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ACeSYRI

Preface

This proceeding presents post-workshop publications of young researchers from different countries. The presentations from two workshops on ACeSYRI have been included in this book.

The ***Third Workshop on ACeSYRI: Modern Experience for PhD students and Young Researchers*** is organized as an extra event of the International Conference on Information and Digital Technologies (IDT 2023). The main objective of the event is to bring together PhD students, young researchers, and teachers from the academy as well as industry working in Informatics. We expected that young workshop participants would obtain useful information about modern trends in Informatics. The young researchers made also short presentations about their own research, and the workshop allowed them to discuss it with recognized experts. This Workshop on ACeSYRI was managed by the *Faculty of Management Science and Informatics of the University of Zilina* (Slovakia).

The other was the ***Fourth Workshop on ACeSYRI: Modern Experience for PhD students and Young Researchers***. The workshop was managed by the *Research Center for Automatic Control of Nancy* (CRAN) which is a joint research unit between the University of Lorraine and the French National Scientific Research Center (CNRS), and in cooperation with the *Faculty of Management Science and Informatics* of the University of Žilina. This event provided a forum for the presentation and discussion of scientific contributions covering the theories and methods in the field of information technologies, and their application to a wide range of industrial, civil, and social sectors and problem areas. The workshop was also an opportunity for researchers, practitioners, academics, and engineers to meet, exchange ideas, and gain insights from each other.

The organization of these events was supported by the project: ***Advanced Centre for PhD Students and Young Researchers in Informatics*** (ACeSYRI) (Project EACEA.CBHE no.: 610166-EPP-1-2019-1-SK-EPPKA2-CBHE-JP supported by the European Union's Erasmus+ programme).

These ACeSYRI workshops were intended for PhD students, young researchers, and educators. The main goal of the workshop is a presentation of ACeSYRI project results to representatives from the EU and other countries. The young researchers could present at the workshop with their lectures about their own scientific research. The next aim was to establish and expand international contacts and cooperation among young researchers.

The review process was mainly organized by the ACeSYRI project management Team and the process was made by a large number of reviewers, who are gratefully acknowledged for their contributions to the improvement of quality of the accepted papers. The members of the Program committees of these workshops were grateful to all reviewers who helped us to select papers for presentation at the workshops and publication in this proceeding.

We thank all the contributed paper authors for their submissions and presentations.

The organization teams of ACeSYRI workshops

Website of the Third Workshop on ACeSYRI:
https://idt.fri.uniza.sk/index.php?clanok=workshop_acesyri

Website of the Fourth Workshop on ACeSYRI: **https://acesyri.sciencesconf.org**

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ANALYSIS OF EDUCATIONAL DATA USING DATA-MINING TOOLS

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Abstract- The changes currently taking place in the world impose qualitatively new requirements for systems and their management. Process management in educational institutions requires reliable information, for this purpose a large amount of data is collected and analyzed. The paper presents the results of a study to identify factors that influence the learning outcome of students, that is, the probability of completing a full course of OP using regression analysis and building a neural network. The study was conducted on the basis of a regional university of Kazakhstan.

Keywords- data analysis, management in education, regression analysis, neural networks.

I. INTRODUCTION

The education system has always been considered a conservative industry, and is currently crossing the threshold of fundamental changes. For example, many believed that "digital learning" is just a fashionable topic that will pass over time, but now we are seeing the widespread development of online learning platforms. Microsoft has published data that more than 30 million people in 249 countries gained access to new digital skills during the COVID-19 pandemic. More than 10,000 Kazakhstanis are among the participants of the program [1]. School graduates have become more likely to choose online courses for obtaining a profession [2]. In developing countries, many experts believe that digital learning will lead to mass education among the population, because the costs of creating online platforms, mobile applications are significantly lower than the construction of university educational buildings, dormitories [3]. People have increasingly begun to prefer online courses rather than studying in educational institutions. The Digital Kazakhstan program notes that "Digitalization is significantly ahead of the existing system of production requirements for the composition of professions employed in the labor market. The lack of an operational link between the labor market and the education system can simultaneously lead to the training of no longer in demand personnel and the release of personnel in disappearing professions" [4]. Based on the above, it can be argued about the impending crisis of modern universities. It is obvious that not all universities will remain relevant and in demand in the world community, but only those who responded to global challenges in time by studying the behavior of applicants studying under changing conditions. Thus, the analysis of educational data is always relevant in scientific and practical terms.

Currently, many universities invest in predictive analytics, which is provided by data generated by educational activities on the Internet, survey results, statistical indicators, and also relies on access to external consulting experts. Mathematical modeling, machine learning and artificial intelligence are increasingly being used to analyze educational data, optimize services and support students. Many universities are introducing chatbots based on artificial intelligence - to assist students when applying for admission, settling in dormitories, getting advice on various issues, etc., thereby reducing costs, as well as to obtain data on students' problems, their preferences and suggestions. For example, the project "Digital Admissions Committee" was implemented at the M.Kozybayev National Research University, within the framework of which a telegram channel (@skgu_pk_2020) and an official chatbot of the admissions committee (@Inform_PKBot) were created. Around the clock, applicants could get the information they were interested in. The London-based Edge company has invested about 3.4 million euros in the

innovative educational technology platform Springpod for student recruitment. The online platform allows employers and educational service providers to orient themselves, inform and attract students at the stage of career choice [5]. Such tools are created with the aim of the best career guidance for applicants, because many universities face the problem of large deductions of students after the end of the first year. A lot of works are devoted to this problem. For example, in [6] the authors use the predictive properties of "balanced" decision trees in identifying students who are at risk for academic performance. In [7] a methodology for predicting student performance based on cluster analysis methods is proposed. In [8] the influence of family income on the results of entrance exams, the choice of university and strategies for preparing for entrance exams is investigated. The work is based on conducting a survey and analyzing its results.

