help you provide customer service, including both self-service and representative-assisted issue resolution. Portal-heritage DXPs also support digital workplace scenarios (traditionally intranets, though digital workplace solutions must be much more dynamic and engaging) and scenarios for engaging supporting audiences such as partners, suppliers, and franchisees. A full digital transformation strategy can potentially encompass all of these groups, which play important roles in supporting strong customer experiences. Good portal-heritage DXPs should also have a strong story around integration, which is essential to deep digital transformation of business operations, according to Forrester. Management of reusable services and modules is helpful when strategy is evolving quickly. Some portal-heritage DXPs include a broad feature set, including content management, targeting, mobile support, workflow, and forms; others concentrate mainly on the presentation layer. [7]

Portal DXPs are specifically designed to work with B2B and B2C financial technology and manufacturing-based companies for of customer support initiatives and customer relationship management, focused on activities such as customer renewal, loyalty and/or retention. Portal DXP functionality works seamlessly with corporate intranet portals to engage both partners and suppliers. [9]

Features include:

- Workflow automation
- CMS
- Front-end presentation
- Mobile support [9]

Commerce-heritage DXPs – They are used in online shopping scenarios by companies in retail and related industries. In addition to product-related content delivery to e-commerce-style web interfaces, these products usually also provide capabilities around inventory management, shopping cart, payment integration, check-out and fulfillment. Though these

features aren't strictly related to digital experience management, it's clear that a great digital retail experience requires seamless integration to these functions, which come naturally to commerce-heritage DXPs. Naturally, commerce-heritage DXPs are also adding adjacent capabilities, though in a commerce-centric way. For example, many commerce products have needed to add content management capability to support the promotion of products in the catalog. It may seem that DXPs are just re-branded versions of CMS, portal, and commerce products, but DXP vendors take a different approach to the traditional features of those products, to meet new customer expectations and take advantage of new technologies. When selecting a DXP, companies should decide whether they are ready for deep transformation of their business operations, or are focused primarily on marketing and brand awareness, as these priorities tend to reflect the different strengths among the DXP vendors. [7]

Commercial DXPs are primarily used to push promotional content to company websites. [9]

Features include:

- Shopping cart management
- Pre-purchasing
- Inventory management
- Product returns
- Payment management
- Fulfillment [9]

Digital Experience Platform was born as a natural successor of this three heritage categories. This solution allows companies to value the sharing of information between the interactions points, while also focusing on meeting the audience's needs. In fact, the concern with the experience should be at the moment of purchase and throughout the whole journey. In other words, a good experience matters from the first contacts until the moment that the person becomes a promoter or defender of the brand. [10]

6. DXPs - Classification by heritage ^[7]

	CMS-heritage	Portal-heritage	Commerce-heritage
Sample Vendors	Adobe Experience Manager (formerly Day CQ5; part of Adobe Marketing Cloud) Sitecore Experience Platform (formerly Sitecore CMS)	Backbase Customer Experience Platform Liferay Digital Experience Platform (includes the former Liferay Portal product and additional supporting products)	Hybris (acquired by SAP) Broadleaf Commerce Demandware
Business type	B2C, especially transactional purchases	B2B, or B2C with complex sales cycles and repeat business	B2C, especially retail Industries

Industries	Retail, fashion, advertising, media and broadcasting, entertainment, journalism	Insurance, government, retail banking, manufacturing	Retail, fashion, food, music/entertainment, electronics, travel, hospitality, telecommunications
Customer Relationship Stage	Pre-purchase	Lead nurturing and qualification, on-boarding, customer service	Pre-purchase, order fulfillment, returns
Strengths	Some of the leaders in this segment have mature email marketing, analytics, and ad spending tracking.	Deep systems integration for improved customer experience comes naturally to portal-heritage DXPs, which also store data for individuals, not just segment data.	Retail transactions in e-commerce scenarios are a natural fit for commerce-heritage DXPs.
Weaknesses	CMS-heritage DXPs are less likely to have individual customer data and profiles, and are less suited for customer service scenarios.	Some older portal-heritage DXPs may have the negative aspects of traditional portals, such as poor user experience and poor support for mobile.	Some vendors in the segment have difficult-to-use content management systems with poor targeting capabilities. These are also not designed for deeper integration per se. These vendors also tend to be most relevant (limited) to retail scenarios, with functionality lacking in supporting more of the customer life cycle.

7. Conclusion

The paper clearly shows the essence of the DXP concept by giving several definitions of it and presenting the author's point of view. In addition, the paper examines the roots, history, origins, and evolution of DXP, as well as its connections to other related concepts. It also provides a brief presentation of all significant concepts that are directly related to DXP. The paper provides additional information about DXP, as well as steps in choosing a suitable platform. A brief classification and comparative characteristics of all significant DXP systems based on their inherited origin are also presented in the paper.

The paper can be very useful as an introduction to the world of DXP and as a short guide for choosing DXP platform. It can also be a quick reference in the field of DXP research and DXP applications.

DXP is increasingly used in business practice and is becoming important in today's business world. DXP is already a key element in the strategies of many organizations that have realized that digital transformation and improving the overall user experience of their users is key to improve the performance of organizations as a whole. Moreover, the application of DXP in the conditions of strong competition is an important factor for the existence and prosperity of the organization in the modern digital age. For these reasons, the application of DXP appears to be a promising area for future research.

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Fundamental Relations, Similarities and Differences Between DXP and CMS

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Abstract. The paper reviews current state of relations between DXP and CMS concepts. It traces the emergence and development of the DXP related to CMS. The general similarities between DXP and CMS are outlined, combined with the vision of the author. Basic differences between DXP and CMS are tracked. Promising directions for future research are outlined.

Keywords. DXP, Digital experience platform, CMS, DXP vs. CMS, CMS-heritage DXPs

1. Introduction

In the last 10 years, the use of the Internet and mobile devices by a wide range of users has increased enormously. In addition, the development of technology has led to the emergence of much more affordable solutions for the digital transformation of various industries and organizations. Increasing competition and increasing demands from consumers are forcing many different organizations of different sizes to look for efficient products, services and complete solutions that provide them with the necessary infrastructure to be able to adequately meet the new requirements of the modern digital age.

Nowadays, the presence on the Internet is a de facto mandatory standard for every business and for every organization, because most of their users often interact with them through the Internet. One of the oldest established channels for Internet communication between organizations and their users are websites, web portals and online stores, and they are often based on the Content Management System (CMS). The evolution of CMS systems has led to their significant development and they are often used as a tool to solve various tasks that are different from building websites and managing their content.

In the last few years, a new concept has emerged - Digital Experience Platform (DXP), which in its beginning was something similar to an upgraded CMS system, but with the advancement of DXP, some notable differences have emerged between them. In the scientific literature, a clear definition of the term DXP and its relationship to CMS is rare. It is also rare to find a comparative characteristic between DXP and CMS to outline the relationships, similarities, and differences between them. The purpose of this paper is to define the relationships between the concepts of DXP and CMS, to show the dependencies between them, as well as to show the main similarities and differences between them. A comparative characteristic between the most important DXP and CMS systems will also be presented, as well as some selection criteria between them. Additional information on DXP and CMS will be presented, which is useful in their research and use, both conceptually and practically.