II. MATERIALS AND METHODS

During the study, statistical data for 2006-2017 for a regional university of the Republic of Kazakhstan and data taken from the website of the Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan were used as initial data [9] (Table I). The sample size for students was 14,877 students.

TABLE I
Data for analysis

X_1	Place of residence	X_1=1 if the place of residence is Petropavlovsk, X_1=0 otherwise
X_2	The average score of the school certificate	The arithmetic mean of all grades given in the document on education
X_3	Characteristics of the form of educating	X_3=1, if the student is studying on a budget basis, X_3=0 - for students on a commercial basis
X_4	GPA	Average academic performance at the university
X_5	The percentage of the population with incomes below the subsistence minimum, as a percentage	Indicator for Kazakhstan
X_6	Unemployment rate, as a percentage	Indicator for Kazakhstan
Y	the result of the educating	Y=1 if the student was expelled, Y=0 if the student graduated

Multiple correlation and regression analysis was applied to analyze the factors affecting the student's probability of graduating from university, and a neural network was built and trained. When building a neural network, the Levenberg-Marquardt method was used, according to which learning occurs "by epochs". In this case, the network error is considered for the entire training epoch and the network parameters change when all the elements of the training set have already been presented to the network [10].

III. RESULTS OF WORK

Having constructed a matrix of paired correlation coefficients in the Statistica package, it was revealed that some of the regressors are collinear with each other (X_5 and X_6,), i.e. there is a suspicion of the presence of multicollinearity. To eliminate the multicollinearity of regressors, a step-by-step regression analysis was performed, as a result of which the number of factors decreased. All parameters of the resulting model are statistically significant, the equation is significant ($p - value = 0.3 \cdot 10^{-8}$):

$$Y = 0.061 \cdot X_2 + 0.052 \cdot X_3 - 0.63 \cdot X_4 - 0.08 \cdot X_5 + \varepsilon \qquad (1)$$

The coefficient of determination (R^2 = 0.81) proves the adequacy of the model to the process under study. The analysis of random residuals indicates the absence of autocorrelation (the Darbin-Watson criterion dw = 2.09 at critical values 0.79 and 1.44), and also checked the normality of their distribution ($p - value$ = 0.91).

When building a neural network, the available statistical data were divided into 3 subsamples: training, control and test (the division was chosen as follows: 70% of the data was

used for training, 15% of the data was used for verification, 15% of the data was used during testing). The neural network training results were determined by the root-mean-square error and the value of the correlation coefficient between the network outputs and the target values (Table II).

TABLE II
Values of neural network training results by samples

	Root-mean-square error	Correlation coefficient
Training sample	0,061	0,692
Control sample	0,056	0,728
Test sample	0,065	0,638

According to the graph (Fig.1), we can notice a decrease in error during the learning process at each epoch. The training was stopped when the error on the test set stopped decreasing (at the 12th epoch).

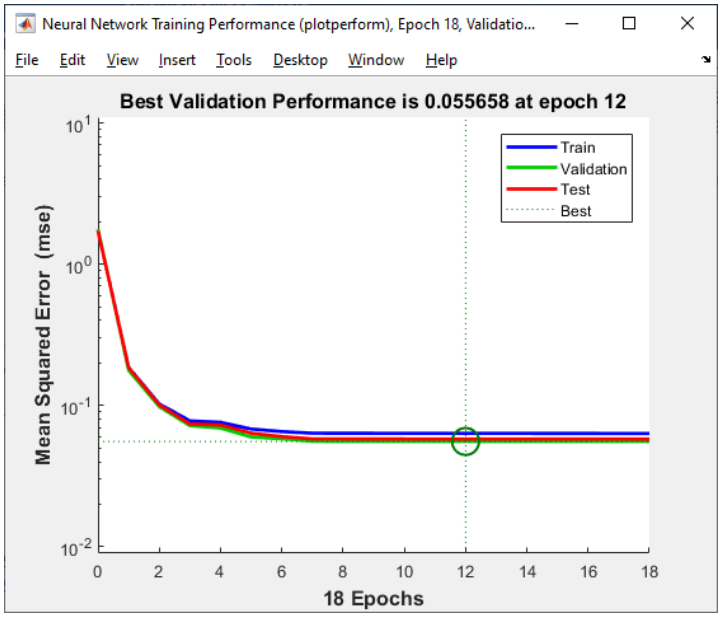

Fig. 1 Graph of the effectiveness of network training

IV. CONCLUSION

Based on the results of the data analysis, the following conclusions were made: with a decrease in the average academic achievement score (GPA), the probability of a student's expulsion will increase, this factor has the greatest impact on the learning outcome. Other factors also have an impact on the learning outcome, but their impact was the least significant. The study used a limited amount of data, in the case of a large number of data, it was possible to obtain more accurate and interesting conclusions.

Conducting this kind of research is necessary to provide the administrative management of the university with information about the current state, as well as to identify problems and develop concrete actions based on the results of the analysis to solve them.

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INTRODUCTION TO THE CAPABILITIES OF NEURAL NETWORK TECHNOLOGIES IN THE FIELD OF INDUSTRIAL PRODUCTION

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Abstract- The main goal of present article is the introduction to the capabilities of neural network technologies in the field of industrial production, especially the machine processing. On the basis of that knowledge, this article will propose a number of applications and solutions for the neural network technologies to be used in multi-purposed production lines, as well as driving force of industrial manipulators.

Keywords- neural networks; machine processing; multi-purposed production lines; industrial manipulator.

I. INTRODUCTION

Humanity's dreams of artificial intelligence are closer than ever to realization thanks to the development of neural network technologies. Although they do not directly simulate the entire biological and chemical basis of the human thought process, thanks to them it is possible to obtain a result indistinguishable from human interaction.

Neural networks do not analyze input data using embedded mathematical formulas and equations. They pass them through the so-called «neurons» formed with the help of already existing input data and the desired result. Therefore, unfortunately, large databases with similar data are required to fine-tune the neural network. However, the positive features of neural networks include the fact that even after tuning, they continue to replenish themselves with new neurons even during the execution of their algorithms.

Such technologies are convenient to use for industries where excessive accuracy can lead to massive losses in unforeseen circumstances, as well as where a wide spread and anticipated inaccuracy exclude accuracy and clarity of execution. For example, when assembling some complex mechanism on a long assembly line, manipulators and other equipment do not imply any inaccuracy in their setup. The exact part will be in its exact place, and there is no way. In complex systems, there are cases when the presence or absence of detail is monitored, but the adaptation of mechanisms to inaccuracy is not implemented due to the current approach, guided by the opinion that it is easier to eliminate inaccuracy than to take it into account. However, if we take the inaccuracy into account, which neural systems perfectly cope with, then the range of these very inaccuracies can be expanded and eliminated by adapting to them, which will lead to an obvious increase in efficiency and a radical reduction in defects, and hence losses.

Neural networks are a relatively new and very promising technology that provides new approaches to the study of dynamic problems in various fields, mainly in computing. Initially, neural networks opened up new opportunities in the field of pattern recognition, and then statistical and artificial intelligence-based decision support and problem-solving tools in the field of finance were added to this.

The ability to model nonlinear processes, work with noisy data and adaptability make it possible to use neural networks to solve a wide class of problems. In the last few years, many software systems have been developed based on neural networks for use in such matters as operations on the commodity market, image generation, simulation of human speech and behavior, making various kinds of predictions. Neural network applications cover a wide variety of areas of interest: pattern recognition and augmentation, associative search, classification, optimization, prediction, diagnostics, signal processing, abstraction, process management, data segmentation, information compression, complex mapping, modeling of complex processes, machine vision, speech recognition.

The main difference and advantage of neural networks over classical means of forecasting and classification lies in their ability to learn. At the training stage, synoptic coefficients are calculated in the process of solving problems by a neural network, in which the desired answer is determined not by rules, but by using examples grouped into training sets. So, the neural network at the training stage itself plays the role of an expert in the process of preparing data for building an expert system. Training data is required to train a neural network and it is assumed that the rules are in the structure that data. They must meet the properties of representativeness, randomness and consistency. It all depends on the class of the problem being solved. Such data are a series of examples with an indication for each of them of the value of the output parameter that would be desirable to obtain. The actions that occur in this case can be called controlled learning: a vector of source data is fed to the input of the network, and the desired value of the calculation result is reported to the output node.

Supervised learning of a neural network can be considered as a solution to an optimization problem. Its purpose is to minimize the error function on a given set of examples by selecting the values of weights. Achieving the minimum is called convergence of the learning process. Since the error depends on the weights non-linearly, it is impossible to obtain a solution in an analytical form, and the search for the global minimum is carried out through an iterative process of the so-called training algorithm. More than a hundred different training algorithms have already been developed, differing from each other in optimization strategy and error criterion.

Despite all the possibilities of neural network technologies, there is a need for their competent compilation and configuration. They absolutely rely on the object of application in everything, since it is precisely all its aspects that are analyzed. Therefore, in order to fully and correctly build such a system, it is necessary to determine the most important influencing factors to take into account, and ideally – all such factors. Only in this way will the neural system be able to fully unleash its potential as an analyzer of the full picture of the process.

This task is performed by a complex of sensors that directly collect data for the training base. This is an experimental method that involves a lot of time and resources. As a cheap, but more distant from reality method, these are mathematical models.

With the help of mathematical models, even such modeling results can be introduced into the system for training, which cannot happen during application in practice, but the system will be ready for them and used as an experience. Thus, in the absence of a database for training, which is critical for the installation of a neural network system, it is possible to correct the situation with the help of modeling and simulations. The only question is in proper design and computing power.