2. Basic concepts and definitions of DXP and CMS

A Content management system (CMS) powers an organization's website and applications with the tools needed to deliver content – including editorial, workflow, reporting, organization, security, and user administration. It's the foundational software for digital identity, strategy, and engagement. [6]

A Digital experience platform (DXP) provides the full suite of tools to power the delivery of personalized experiences that scale and connect – across channels, geographies, and languages. [6]

Sometimes these two kinds of platforms can overlap. As the martech space continues its rapid expansion, it's increasingly important for researchers and decision makers to have at least a working understanding of the nuances between these two technologies. [6]

At a minimum, a content management system (CMS) powers an organization's website and applications. Teams need to deliver the content they've created, and a CMS provides the workflow, reporting, organizing, and user administration tools to do just that. For some small organizations, these tools might be all that are needed. But for most, they're just the beginning. [6]

2.1. Digital Experience Platform (DXP):

Gartner defines a digital experience platform (DXP) as an integrated set of technologies, based on a common platform, that provides a broad range of audiences with consistent, secure and personalized access to information and applications across many digital touch points. Organizations use DXPs to build, deploy and continually improve websites, portals, mobile and other digital experiences. DXPs manage the presentation layer based on the role, security privileges and preferences of an individual. They combine and coordinate applications, including content management, search and navigation, personalization, integration and aggregation, collaboration, workflow, analytics, mobile and multichannel support. [1]

Gartner defines also a digital experience platform (DXP) as “an integrated and cohesive piece of technology designed to enable the composition, management, delivery and optimization of contextualized digital experiences across multiexperience customer journeys.” In today's digital world, organizations stay competitive by building relationships through communication, which requires speaking and listening. Organizations use content to speak and data to listen. Digital experience platforms offer organizations an integrated suite of tools to foster meaningful relationships by speaking and listening to customers, prospects, partners, employees, and other audiences. [2] [3]

Digital Experience Platform (DXP) and Web Experience Management (WEM) - definitions from BloomReach.com:

Digital Experience Platform (DXP) is as an integrated software framework for engaging a broad array of audiences across a broad array of digital touchpoints. Organizations use DXPs to build, deploy and continually improve websites, portals, mobile apps and other digital experiences. It takes multiple integrated technologies to control a wide span of touch points and there is a need for one central platform to be the control center for this expanded experience. As with all new things, the standardization of the particulars takes time and there's a natural selection of which standard features end up sticking. [5]

Web Experience Management (WEM): As digital became a major facet of brands, new customer channels popped up, and cross-departmental collaboration began to rely on sharing digital information, WEM emerged. These systems introduced rule-based personalization to the online experience, and gave the ability to collect user behavior, define personas, and create and provide unique content to the targeted audience. Most importantly, WEMs allow

companies to share content, data, logic, and other elements across channels consistently. The call for relevance and customer experience has been around for quite some time now in both B2C and B2B. [5]

The next generation of CMS, Web Experience Management systems (WEM), changed websites from brochures into an integral part of the customer journey. This gave companies new ways to collect customer data, define personas and create exceptional experiences with unique content for specific audiences. Moreover, it connected new digital channels such as mobile apps and social media. [5]

In practice, marketers found that these systems are designed to work with native data. WEM systems are stand-alone marketing tools that are difficult to connect to other systems. Data, profiling and applying business logic is limited when you work from a silo. [5]

This realization launched the **Digital Experience Platform (DXP)**. An open platform that easily integrates with other systems and departments. That enables companies to craft truly personal experiences to customers. [5]

The experience quickly moved beyond just content, and just the web - businesses want to share any type of asset, or group of assets, across any digital touch point - online, in-store, billboards, kiosks, customer portals, e-commerce systems, and more. It also became clear that the digital experience was no longer just a way to get people in the door, but critical to growing customer satisfaction and loyalty post-acquisition. The digital journey has expanded, more back end applications are being used by different departments to handle their piece of that journey. For the customer experience to remain consistent from acquisition to advocate, these back end systems need to integrate. Digital is no longer just in Marketing's hands, the entire business is responsible for it. This need for a connected, consistent experience - both internal and customer facing - led to the rise of the agile DXP. At their core, all DXP vendors are trying to supercharge the way the digital experience is delivered. [5]

The digital age has led to empowered and connected consumers with rising expectations. And these consumer expectations are driving organizational change across industries – from manufacturing to retail to healthcare and beyond. [6]

Digital experience platforms (DXPs) support organizations as they adapt to the exponential shifts of the digital age. [6]

While a CMS supports the orchestration and delivery of the content essential to digital experiences, a DXP goes beyond this by providing automation and smart delivery across websites and portals, apps and IoT devices, and more. It also provides insight into the reception and result of these experiences with data, analytics, and often AI and machine learning. [6]

A DXP streamlines engagement and provides the coveted 360-degree view of customers, across channels, and continuously updated in real time, taking the analytics of a CMS to a whole new personalized level. [6]

In short, a DXP is the tool (or set of tools) that powers personalized, cross-channel digital experiences. The right one will replace much of your current martech stack and fluidly integrate with the rest of it. The benefits are clear [6]:

- Omnichannel reach: With voice-enablement rising and IoT devices proliferating, reaching your audience where they are and where they will be has never been more essential.
- Build lasting relationships: Smart organizations know that a conversion isn't the end of the relationship, it's a new beginning. DXP powers and tracks engagements throughout the entire lifecycle.
- Integrations that deliver: Disparate data isn't actionable. Connected data is. And with the market in continual flux, knowing that future integrations won't be an issue delivers maybe the rarest commodity today – peace of mind. [6]

As a robust platform of marketing tools, a DXP always includes a CMS (often as its core), but it also usually includes the following functionalities [6]:

- Contextual Intelligence and Relevance (customer profile engine, language translation, omnichannel, etc.)
- Commerce (PCM, payment & billing, shopping, etc.)
- Asset management (DAM, web-to-print, etc.)
- Engagement (chatbots, mobile apps, marketing automation, etc.)
- Digital process (BPM, MRM, case management, etc.)
- Cognitive (predictive analytics, machine learning, AI automation, etc.)
- Data Center (CRM, MDM, etc.) [6]

DXPs can be single-vendor solutions or a combination of solutions from various vendors, depending on organizational needs. However, as DXPs continually evolve to keep pace with the ever-changing competitive needs of today, most organizations won't find a single-vendor solution. And those who do will almost always require multiple products from their vendor. [6]

Therefore, it's critical to find a DXP that includes easy integrations, future-oriented extensibility, and an expansive partner ecosystem. [6]

Having gone through all that, we can now return to our statement above with a deeper level of understanding. [6]

A CMS is the foundational software for digital identity, strategy, and engagement. A DXP is the full suite of tools powering the delivery of personalized experiences that scale and connect – across channels, geographies, and languages. [6]

Abbreviated as DXP, a digital experience platform is also defined by VirtoCommerce.com as an integrated software framework meant to engage a wide range of players in the broad array of digital touch points. Most organizations deploy DXPs to improve their websites, portals, mobile applications, and other digital experiences. From this definition, DXPs may not be as clear as you may want to understand them. However, organizations need one central platform responsible for controlling the wide span of its touch points. This central platform for the expanded experience for an organization is the so-called digital experience platform. [8]

2.2. Content Management System (CMS):

A content management system is for creating, managing, and optimizing your customers' digital experience. [4]

More specifically, a CMS is a software application that allows users to collaborate in the creation, editing, and production of digital content: web pages, blog posts, etc. The CMS (or WCM—web content management system) is evolving from just helping you launch digital content to a more robust system that is core to managing an overall digital experience across many different channels, such as email, mobile apps, social media, web sites, and more. [4]

Any basic solution for web content management helps you upload or write content, format it, add headlines and images, and do a number of backstage things like SEO. But in a multi-device, user-centric world, that's not enough. Digital marketing has evolved, focusing more deeply on customer experience while incorporating mobile apps, the Internet of Things, and more. All that depends on a web content management system that separates content management from content presentation. [4]

The terms “content management system” and “web content management” system (WCM or WCMS) are often used interchangeably, and there's no clear industry definition that lets you tell one from the other. [4]

CMS tends to imply the creation, editing, and management of content, while WCM implies all that, plus management of your websites themselves. But today, whether a vendor prefers one term or the other doesn't tell you what you need to know, so you've got to look "under the hood" to see what's really being offered. [4]

Important capabilities in a content management solution will include [4]:

- Content management: How, and how easily, can you create, edit, post, and manage web content (including text, images, video, and audio)?
- Presentation: Customers jump from device to device, and no marketing org can put human effort into optimizing every blog post or catalog page for laptop, tablet, and top smart phone formats. You want to create it once and have the CMS automate the presentation to suit the device.
- Integration: Is the solution holistic, like Sitecore's Experience Platform, or does it rely on APIs to connect your content to other applications, such as CRM and ERP tools, and to crucial external platforms such as Facebook? Are the APIs you're going to need available?
- Commerce: A crucial integration is being able to connect a personalized marketing presentation to your digital commerce systems. You can't address the "customer journey" if you leave this destination off your map.
- Personalization: Can it target relevant content to unique visitors, by persona, location, or even individually based on past interaction with your brand?
- Analytics: You're serving up content, but is anyone reading it? And what do they do next? Demand visibility into performance so you can optimize your efforts and define ROI.
- Governance: Can you find stuff after you post it? Can you strictly control who's allowed to approve it, change it, publish it, take it down? Can you tell when content has aged out of usefulness?
- Multilingual support: Are you translating into other languages and publishing globally? Can the solution support that?
- Scalability/Performance/Stability: Is the solution reliable from a fundamental technology standpoint, and will it grow with your organization's needs?
- Training/vendor support: WCM solutions are increasingly complex, with ever-greater promises, but most teams need help to get up and running beyond a basic level. [4]

Content Management System (CMS) – definition by BloomReach.com: The basic system to help enterprises organize written content, images, data, and other collateral needed for their online presence. [5]

A CMS provides version management and authoring workflow to keep large, global sites consistent. Web Content Management (WCM) is more or less another name for CMS, because we are an industry that loves acronyms. [5]

All of these systems - CMS, WEM, and DXP - are still after the same thing - making the interaction between customer and brand meet both parties needs - but the way they enable this has evolved. [5]

Here's a full list of the functionalities often included in the modern CMS [6]:

- **Security and compliance** - Whether authenticating users and levels of access or keeping user data safe, you need security. And regulations such as GDPR and California's A.B. 375 require all businesses operating within their jurisdictions to meet stringent requirements around data security, transparency, and consumer data rights. Most organizations today need a security-first CMS, one that includes data encryption

(both at rest and in transit), advanced personal identifying information (PII) compliance, and smooth integrations with enterprise security providers and/or third-party authentication systems.

- **Workflow management** - Authoring, editing, staging, approval, translation, publishing, promotion, reporting, and iterating – your busy team needs a workflow that adapts to their needs, an intuitive performance dashboard, and support in tagging all content with the appropriate metadata.
- **Omnichannel** - People expect to engage with your organization on whatever device they choose. Your CMS must not only make it simple to deliver content to today's and tomorrow's various channels but also future applications and services.
- **Global delivery** - If you currently have multiple sites across various nations, or plan to in the future, you'll need a CMS with multi-site and multi-language support, smooth integrations with localization and translation services, and regulatory compliance for multinational content.
- **Flexibility, extensibility, and performance** - Organic visits over time, seasonal spikes, entry into new countries, creating new websites and campaigns quickly – a modern CMS must be flexible enough to handle it all. It should integrate with other technologies, include a wide array of modern APIs and connectors, manage multiple sites from one centralized location, and more. And it should be capable of deploying on the cloud. Cloud: Allows continuous deployment, automated updates, speedy delivery of new features, and more. Cloud deployment also powers the launch of campaigns and websites in hours or days versus weeks or months.
- **Publishing** - A modern CMS makes it easy to edit and view content before publishing and schedule items for future publication.
- **Commerce and content integrations** - Content and commerce are now connected – from initial research to purchased-product use. Make sure your CMS includes a unified interface for commerce, migration tools, seamless inventory management, adaptable inventory handling, automated actions (such as cart-abandonment or purchase follow-up), third-party integration, user-generated content creation, and testing capabilities. [6]

This may seem like a lot to expect from a CMS. In part, this is just the reality of doing business in our digital age. But it also raises an important truth: as the martech space becomes increasingly convoluted, the distinctions between the various tools needed to compete in it become somewhat fluid. In fact, the last category, commerce and content integrations, is a functionality that begins to push this technology away from being defined as a simple CMS to being defined as a digital experience platform (DXP). [6]

A CMS is software that contains [6]:

- A programming framework (such as ASP.NET or Java)
- A database that stores content
- A user interface for web editors [6]

These are all hosted on a web server, which has an operating system, or in the cloud. CMS software also includes multiple application layers. An application layer supports CMS functionality and defines how different parts of the software connect to each other and the host system. [6]

To get content to an audience, the delivery layer requests content from the content layer through an application programming interface (API). That content then moves through a third layer, the rendering or "presentation layer," which takes what the delivery layer has produced and renders (or presents) it on a screen. [6]

As there are different ways to deal with application layers, there are also different ways to store content within a CMS. Without getting too technical, we can say that some systems store content as whole pages, while others store content in smaller chunks called “items” or “objects.” [6]

There are two reasons to store content as items or objects. The first is that it makes it easier to reuse content across multiple pages and applications. The second is that content is not bound by any presentation requirements – it’s not bound to a page’s format, for example. [6]

But why does that matter? Here are three reasons: Fitbit, Amazon’s Alexa, and Facebook’s Oculus. Devices like these have unique (and increasingly divergent) requirements for presenting content. When pulling content from a CMS, they only want the underlying content, not page layouts, styles, management frameworks, etc. [6]

3. Evolution of DXP from CMS

Having conversations might sound easy. But in today’s complex world, it’s anything but. It requires not only delivering content to websites, email, mobile apps, customer portals, social platforms, IoT devices, virtual and augmented reality devices, in-store kiosks, digital signage, POS systems, and more; but also connecting the experiences on them. [3]

There are 6.5 connected devices per person today, and most people use multiple devices on their path to purchase. It’s not enough to simply deliver content to each channel – they must coalesce into a consistent, connected, and continuous experience that nurtures people toward a clear outcome. [3]

For example, no one wants to get an email advertising a product they just purchased on Instagram. Or to click a link in a promotional email, only to be taken to the company’s homepage instead of the page for the product they’re considering. [3]

Digital experience platforms evolved to meet the challenges of today. [3]

CMS to WEM to DXP:

The first content management systems (CMSs) appeared in the late 1980s and early ‘90s. These monolithic CMSs enabled brochure-like static content. By the late ‘90s, organizations were beginning to serve up the dynamic content that would give rise to the social web. [3]

As the social web expanded with user-generated content and the rise of mobile, the need for more personalized engagement and deeper business integration led to web experience management (WEM) solutions. With WEM, organizations began gathering engagement data, building out personas, and using both to serve up more personalized experiences. [3]

The problem with WEM systems, however, was that they were designed solely for marketing departments — and thus were hard to connect to the rest of the organization’s technology stack, such as their CRM or ERP. [3]

Take an insurance company, for example. After being marketed to, some targeted prospects would come to the company’s website and apply for a quote. But because the site was on a WEM, there was no easy way to pass on these leads and their information to a salesperson. Closing the sales loop was neither efficient nor fluid, which meant a lot of leads were lost. [3]

As digital experiences became more and more important to organizations of all types and sizes and technology solutions proliferated, the need for deeper integrations grew, leading to the rise of headless, microservices architecture. [3]

This architectural innovation offered two things:

- First, it enabled integrations with other systems — such as CRMs, commerce systems, and call centers — to better connect the experiences on each. Finally, the insurance

company above could track leads, get them to sales, and close the sales loop with ease. [3]

- Second, it empowered developers to experiment with new touch points. [3]
- Together, these two capabilities paved the way for digital experience platforms (DXPs) to provide a fully integrated customer experience flowing seamlessly across channels and devices, throughout the entire journey. [3]

CMS-WEM-DXP – Use Case Table [3]