Now, after a full study of the subject area, with a full understanding of the work of neural networks and their potential, it is possible to assess the possibility of their introduction into industry and the consequences of such a decision. It is worth noting that all solutions imply the presence of a database and/or accounting of the data that became the cause and result in the implementation objects.

Neural network technologies were primarily developed as a means of calculation and analysis. This function is the best suited for regulatory tasks. If traditional regulators are responsible for monitoring and working in real time, then their task is to respond at a specific time to the situation in accordance with the program. That is, traditional simple solutions do not set themselves the goal of analysis, but only instant response and subsequent impact.

Neural network technologies allow us to assess the situation in a broader sense and compare experimental data with current ones. Traditional methods are not able to take into account experimental data that contain information about undesirable results. This possibly non-obvious information can be obtained by a neural network through training, since it independently creates connections based on input and output data. Thus, the neural network system is able to foresee impacts that will entail undesirable consequences. Such effects, which in traditional systems can be the only correct in a given situation by the standards of this very system.

Another function of neural networks – recognition – can be used to identify the object with which the system interacts. For example, physical processing: with this approach, samples can be

evaluated and directed to the most effective needs, perhaps even directly on the spot; physical properties such as weight, shape and other factors important for the system itself and for the final product can be determined. With the intelligent approach of neural networks to information processing, it is possible to avoid unnecessary losses, defects and thereby improve the quality of production. In the same way, multifunctional processing lines can also be configured, which adapt their programs and algorithms in accordance with heterogeneous objects, thereby creating a multi-purpose line capable of servicing multiple streams at the same time.

With the introduction of multifunctional lines based on neural networks, there is no need to narrow specialization, when the system can orient itself according to the situation. There is also a factor of reducing the amount of production waste.

This is a small part of the examples that clearly demonstrate the benefits brought by the complexity of the structures and analyses of the intelligent approach of neural network technologies. Every year this technology is being improved, as it is directly related to the computing power of the machine on which it is deployed. The greater the power, the more neurons it can create, and through more of them in a period of time, a signal can be passed for processing. Taking into account the fact that computing technology is becoming more powerful and faster every day, we can conclude about the growing capabilities of neural networks in the future.

Automated production is a complex and high–precision process in which all possible scenarios for the development of events in an industrial scenario are implied or provided for. This precision is an integral part of the process of creating this kind of production, since it relies entirely on computer technology and its programming. And they, in turn, have accuracy as their fundamental property – the program, as the embodiment of accuracy in the task performance.

Neural networks, on the other hand, destroy this fundamental concept and thereby create a new approach to programming, where accuracy is required only from the final result, and then with an acceptable error. Along with new approaches to creating programs, new opportunities for the industrial field are opening up, radically different from standard programming.

Neural network generation of the result may vary even with identical input data, which is why at the current time a significant proportion of the use of neural networks falls on obtaining various possible solutions. And since the neurons of these networks are obtained by training the system based on large volumes of already existing data, the solutions provided are usually acceptable and correct. Solutions may also include rare and non-obvious ones, resulting from the discovery of patterns that seem to be coincidences. This is also an important property of well-trained neural networks.

With the help of the described approach, it is possible to imagine the work of an industrial center, not limited to the production of specific parts, but a center capable of producing various kinds of products in parallel or simultaneously with a minimum amount of waste, from rough blanks, on the same production lines. The root driving force of such a center can be multi-purpose conveyor systems.

Neural network technology, as noted earlier, is a relatively new field that opens up completely new perspectives for working with computer technology. Computers have been able to solve previously inaccessible tasks, such as pattern recognition or making their own decisions based on large statistical data.

It was also noted earlier that the most significant properties of neural networks are adaptation and forecasting. It is these properties that attract the attention of engineers and programmers seeking to improve the operation of their systems. Neural networks are most actively implemented in management systems and economic forecasting systems in the modern world.

In the second case, such technology is used as a driving force for processing large amounts of data on financial flows and modeling possible outcomes. Such a model will have properties as close to reality as possible, which makes it possible to track processes and patterns with the highest possible accuracy at the moment.

In this paper, the first example, which directly relates to industry, is of greater interest. Control systems with the introduction of neural network technologies have become more flexible

and broader in every sense of these words: more tasks, more solutions, more precision, more control. The following few examples clearly show how a new type of computer thinking transforms production processes for the better.

The technology of the so-called «digital double» serves to obtain complete information about the production process. It can be applied both to individual parts and parts of mechanical support, and to the entire enterprise as a whole. With its help, a digital version of the monitored object is created, which receives input data and information from sensors. This data is processed by the system and creates an accurate model of the object. Information can be transmitted to the user both via the interface and using various tables. The purpose of the digital double is to exclude from the production process the need to conduct analysis, accounting and inspections directly on the spot. Because the digital double, thanks to deep learning on statistical data, makes a portrait of the object in real time. Such systems allow you to have an idea about the condition of the equipment, about wear and other characteristics that have an important impact on the flow of the production process, on the occurrence of emergency incidents or situations that can slow it down. More automated systems of this type have the ability not just to provide a picture of the condition of the object for analysis, but to make a program for possible inspection, repair or replacement of equipment. Because these systems have the ability to detect structural defects that may not be detected during a standard inspection. However, timely response to such comments helps to avoid sudden breakdowns, thereby improving the production process. Thus, the digital double is aimed at timely maintenance of equipment to eliminate emergency and emergency situations.