Platform	Use case
CMS	Create and manage text and image content across traditional desktop and mobile websites
WEM	Expands CMS: Deliver content to digital marketing and commerce channels. Includes analytics to understand customer behavior and better serve their needs
DXP	Expands WEM: Provide a fully integrated and seamless digital experience across channels and devices and throughout the entire customer journey

During this time, another phenomenon was developing: the age of the consumer. With each Google search, consumers' knowledge grew. With each new option to buy online, their power increased. With each transaction on Amazon, their expectations expanded. And they brought their expectations to every interaction — whether purchasing products for their business, shopping for themselves, or communicating with the company they work for. As early as 2016, McKinsey highlighted that, according to research, three-fourths of customers “expect ‘now’ service within five minutes of making contact online.” In 2018, Salesforce research found that 76% of customers today expect companies to understand their needs and expectations. It's often neither the product nor the price that's the main competitive advantage today but the customer experience. On top of heightened expectations, consumers' behavior changed as they took the reins digital provided. Instead of a linear flow from search to website to transaction, consumers now step in and out of their journeys, often using different devices for different phases. To meet the heightened expectations and divergent behavior of audiences today, organizations need a way to provide the right content, at the right time — no matter the device or reason for engagement. To do this, they need to align teams, streamline processes, connect systems, and often transform workflows to provide the customer experiences we have all come to expect. [3]

DXPs Come From Heritage Categories

Most products being positioned as DXPs have their roots in one of three categories: **Content Management Systems**, **Portal Servers**, and **Commerce Servers**. These roots give each set of offerings a particular orientation. [7]

CMS-heritage DXPs focus on the needs of marketing departments and creative agencies. Customer data they collect tend to be anonymous and generalized into audience segments. Most business problems solved by these products are related to the acquisition of customers: generating awareness and interest, targeting offers, and accelerating purchases. They do particularly well in B2C (retail, fashion) scenarios where the sales cycle is short and transactional, and audiences are large. [7]

The leading CMS-heritage DXPs have strong offerings for web-based analytics, user segmentation, advertising campaigns, and email campaigns. These are often provided by

products in the platform suite, but because they are separate (and likely acquired from other vendors) they may be less or more well integrated with each other. [7]

Some CMS-heritage DXPs have tried to add portal-like features like logged-in experiences, and some include commerce capabilities; the latter are often the result of an acquisition or partnership. [7]

It may seem that DXPs are just re-branded versions of CMS, portal, and commerce products, but DXP vendors take a different approach to the traditional features of those products, to meet new customer expectations and take advantage of new technologies. [7]

The technology behind digital experience platforms has evolved over the years due to the increased digital space venture by both customers and workers. The predecessor platforms that were DXP equivalents included CMS. A content management system is a basic system used to organize content, data, and images for enterprises. Digital experience platforms soon took over due to the various challenges that CMS introduced, such as silos in organizations. [8]

WEM (Web Experience Management) came soon after. These platforms helped leverage web technologies and integrated them with the existing enterprise systems. WEM provided centralization and a better way of content management. These two early technologies gave rise to digital experience platforms, that combined WEM's power with the benefits of other open platforms to reduce the complexity of IT. [8]

4. DXP and Digital Transformation

In addition to providing the integrated tools organizations need to speak and listen to their audience, digital experience platforms provide the technology that supports the organizational transformation needed to improve customer experiences. [3]

While a digital experience platform is necessary for most organizations' digital transformation, it isn't as simple as just purchasing a new solution. [3]

You can begin by tracking experiences across your site, for example, but true digital transformation requires an organizational shift in thinking and doing — connecting silos, building out teams, moving to agile workflows, creating feedback loops to continuously evaluate and respond to customer data cues, and more. [3]

By providing the architecture, digital experience platforms help with all of this. They offer a centralized location to collaborate on the development and delivery of experiences across the lifecycle. They provide the infrastructure for collecting and connecting data from every channel. And with intuitive dashboards and machine-learning driven insights and suggestions, they give everyone access to deep customer insight and KPIs to track the process and its results while staying aligned. [3]

Digital experience platforms also provide a way for organizations to begin implementing artificial intelligence (AI), which is changing work quickly. Whether using natural language processing to tag content or automatically identifying visitor trends, creating customer segments, and modifying pages, machine learning and AI are increasing organizations' productivity, customer insight, and ROI. [3]

Many teams are also realizing that it's not only downstream needs — such as experience delivery and data collection — that are needed but also upstream needs — such as digital asset management and collaborative content creation. Digital experience platforms should integrate fluidly with other systems to offer end-to-end content management. [3]

Digital has transformed everything today. It creates both risk (disruption) and opportunity (customer-obsessed engagement) for organizations across industries and sizes. Digital experience platforms are continually adapting solutions built to meet the constant evolution of our digital age. [3]

Benefits from DXP [3]:

DXPs provide	Organizational benefits	Audience benefits
Integrated control center	Combined omnichannel content management, customer data, and analytics enable experiences that increase customer retention	Connected, consistent journeys
Content flexibility	Use hybrid-headless and microservices architecture to deliver the same content across all channels, freeing teams up to create more content for better experiences	Better experiences on preferred channels
Better personalization	Integrations with other systems — such as CRMs, contact centers, and social media — provide a 360-degree view of each customer; intuitive dashboards and machine learning power deep insights	The right value at each touchpoint (e.g. the call center has the information you entered in the online form before calling)
Future-proof adaptability	Ability to integrate new technologies, adapt, and connect with audiences as digital maturity increases or new technologies appear	Connect how they want, when they want

Other benefits [10]:

- Identify immediate needs in digital customer experience
- Improve the accuracy of your marketing and customer engagement through holistic customer data and information
- Use integration and flexible architecture to stay on the cutting-edge of digital trends [10]

5. List of notable DXPs and comparing

20 notable DXPs by Gartner ranking [1]:

- Office 365 (including SharePoint Online) by Microsoft
- Office 365 by Microsoft
- Adobe Experience Manager by Adobe

- SharePoint Server by Microsoft
- Salesforce Community Cloud by Salesforce
- Sitecore Experience Platform (XP) by Sitecore
- Acquia Platform by Acquia
- FirstSpirit by e-Spirit
- Kentico EMS by Kentico Software
- Bloomreach Experience Cloud (brX) by Bloomreach
- Liferay Digital Experience Platform by Liferay
- SAP Cloud Platform Experience Maker by SAP
- CoreMedia Content Cloud by CoreMedia
- Magnolia (DX Core) by Magnolia
- Crownpeak Digital Experience Management Platform by Crownpeak
- Squiz Digital Experience Platform by Squiz
- Oracle Content and Experience by Oracle
- OpenText Experience Platform by OpenText
- OpenText TeamSite by OpenText
- Xoxoday Plum by Xoxoday [1]

Comparing some notable DXPs [9]:

1. LIFERAY DXP	PROS	CONS
The Liferay Digital Experience Platform is an open-source, cloud-ready framework for building custom digital solutions. The platform is best for enterprises that need to deliver dynamic portals for employees, customers, or partners.	The Liferay platform makes it easier to create dynamic enterprise-grade portals. Beyond that, the platform has many applications and tools in the form of portlets out of the box that enables further customization.	Many Liferay customers complain about its lack of user-friendly documentation despite a large and active open-source community. This makes implementations and integrations slower for internal development teams.
2. IBM EXPERIENCE MANAGER	PROS	CONS
The IBM Digital Experience Platform is a combination of its IBM Digital Experience Manager and its Watson Content Hub. The platform is best for enterprises that need to manage and publish content to a multitude of devices.	The IBM DXP has many personalization features out of the box for creating highly engaging customers experiences. The tools are user-friendly and deeply customizable for managing dynamic content.	Many commonly used features like deploying new tasks or installing new nodes are not built into the platform, so implementation can take a long time. From a content authoring standpoint, changing templates is difficult and time-consuming.

3. ADOBE EXPERIENCE MANAGER	PROS	CONS
The Adobe Experience Manager combines digital asset management with content management to deliver personalized experiences to market fast. The platform is best for global companies that have multiple websites for different brands or regions.	Adobe's digital experience platform makes managing large volumes of content across multiple sites easier with drag-and-drop components, multisite live copy features, and features that support content repurposing. It's also seamless to integrate with other products from the vendor such as Adobe Analytics.	Many users complain that the platform is complicated to use, citing an inconsistent UI/UX. That's often the case because many of the technologies within Adobe AEM (and the wider Adobe software landscape) were integrated after following Adobe's acquisition and amalgamation of third-party software.
4. CORE DNA	PROS	CONS
The Core dna platform is a headless CMS and digital experience platform that's built for innovative digital teams who want agile vendor support, the ability to scale up and down quickly, as well as regular software upgrades behind the scenes.	Core dna's all-in-one DXP has the ability to deliver websites, eCommerce site, intranets, portals, single-page applications, progressive web apps, and digital communities out of the box. Core dna has the tooling necessary to build complex, content-rich websites in a matter of weeks. Everything is one place, seamlessly integrated with CRMs, ERPs, payment gateways, and other external systems.	In comparison to other vendors, Core dna has a small number of implementation agency partners for customers to choose from. However, the Core dna team regularly supports implementations and new projects for existing Core dna customers.

6. Conclusion

The paper clearly shows most relations between Digital Experience Platform (DXP) and Content Management System (CMS) and also explains all notable similarities and differences between DXP and CMS. The paper traces in parallel and together the roots, history, evolution and current development of DXP and CMS and the interdependencies between them.

The paper gives simple comparative characteristic between the most important DXP and CMS systems. It also present some brief selection criteria which are helpful during the practical process for choosing appropriate business solution between DXP and CMS. The paper provide additional information on DXP and CMS, which can be useful on conceptual and practical level.

The paper can be very useful as an introduction to the world of DXP and CMS and as a short guide for choosing between DXP and CMS platform. It can also be a quick reference in the field of DXP research and DXP applications.

The appliance of DXP and CMS platforms is becoming very important for different types of organizations and businesses due to increasing competition and increasing demands from their users. DXP and CMS are often one of the most used links between organizations and their users, customers, suppliers, partners and other stakeholders. For this reason, some modern and adaptive organizations and companies have begun to apply DXP and CMS as a key element in their strategies, so that they can manage and improve the overall user experience of their customers and have a competitive advantage. For this reason, managers and experts from these organizations need up-to-date information that allows them to make informed decisions about the use of DXP and CMS in their business. For these reasons the relation between DXP and CMS is a promising area for future research.

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Natural Language Processing Techniques for Understanding Information

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Abstract. Learning from unstructured data is essential in Natural language processing (NLP). NLP's specific tasks, such as text or speech processing and summarization require creating specific models to enable detection of patterns and meaningful information. Challenges in natural language processing exclusively begin with understanding data using necessary data mining and learning approaches. This paper reviews Natural language understanding's main tasks – analysing aspects of a language and transforming the data into useful representations. The text describes common techniques used when mining language data and reviews three of the most used techniques for extracting information to process natural languages. These are the basic technique for identifying objects in a text - Named entity recognition (NER), the widely used sentiment analysis, and text summarization. The main goal of the paper is to outline basic use cases of Natural language processing to understand data and to examine the problems of mining unstructured language data.

Keywords. Natural Language Processing, Natural Language Understanding, Data Mining, Text analysis, Language Recognition

1. Introduction

Natural-language processing (NLP) technology involves the ability to turn text or audio speech into encoded, structured information, based on an appropriate ontology. The structured data may be used simply to classify a document, or it may be used to identify findings, procedures, medications, allergies and participants. Considered a subtopic of NLP, Natural Language Understanding (NLU) is a vital part of achieving successful NLP. NLU is narrower in purpose, focusing primarily on machine reading comprehension: getting the computer to comprehend what a body of text really means in order to successfully comprehend the content, and process it accordingly.

Natural language understanding can be applied to a bunch of processes, such as:

- Categorizing text;
- Gathering news;
- Archiving individual pieces of text;
- On a larger scale, analyzing content.

Real-world examples of NLU range from small tasks like issuing short commands based on comprehending text to some small degree, like rerouting an email to the right person based on a basic syntax and lexicons.

It's best to view Natural Language Understanding as a first step towards achieving NLP - before a language can be processed by a computer program, it must be understood at first. Language understanding is often broken down into three levels:

- Syntax - understanding the grammar of the text;

- Semantics - understanding the meaning of the text;
- Pragmatics - understanding what the text is trying to achieve.

Language is hard enough for a person to learn—we don't have a single way to ensure language acquisition. More complicated are the ways that languages are always shifting, adding and subtracting from a vast lexicon, incorporating ways that emails, texts, social media are used to affect language. In order to achieve such complex goals, NLU uses tools and techniques, such as:

- Named Entity Recognition - processing a text and identifying certain occurrences of words or expressions as belonging to particular categories of Named Entities;
- Sentiment Analysis - automating the process of extracting knowledge and insight from text;
- Text Summarization - the task of producing a concise and fluent summary while preserving key information content and overall meaning.

Therefore, to understand fully how NLU works and how it contributes to the whole NLP paradigm, shall we investigate the three mentioned above techniques.

2. Named Entity Recognition

Named Entity recognition involves processing a text and identifying certain occurrences of words or expressions as belonging to particular categories of Named Entities (NE). NE recognition software may serve as an important pre-processing tool for tasks such as information extraction, information retrieval and other text processing applications. To continue with, Named Entity Extraction forms a core subtask to build knowledge from semi-structured and unstructured text sources. Some of the first researchers working to extract information from unstructured texts recognized the importance of "units of information" like names (such as person, organization, and location names) and numeric expressions (such as time, date, money, and percent expressions). They coined the term Named Entity in 1996 to represent these.

NER is intuitively simple, because many named entities are proper names and most of them have initial capital letters and can easily be recognized by that way, but for machine, it is so hard. One might think the named entities can be classified easily using dictionaries, because most of named entities are proper nouns, but this is a wrong opinion. Even though named entities are registered in the dictionary, it is not easy to decide their senses. Most problems in NER are that they have semantic (sense) ambiguity, on the other hand, a proper noun has Different senses according to the context. For e.g., when is The White house an organization, and when is it a location? When is August a person's name? And when is it a month name?

Automatically extracting proper names is useful to many problems such as machine translation, information retrieval, question answering and summarization. For instance, the key to a question processor is to identify the asking point (who, what, when, where etc), so in many cases the asking point corresponds to a NE. In biology text data, the named entity system, can automatically extract the predefined names from raw documents. The goal of named entity recognition and extraction is to extract and classify names into some particular categories from text by respect to the sense of names. Extraction rules are what fuel the extraction of entities in text and may be based on pattern matching, linguistics, syntax, semantics or a combination of approaches. Entity extraction based on semantic technologies can disambiguate meaning and understand context, therefore enabling a number of useful downstream operations valuable for a variety of functions for business and security/intelligence. These include:

- Entity Relation Extraction – it reveals direct relationships, connections or events shared among different entities as well as complex relationships through inferred, indirect connections;
- Linking - it establishes links between knowledge banks; for example, it could identify all of the places mentioned in a corpus and link to the corresponding location on a map, or cross-reference entities with other information sources;
- Fact Extraction – it extracts all of the data associated with an entity to respond to question answering or queries from a corpus (in contrast to a query that would just return a list of documents containing the “answers”).