Computer vision was one of the first functions assigned to neural networks at the beginning of their implementation. Cameras that tracked objects made it possible to significantly improve security systems of all types: from alarm systems to labor protection. In industry, computer vision is mainly used for the operation of sorting lines, which "select" the necessary objects with the help of cameras and carry out various manipulations with them. As a rule, their work relies on color orientation, when the object contrasts strongly with the background, in particular with the conveyor belt, which makes it easier and faster to work the entire system. A relatively simpler task is to use computer neural network vision to control the quality of production. High-precision cameras get a high-quality image of the object, which analyzes the neural network to search for defects, defects, or other inconsistencies with the final product. In case of detection of a product that does not meet production quality standards, it is removed from the production process. A simple neural network task, like image analysis, becomes much more complicated when it is necessary to analyze a large flow of objects. Therefore, the quality of the resulting image and the power of computer technology directly affect the speed and quality of product analysis. It is worth noting that cameras in their simplest sense are not always used for this purpose. There are cases when it is necessary to use specialized scanners, which perform exactly the same functions.

Competent logistics is at the heart of any effective warehousing, sorting and transportation system. Each such structure should have a queue system that monitors the intensity of each of its components. Small queues and easy accessibility guarantee logistics efficiency. However, even such an obvious solution is practically not implemented in most modern warehouses, in which everything is still managed by a commodity expert or storekeeper, even if he uses modern equipment. Neural network logistics allows the system to independently make decisions about the location and transportation of goods, relying on statistical data and monitoring. Basically, such systems make up action programs for personnel. The computer system is able to conduct simulations of hundreds of decisions in a matter of moments, which gives the maximum opportunity to make the most effective decision, unlike even the most trained specialist. But the most striking example of such logistics, even if not the most common, is a fully automated robotic warehouse. Such an object completely excludes human intervention, thereby does not rely on random factors that slow down work processes.

From all the examples above, one conclusion suggests itself – in no system do neural networks directly affect the appearance, structure or properties of the final product. They perform a support and monitoring functions. And even when neural networks have the right to make their

own decisions, they are aimed at improving an existing process, and not at creating something new. Neural technologies in the modern world are able not only to adapt to the existing situation, but also to create new solutions of their own. This property does not fit into a finely honed production process, because its competent implementation requires a long, costly testing process. Let the extra costs in the industry frighten the staff, but there is a potential for such production.

As an example of a system, where decisions that are made by a neural network directly affect the end result of the product, multi-purpose conveyor system is proposed. The main task and feature of the system, which is based on the transfer of most powers to neural networks, is the independent decision-making about the manufacture of a product or part.

Rough blank pieces made of a homogeneous material, such as metal, stone or wood, first pass through an analyzer unit equipped with a variety of sensors and scanners that make up the «portrait» of the workpiece. This list of characteristics should include the most important physical properties for production: shape, weight, density, uniformity and other important parameters. Having received all the necessary information about the instance, the neural network decides on the assignment of the target product for this workpiece. The target product can be either a specific pre-embedded part in the database, or a completely new, generated 3D model. Generating such models with modern neural networks is quite feasible and a simple task. Such generation can be applied to production, where the target product is not one product of a large circulation, but a product whose shape is not defined and varies from instance to instance, for example decorative or architectural elements. The neural network is guided by minimizing waste after processing and the necessary production rate of products by quantity.

Further, after the work in the analyzer unit is completed, a unique identifier is assigned to the workpiece, by which the system determines the target product for this particular workpiece. The identifiers can be contained in electronic tags or QR codes located on the shipping baskets in which the workpieces are moved along conveyor lines inside the system.

The workpieces move along a conveyor belt or belts through a number of manipulators for various purposes, responsible directly for the work of mechanical processing.

This stage needs to be carefully worked out, because the location, order, purpose and number of these manipulators; the number and direction of conveyor belts are all determining parameters of the quality and performance of the entire system. It is necessary to develop several solutions with different specified parameters and conduct simulation with simulation to check their operability. The solution with maximum performance, that is, with minimal queues and downtime, will be decisive. In these simulations, waste minimization is no longer an influencing factor, since it played a role in determining the target function of the workpiece and does not need simulation.

There is a finished product at the exit of the system. An additional solution is the location of the second analyzer unit, which is aimed at matching the output result with the task. In this way, a qualitative assessment will be performed, as well as potential data collection for the continuation of machine learning of the neural network.

ACKNOWLEDGMENT

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PROTECTION OF INFORMATION USING TRUSTED LOADER FOR HARDWARE PLATFORMS WITH UEFI BIOS

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Abstract- The article discusses the interface between the operating system and low-level hardware management firmware - UEFI, which replaced the BIOS. It is proposed to use the capabilities of UEFI in the interests of increasing the protection of information on a personal computer. To do this, a hypothetical security module that is implemented in the UEFI firmware is described, and its functionality is given. Tasks for further research are set.

Keywords- UEFI, BIOS, trusted boot tools, information security.