3. Sentiment Analysis

Deciding what letter, word, or image has been presented to us, recognizing faces or voices, sorting mail, assigning grades to homeworks is what the human brain does in order to “assign” a category to an input. One common text categorization task, sentiment analysis, the extraction of sentiment, the positive or negative orientation that a writer expresses toward some object. A review of a movie, book, or product on the web expresses the author’s sentiment toward the product, while an editorial or political text expresses sentiment toward a candidate or political action. Sentiment analysis (or opinion mining) is a natural language processing technique used to determine whether data is positive, negative or neutral. Sentiment analysis is often performed on textual data to help businesses monitor brand and product sentiment in customer feedback and understand customer needs.

The simplest version of sentiment analysis is a binary classification task, and the words of the review provide excellent cues. Words like *delicious*, *amazing*, *bad* or *good* are informative enough. However, sentiment analysis models focus on polarity (positive, negative, neutral) but also on feelings and emotions (angry, happy, sad, etc), urgency (urgent, not urgent) and even intentions. Depending on how you want to interpret queries, you can define categories to meet your sentiment analysis needs. Thus, these are some of the most popular types of sentiment analysis:

- Fine-grained Sentiment Analysis

If polarity precision is important to the current task, polarity categories can include descriptions, such as:

- Very positive;
- Positive;
- Neutral;
- Negative;
- Very negative.

This is usually referred to as fine-grained sentiment analysis, and could be used to interpret 5-star ratings in a review, for example:

- Very Positive = 5 stars;
- Very Negative = 1 star

- Emotion detection

This type of sentiment analysis aims to detect emotions, like happiness, anger, sadness, etc. Many emotion detection systems use lexicons (lists of words and the emotions they convey) or complex machine learning algorithms. One of the downsides of using lexicons is that people express emotions in different ways. Some words that typically express anger, like bad or kill might also express happiness.

- Aspect-based Sentiment Analysis

Usually, when analysing sentiments of texts, for e.g. product reviews, people want to know which particular aspects or features others are mentioning in a positive, neutral, or negative way. That's where aspect-based sentiment analysis can help.

4. Text Summarization

Text summarization is the task of producing a concise and fluent summary while preserving key information content and overall meaning. There are two different approaches that are used for text summarization:

- Extractive Summarization - this approach allows to be identified the important sentences or phrases from the original text and extract only those from the text;
- Abstractive Summarization – this approach generates new sentences from the original text. The sentences generated through abstractive summarization might not be present in the original text.

4.1. Extractive Summarization

All extractive summarizers are formed of three tasks:

1. *Construction of an intermediate representation of the input text*

There are two types of representation-based approaches: topic representation and indicator representation. Topic representation transforms the text into an intermediate representation and interpret the topics discussed in the text. The techniques used for this differ in terms of their complexity, and are divided into frequency-driven approaches, topic word approaches, latent semantic analysis and Bayesian networks models. Indicator representation describes every sentence as a list of formal features (indicators) of importance such as sentence length, position in the document, having certain phrases, etc.

2. *Scoring the sentences based on the representation*

When the intermediate representation is generated, an importance score is assigned to each sentence. In topic representation approaches, the score of a sentence represents how well the sentence explains some of the most important topics of the text. In indicator representation, the score is computed by aggregating the evidence from different weighted indicators.

3. *Selection of a summary comprising of a number of sentences*

The summarizer system selects the **top k most important sentences** to produce a summary. Some approaches use algorithms to select the important sentences and some approaches may convert the selection of sentences into an optimization problem where a collection of sentences is chosen, considering the constraint that it should maximize overall importance and coherency and minimize the redundancy.

4.2. Abstractive Text Summarization

Abstractive summarizers do not select sentences from the originally given text passage to create the summary. Instead, they produce a paraphrasing of the main contents of the given text, using a vocabulary set different from the original document. People also create a semantic representation of the document in their brains. Then they pick words from their general vocabulary that fit in the semantics, to create a short summary that represents all the points of the actual document. Let's look at the most used approaches to the problem:

1. *Extraction of keywords*

Usually word embeddings are not enough, because for summarization it is needed to focus on the context and the keywords in the piece of text. The embeddings help to get a

general idea about a word, but it has nothing to do with the context of the text. So, the paper proposed to take into consideration factors like part of speech tags, named-entity tags, and TFIDF statistics of a word alongside embeddings to represent a word. We convert the continuous TFIDF values into categorical value, using bins. Finally, we take all of the features and embeddings for a word and create a new embedding for the words. So, basically the TFIDF, POS tags gives us an idea about how important are the words are in the context of the document and the word embeddings give a general idea about the word. Next, we concatenate them into a single long vector and feed to network. One thing to notice is, we use only word embeddings to represent the words in the target side.

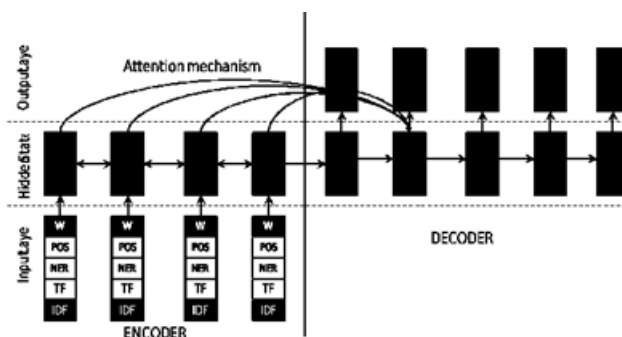


Fig. 1. Keyword Extraction Using Decoder

2. Application of sequence-to-sequence RNNs

This approach is originally proposed in a paper by R. Nallapati, B. Zhou and their colleagues from IBM. The term “sequence to sequence models” is used because the models are designed to create an output sequence of words from an input sequence of words. The input sequence in the considered case is the actual text document and the output sequence is the shortened summary.

The paper proposes a model inspired by an attentional Recurrent Neural Network encoder-decoder model which was first proposed for machine translation by Dzmitry Bahdanau, Jacob’s University, Germany.

Though, the problems are a lot different as you can already sense. First, for machine translation, we need the translation to be loss-less as we want the exact sentence in a translated form, but for Summary Generation, we need to compress the original document, to create the summary, so it needs to be a bit lossy. Secondly, for a summary generation, the length of the summary does not depend on the original text. These two points are the key challenges in the problem as given by the problem.

4. Conclusion

Challenges in natural language processing begin with understanding data using necessary data mining and learning approaches. Natural language understanding’s main task – analysing aspects of a language and transforming the data into useful representations, usually begin their running using tools and techniques which involve natural language understanding. Mining language data using three of the most used techniques for extracting information to process natural language - Named entity recognition (NER), the widely used sentiment analysis, and text summarization, lead to outstanding results and allow deeper and sophisticated research.

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Some Theorems and Approaches for the Studying of Pendulum Equations

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Abstract. Some theorems are worked out in the article, which refer to an autonomous case of a second-order differential equation with constant coefficient, known as pendulum equation. The conservative and the dissipative case are examined thoroughly. An original approach for the studying of the oscillations of two connected oscillators is attached.

Keywords. Dynamical systems, Ordinary differential equation, Autonomous differential equations.

1. Introduction

Second-order ordinary differential equations are most commonly used to describe processes in a variety of fields of science. For example, the second principle of Newton's dynamics is expressed by a second-order differential equation. When equations are time-dependent, they are called non-autonomous, otherwise they are autonomous. In this paper, cases are analyzed when these equations have a periodic solutions. We have limited ourselves to linear systems that are well studied, but offer a different approach than conventional acceptance. The purpose in this case is to show that even for relatively simple systems, things can always be viewed differently.

2. Ordinary Differential Equations

We consider the pendulum equation, using some ideas of [1]:

$$\ddot{q} + \omega^2 q = 0. \tag{1}$$

Lemma .1. Let q_1 be the solution of equation (1), then the function

$$p_1 = q_1 \int \frac{dt}{q_1^2}$$

is also solution of equation (1).

Proof. Let q_1 be a solution of equation (1). Let x be a differentiable function, which we will choose so that $q_2 = q_1 \cdot x$ is also a solution of equation (1). The existence of x is guaranteed by the fact that for $x = 1$ follows the trivial case $q_2 = q_1$. Then replacing q_2 in (1) we arrive at the equation:

$$\ddot{x}q_1 + 2\dot{q}_1\dot{x} = 0. \quad (2)$$

From equation (2) it is easy to find a solution for \dot{x}

$$\dot{x} = C_1 q_1^{-2}, \quad (3)$$

$$C_1 = \text{const}, C_1 \neq 0.$$

We integrate (3) and finally we get:

$$x = C_1 \int \frac{dt}{q_1^2} + C_2, C_2 = \text{const}. \quad (4)$$

By performing the multiplication we get:

$$q_2 = q_1 \cdot x = C_1 q_1 \int \frac{dt}{q_1^2} + C_2 q_1. \quad (5)$$

Since q_2 and q_1 are solutions of (1) and from the linearity of the equation, it follows that:

$$p_1 = q_1 \int \frac{dt}{q_1^2} = \frac{1}{C_1} q_2 - \frac{C_2}{C_1} q_1, \quad (6)$$

is also solution of (1).

Theorem .1. If q_1 is a solution of equation (1) and

$$p_1 = q_1 \int \frac{dt}{q_1^2},$$

then q_1 and p_1 form a fundamental system of solutions for equation (1).

Proof. From the previous lemma if q_1 is a solution of equation (1)

$$p_1 = q_1 \int \frac{dt}{q_1^2}$$

it is also a solution of (1). We form Wronski's determinant for the two private solutions:

$$W = \begin{vmatrix} q_1 & p_1 \\ \dot{q}_1 & \dot{p}_1 \end{vmatrix} = q_1 \dot{p}_1 - \dot{q}_1 p_1 = q_1^2 \cdot \frac{d}{dt} \left(\int \frac{dt}{q_1^2} \right) = 1.$$

Therefore q_1 and p_1 form a fundamental system of solutions for equation (1).

We pass from equation (1) to a system of first order linear equations:

$$\dot{q} = p, \quad (7)$$

$$\dot{p} = -\omega^2 q. \quad (8)$$

We lay

$$\psi = \omega q + i\dot{q}, \quad (9)$$

$$\psi^* = \omega q - i\dot{q}. \quad (10)$$

We reach the differential equations:

$$i\dot{\psi} = \omega\psi, \quad (11)$$

$$i\dot{\psi}^* = -\omega\psi^*. \quad (12)$$

For the system of equations (11) and (12) the equality is valid:

$$\psi\psi^* = 2E = \text{const} . \quad (13)$$

Proof. The equations are fulfilled:

$$i \frac{d}{dt}(\psi\psi^*) = i\dot{\psi}\psi^* + i\dot{\psi}^*\psi = \omega\psi\psi^* - \omega\psi^*\psi = 0 ,$$

$$p^2 + \omega^2 q^2 = \text{const} = 2E .$$

It can be easily proved, that the solution of equation (11) is given by the expression:

$$\psi = \frac{C_1}{\omega} \cos \tau + \frac{C_2}{\omega} \sin \tau + i(-C_1 \sin \tau - C_2 \cos \tau) , \quad (14)$$

where $\tau = \omega t + \theta$, $\theta = \text{const}$, $C_1 = \text{const}$, $C_2 = \text{const}$.

Indeed, the solution of (11) is generally the expression:

$$\psi = \psi_0 \exp(-i\omega t) = (C_1 + iC_2) \exp(-i\theta) \exp(-i\omega t) .$$

From the Euler formula is obtained:

$$\psi = C_1 \cos \tau + C_2 \sin \tau - iC_1 \sin \tau + iC_2 \cos \tau .$$

We compare with (9) and we get:

$$\omega q = C_1 \cos \tau + C_2 \sin \tau ,$$

$$\dot{q} = -C_1 \sin \tau + C_2 \cos \tau .$$

Lemma .2. Let

$$i\dot{\psi} = (\omega_1 + \omega_2)\psi , \quad (15)$$

then the solution of equation (15) is given by the expression:

$$\psi = \psi_1 \psi_2 ,$$

where

$$i\dot{\psi}_1 = \omega_1 \psi_1 ,$$

$$i\dot{\psi}_2 = \omega_2 \psi_2 .$$

Proof. Let

$$i\dot{\psi} = (\omega_1 + \omega_2)\psi$$

and

$$i\dot{\psi}_1 = \omega_1 \psi_1 ,$$

$$i\dot{\psi}_2 = \omega_2 \psi_2 .$$

Then it is done:

$$i \frac{d}{dt}(\psi_1 \psi_2) = \omega_1 \psi_1 \psi_2 + \omega_2 \psi_1 \psi_2 = (\omega_1 + \omega_2) \psi_1 \psi_2 ,$$

therefore

$$\dot{\psi} = \psi_1 \dot{\psi}_2 .$$

Theorem .2. The equation:

$$i \dot{\psi} = \omega \psi ,$$

where ω is complex number, have a periodic solution at $\text{Re}(\omega) \neq 0$.

Proof. Let $\omega = \omega_0 + i\omega_1$, $\omega_0 \neq 0$, then from the previous considerations and Lemma 2. follows:

$$\psi = e^{\omega t} \left[C_1 \cos(\omega_0 t + \theta) + C_2 \sin(\omega_0 t + \theta) + i(C_3 \sin(\omega_0 t + \theta) + C_4 \cos(\omega_0 t + \theta)) \right]$$

where θ , C_1 , C_2 , C_3 и C_4 are arbitrary constants .

Let $\omega_0 = 0$, then

$$\psi = \psi_0 e^{\omega_1 t} ,$$

The expressions is not a periodic function.

Let us study the differential equation of an oscillator in the presence of friction forces:

$$\ddot{q} + \beta \dot{q} + \omega^2 q = 0 . \quad (16)$$

We perform the substitution:

$$\psi = \omega q + \lambda i \dot{q} , \quad (17)$$

Where λ is the constant to be determined.

By differentiating (17) and using (16) we arrive at the expression:

$$i \dot{\psi} = \lambda \omega \left[\omega q + \left(\frac{\beta}{\omega} + \frac{i}{\lambda} \right) \dot{q} \right] . \quad (18)$$

We will look for such a value of the constant λ that we arrive at a linear differential equation of the form:

$$i \dot{\psi} = \lambda \omega \psi . \quad (19)$$

We choose $i\lambda = \frac{\beta}{\omega} + \frac{i}{\lambda}$. Then we determine the value of the constant

$$\lambda_{1,2} = \frac{-i\frac{\beta}{\omega} \pm \sqrt{\frac{4\omega^2 - \beta^2}{\omega^2}}}{2}. \quad (20)$$

Let's look at the important case: $\frac{\beta}{2} < \omega$. Then:

$$\lambda_{1,2} = -\frac{i\beta}{2\omega} \pm 1 + O\left(\frac{\beta^2}{4\omega^2}\right). \quad (21)$$

Equation (19) yields the species:

$$i\dot{\psi} = \left(-\frac{i\beta}{2} \pm \omega\right)\psi. \quad (22)$$

Let us write down the two equations deriving from (22):

$$\dot{\psi}_1 = \left(-\frac{\beta}{2} + i\omega\right)\psi_1, \quad (23)$$

$$\dot{\psi}_2 = \left(-\frac{\beta}{2} - i\omega\right)\psi_2. \quad (24)$$

The solution of these equations are respectively:

$$\psi_1 = A \exp\left(-\frac{\beta}{2}t + i\omega t + i\theta\right), \psi_2 = B \exp\left(-\frac{\beta}{2}t - i\omega t - i\theta\right),$$

Where A , B and θ are constants. In addition:

$$\psi = C_{01}\psi_1 + C_{02}\psi_2, \quad (25)$$

C_{01} and C_{02} are constants. Using the formulas of Euler and Lemma.2.