I. INTRODUCTION.

Nowadays, when information plays a key role in various areas of life, data protection is becoming an increasingly important task. Hardware platforms with UEFI BIOS (Unified Extensible Firmware Interface) are the basis for the operation of computer systems, and ensuring their security becomes an integral part of information protection.

Trusted boot tools or modules are software or firmware tools that allow you to start the operating system exclusively from trusted storage media (for example, hard drives). At the same time, such devices can control the integrity of software (system files and directories of the operating system) and technical parameters (compare computer configurations at startup with those that were predefined by the administrator during initialization), and act as means of identification and authentication (using passwords and tokens).

II. METHODS

The process of booting a computer and the composition of the components involved in this process is determined by the architecture of the system. At a high level of abstraction, for most computers, boot can be represented as a set of steps shown in Figure 1. [1].

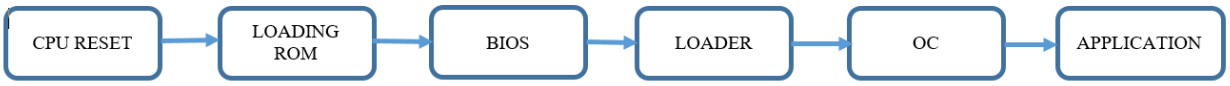

Figure 1 - Computer boot sequence at a high level of abstraction

From among the elements of the sequence presented in Figure 1, this article focuses on the basic input / output system (basic input / output system, BIOS) and UEFI (Unified Extensible Firmware Interface). The BIOS is the first firmware that runs after the computer is powered on and is stored in non-volatile memory, usually a flash memory chip, on the computer's motherboard. The main purpose of the BIOS is:

- providing initialization and testing at a low level of hardware components of the computer, including the central processor, dynamic random access memory, etc.;
- transfer of control to the operating system (OS) loader.

BIOSes can be developed by both original equipment manufacturers (OEMs) and independent developers, and are supplied to end users - motherboard and computer manufacturers.

It should be added that manufacturers frequently update system software, even before shipping, to fix bugs, support new hardware, and block vulnerabilities.

Blocking BIOS vulnerabilities is an urgent task, since, obviously, it is always preferable for a potential intruder to compromise the component that boots first - gaining control at an earlier stage allows you to spread influence to subsequent elements, such as System Management Mode code, SMM), bootloader, hypervisor, OS. If successful attacks on programs executing in user mode, in the current state of affairs, allow the offender to achieve advantages, although very significant, but still limited by the scope of the attacked program, then malicious code written in the BIOS can allow them to gain full control over the system [1]. To make matters worse, since the system BIOS is launched with high privileges early in the system boot, malicious code running at the BIOS level is very difficult to detect; in addition, it can be used to re-infect the system even after the OS has been reinstalled or even the computer's hard drive has been replaced. Under these conditions, obviously, the BIOS and the bootloader should be perceived by the intruder as more attractive objects of attack [2].

Information security tools (ISM) are a set of engineering, electrical, electronic, optical and other devices and devices, devices and technical systems, as well as other real elements used to solve various problems of information protection, including leakage prevention and ensuring the security of protected information. There are three types of information security tools: Hardware - technical devices designed to protect information.

Software - software (or a set of programs) designed to protect information.

Mixed (hardware-software) means of information protection, which include both hardware and software that closely interact with each other [3].

It is more expedient and more reliable to install a mixed type of information security tools. Trusted boot tools are:

Firmware modules of trusted boot at the expansion board level. Such devices are built into the computer case, connecting to the motherboard via a PCI connector.

Software. They are divided into BIOS Trusted Boot and Boot Record Layer. The first are built into the BIOS, which allows you to perform their functions before loading the operating system. Others replace the boot record on the hard disk and act before control passes to the operating system level[4].

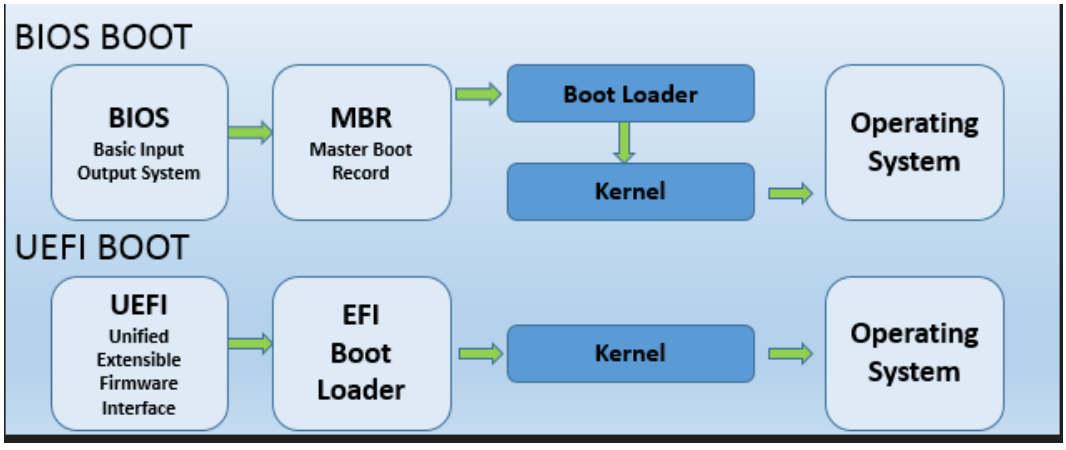

Figure 2 - BIOS vs UEFI [5].