We come to a common solution:

$$\psi = e^{-\frac{\beta}{2}t} \left[C_1 \cos(\omega t + \theta) + C_2 \sin(\omega t + \theta) + i(C_3 \sin(\omega t + \theta) + C_4 \cos(\omega t + \theta)) \right] \quad (26)$$

such as C_1 , C_2 , C_3 and C_4 are arbitrary constants.

3. Systems of differential equations

We consider the system:

$$\ddot{q}_1 + \nu_1^2 q_1 - \lambda_1^2 q_2 = 0, \quad (27)$$

$$\ddot{q}_2 + \nu_2^2 q_2 - \lambda_2^2 q_1 = 0. \quad (28)$$

Let's make the substitution:

$$\Theta = \omega_1 q_1 + \omega_2 q_2 + i\kappa_1 \dot{q}_1 + i\kappa_2 \dot{q}_2, \quad (29)$$

Where $\omega_1, \omega_2 \rightarrow, \kappa_1, \kappa_2$, are constants to be determined so as to reduce the system to a first-order differential equation in the simplest form. We differentiate (29) and multiply it by the imaginary unit:

$$i\dot{\Theta} = (\kappa_1 \nu_1^2 - \lambda_2^2 \kappa_2) q_1 + (\kappa_2 \nu_2^2 - \lambda_1^2 \kappa_1) q_2 + i\omega_1 \dot{q}_1 + i\omega_2 \dot{q}_2. \quad (30)$$

We will determine the coefficients so as to arrive at an equation of the form

$$i\dot{\Theta} = \Omega \Theta. \quad (31)$$

Reaching the system:

$$\begin{aligned} \kappa_1 \nu_1^2 - \lambda_2^2 \kappa_2 &= \omega_1 \Omega, \\ \kappa_2 \nu_2^2 - \lambda_1^2 \kappa_1 &= \omega_2 \Omega, \\ \omega_1 &= \kappa_1 \Omega, \\ \omega_2 &= \kappa_2 \Omega. \end{aligned} \quad (32)$$

This system comes down to a homogeneous algebraic system:

$$\begin{aligned} (\nu_1^2 - \Omega^2) \omega_1 - \lambda_2^2 \omega_2 &= 0, \\ -\lambda_1^2 \omega_1 + (\nu_2^2 - \Omega^2) \omega_2 &= 0. \end{aligned} \quad (33)$$

The system (33) may have non-trivial solutions when:

$$\begin{vmatrix} \nu_1^2 - \Omega^2 & -\lambda_2^2 \\ -\lambda_1^2 & \nu_2^2 - \Omega^2 \end{vmatrix} = 0. \quad (34)$$

From here we get the equation for determining Ω :

$$\Omega^4 - (\nu_1^2 + \nu_2^2) \Omega^2 + \nu_1^2 \nu_2^2 - \lambda_1^2 \lambda_2^2 = 0. \quad (35)$$

The solution of (35) determines two possible values for Ω :

$$\Omega_{1/2} = \frac{1}{2} \left(\nu_1^2 + \nu_2^2 \mp \sqrt{(\nu_1^2 - \nu_2^2)^2 + 4\lambda_1^2 \lambda_2^2} \right). \quad (36)$$

Its quantities ν_1 and ν_2 are called partial frequencies of the system, Ω_1 and Ω_2 are normal frequencies of the system. By determining the two values for Ω , the coefficients ω_1 and ω_2 can be easily found:

$$\omega_1^i = \frac{\lambda_2^2 \kappa_2 \Omega_i}{\nu_1^2 - \Omega_i^2}, \quad (37)$$

$$\omega_2^i = \frac{\lambda_1^2 \lambda_2^2 \kappa_2 \Omega_i}{(\nu_1^2 - \Omega_i^2)(\nu_2^2 - \Omega_i^2)}, \quad i = 1, 2. \quad (38)$$

We are looking for a solution of (31) in the form:

$$\Theta = (A_1 + iA_2)e^{-i(\Omega_1 t + \theta_1)} + (B_1 + iB_2)e^{-i(\Omega_2 t + \theta_2)}. \quad (39)$$

The quantities: $A_1, A_2, B_1, B_2, \theta_1, \theta_2$ are arbitrary constants. In equation (39), the imaginary unit is denoted by i . Using Euler's formulas we arrive at the expression:

$$\begin{aligned} \Theta = & A_1 \cos(\Omega_1 t + \theta_1) + A_2 \sin(\Omega_1 t + \theta_1) + B_1 \cos(\Omega_2 t + \theta_2) + B_2 \sin(\Omega_2 t + \theta_2) + \\ & + i(-A_1 \sin(\Omega_1 t + \theta_1) + A_2 \cos(\Omega_1 t + \theta_1) - B_1 \sin(\Omega_2 t + \theta_2) + B_2 \sin(\Omega_2 t + \theta_2)). \end{aligned} \quad (40)$$

Let

$$q_1 = A_1^1 \cos(\Omega_1 t + \theta_1) + A_2^1 \sin(\Omega_1 t + \theta_1) + B_1^1 \cos(\Omega_2 t + \theta_2) + B_2^1 \sin(\Omega_2 t + \theta_2), \quad (41)$$

$$q_2 = A_1^2 \cos(\Omega_1 t + \theta_1) + A_2^2 \sin(\Omega_1 t + \theta_1) + B_1^2 \cos(\Omega_2 t + \theta_2) + B_2^2 \sin(\Omega_2 t + \theta_2), \quad (42)$$

where A_j^i, B_j^i are constants, $i = 1, 2, j = 1, 2$.

If we define

$$x = A_1^1 \cos(\Omega_1 t + \theta_1) + A_2^1 \sin(\Omega_1 t + \theta_1), \quad (43)$$

$$y = B_1^1 \cos(\Omega_2 t + \theta_2) + B_2^1 \sin(\Omega_2 t + \theta_2), \quad (44)$$

then it will turn out:

$$q_1 = x + y, \quad (45)$$

$$q_2 = \sigma_1 x + \sigma_2 y, \quad (46)$$

where σ_1 and σ_2 are constants to be determined. The variables x and y are called the normal coordinates of the system. It turns out:

$$\begin{aligned}(\nu_1^2 - \Omega_1^2 - \lambda_1^2 \sigma_1)x + (\nu_1^2 - \Omega_2^2 - \lambda_1^2 \sigma_2)y &= 0, \\(\nu_2^2 \sigma_1 - \Omega_1^2 \sigma_1 - \lambda_2^2)x + (\nu_2^2 \sigma_2 - \Omega_2^2 \sigma_2 - \lambda_2^2)y &= 0.\end{aligned}\quad (47)$$

Taking into account equation (35) we obtain:

$$\sigma_1 = \frac{\nu_1^2 - \Omega_1^2}{\lambda_1^2} = \frac{\lambda_1^2}{\nu_2^2 - \Omega_1^2}, \quad (48)$$

$$\sigma_2 = \frac{\nu_1^2 - \Omega_2^2}{\lambda_1^2} = \frac{\lambda_2^2}{\nu_2^2 - \Omega_2^2}. \quad (49)$$

The quantities σ_1 and σ_2 are called the coefficients of distribution of the amplitudes, respectively, for Ω_1 and Ω_2 .

4. Conclusion

Mathematics is considered a science, which is the language in which the sciences dealing with models are expressed. With this article, we want to demonstrate the possibilities of mathematics for this expression to be realized in different ways for the same phenomenon. It is always preferable the most direct way to the goal, but sometimes the goal is not to get the solution. It is often necessary to derive some properties and regularities inherent in a whole class of models or to look for analogies between two different classes of models. Mathematics makes it possible to rediscover the same things in different ways, and therein lies part of the beauty of this science.

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