The Unified Extensible Firmware Interface, abbreviated as UEFI, is low-level software that runs when the computer boots before loading the operating system, such as the BIOS. It aims to solve what the BIOS couldn't [5].

UEFI can (in addition to what the BIOS can):

1. Can boot from a disk larger than 2TB using GPT.

2. Provides the user with a graphical user interface that is easier to use than the old BIOS terminal interface.
3. Provide mouse support. (BIOS rarely can do this)

Some of the technical benefits of using UEFI are:

- Secure Boot. UEFI Secure Boot is an optional setting that ensures that the signature is verified during the boot process. When the PC starts, the firmware verifies the signature of every piece of boot software, including UEFI firmware drivers, EFI applications, and the operating system. If the signatures are valid, the PC boots and the firmware passes control to the operating system. Thus, the system can be protected from malicious attacks, rootkits and unauthorized software updates that can occur before the OS starts.
- GUID Partition Table (GPT): GPT support replaces the legacy Master Boot Record (MBR) partition scheme. GPT allows storage media boot partitions larger than 2 TB, more than 4 partitions (up to 128), and newer storage media such as PCI Express devices. It also improves data integrity through redundant disk layout structures.
- Platform and architecture independent: UEFI supports x86, x86_64, ARM, ARM64, PowerPC, Itanium, and others. UEFI can also be emulated through hypervisors such as Hyper-V, VMware, Xen, KVM, and more. UEFI simplifies device management through a single firmware [5].
- Consistent variables and services. A standardized set of variables, services, and drivers is common to all UEFI implementations, regardless of the host device. UEFI on a desktop PC has the same basic set of UEFI capabilities as on a device such as a smartphone. Application developers can create software tools without having to worry about platform-specific firmware oddities commonly found in BIOSes. Embedded software developers can isolate platform-specific code through modularity.
- Modularity and extensibility. UEFI firmware modules can be added, removed, or upgraded by vendors and device owners. New modules can be created to expand the device's firmware capabilities. Modules can interact with device resources (such as network adapters, RAID controllers), UEFI environment variables, and kernel-mode drivers.
- Improved boot performance: UEFI can run in 32-bit or 64-bit mode and has more address space than BIOS, which means a faster boot process. This also means that UEFI setup screens can be more attractive than BIOS setup screens, including graphics and mouse cursor support. In addition, some UEFI modules and drivers can be loaded in parallel rather than sequentially to improve boot times.

III. RESULTS

A Trusted Bootloader is a mechanism that provides information protection on hardware platforms with UEFI (BIOS) (Unified Extensible Firmware Interface). It is used to secure the boot process and prevent unauthorized access to the system.

Here are a few basic measures that are taken with a trusted downloader to protect information:

1. Digital signature verification: The trusted bootloader uses digital certificates to verify the integrity and authenticity of the boot code and system components. This helps prevent malicious or unauthorized code from loading and executing.
2. Encryption and Integrity Check: The downloader can use encryption and hashing to protect download files from unauthorized access and modification. This allows you to detect changes in the boot code and reject its execution if the integrity is violated.
3. Secure Boot Protection: Secure Boot is a UEFI BIOS feature that provides digital signature verification before the operating system boots. The trusted bootloader can manage the Secure Boot feature and add or remove trusted certificates for signature verification.
4. System startup monitoring: The trusted bootloader can record logs and system boot information for later analysis and detection of unauthorized changes. This helps to detect and respond to potential security breaches.

5. Protection from physical access: Components associated with a trusted bootloader can be physically protected using mechanisms such as write protection, seals, and secure keystores. This helps prevent unauthorized access to bootable components.

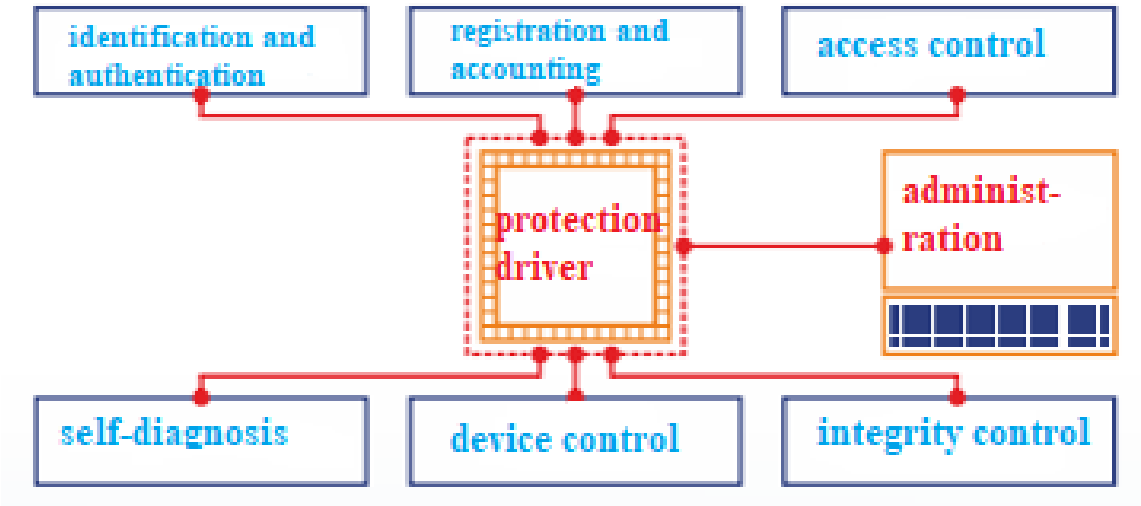

Figure 3 - Functions of the trusted boot tool

Trusted Boot Tools - a protective measure to ensure trusted boot of computer equipment. A personal computer that includes a trusted boot tool allows you to control the integrity of the following types of objects:

- File system.
- Windows registry.
- Areas of the disk.
- BIOS/CMOS.
- Hardware configuration.

In general, a trusted bootloader is an important security component of hardware platforms with UEFI BIOS. It provides information protection at different levels of the boot process and helps prevent unauthorized access and attacks on the system.

IV. CONCLUSIONS AND FURTHER PROSPECTS OF THE RESEARCH.

The BIOS has been an extremely powerful boot solution for over 20 years. However, it has reached certain limitations that hinder its further development. On the other hand, UEFI has taken many of the techniques from the BIOS and made it easier for users. Given all the benefits of UEFI, it is important to learn and master its firmware. In the future, it is necessary to study the UEFI firmware and develop a reliable custom firmware.

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ANALYSIS OF GAMIFICATION MODELS IN EDUCATION

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Abstract **-** This article discusses the gamification approach based on the use of information and gaming technologies, which has become increasingly relevant in the development of education in recent years. The authors analyze the concept of "gamification" in the context of modern education and determine the reasons for its popularity. The concept of gamification is presented, the main differences between the concepts of "game" and "gamification" are compared, and a scheme for the use of gamification in education is proposed. Also, the use of the three game mechanics of the PBL model in the form of points, scores and leaderboards, the six D steps of K. Werbach and D. Hunter, Yu-Kai Chow's "Octalization", the gamification model for e-learning are comprehensively described. The analysis is aimed at determining the rationality of using the results in the educational system through a comparative assessment of the "gamification" approach based on the use of game mechanics and elements in a non-game context. Although gamification in education is still understudied, many of the analyzed studies show its high potential, especially in terms of motivation, engagement in the learning process and improving learning outcomes. Knowing the latest educational gamification models described in this article will help gamification professionals develop new strategies in learning activities to increase student motivation, achievement, and engagement.

Keywords **-** gamification, gamification in education, game, gamification model, motivation

I. INTRODUCTION

Education is and will always be the key to a world of great opportunities. In the context of the development of the information society, the transformation of educational methods is taking place: traditional methods based on imparting knowledge are a thing of the past, and new methods based on the use of information, communication and game technologies are emerging. [1].

In many cases, this is connected with the technologicalization of modern society and the change of generations. The latest millennial generation is characterized by increased familiarity with and use of the Internet, mobile devices, and social media, so they are sometimes referred to as "digital natives." [2] The generation of "digital natives" (digital natives, M. Prensky) is used to receiving information very quickly. They like to multitask, display information visually rather than textually, are used to receiving immediate feedback and constant stimulation in the form of rewards, and prefer games to "serious" work.

Thus, in recent years, new models and approaches based on the use of information and game technologies have appeared in the development of education, for example, "edutainment" (education through entertainment), "gamification" (use of game mechanics and elements in a non-game context), "serious games" " (video games whose primary purpose is not entertainment), "learning games" (games designed for direct learning or with secondary educational value), "game-based learning" (a game-based learning approach), etc. Such technologies make it possible to increase the learner's features of receiving and processing information (quick access to information, variability of its use, interactivity, visual presentation of information), their interests (adaptive, individual educational trajectories), effective creation of communication processes, and motivation [1] .

In the process of digitalization, among the above-mentioned methods, especially gamification is becoming more relevant. In education, we consider gamification models that increase the motivation and attention of children and adults to study.

II. PROCEDURE FOR PAPER SUBMISSION

The study is aimed at determining the rationality of using the results in the educational system through a comparative evaluation of the "gamification" approach, based on the use of game

mechanics and elements in a non-game context. During the research, theoretical analysis, control, expert evaluation of scientific psychological-pedagogical and special literature on the theory and practice of the "gamification" approach, mastering the pedagogical practice of "gamification", analysis, comparative analysis, and analytical research methods were used.

III. RESULTS AND THEIR ANALYSIS.

The term gamification did not become popular until 2010[3]. Beginning in the 1980s, research into the relationship between video games and learning contributed to the development of gamification. Since then, gamification in education has become an object of research. The term itself was first used in 2003 by Nick Pelling [3].

Gamification is the use of game elements and game mechanics in non-game environments to drive targeted behavior and engagement.

Figure 1 shows the difference by dividing the coordinate axes into parts/whole on the horizontal axis of wholeness and play/play on the vertical axis of purposefulness.

Involuntary games and toy designs can be distinguished along the axis of purpose. The use of games in the non-game context is full-fledged games (serious games), and the use of game elements, including game technology, game methods (game experience) and game play, design is gamification.

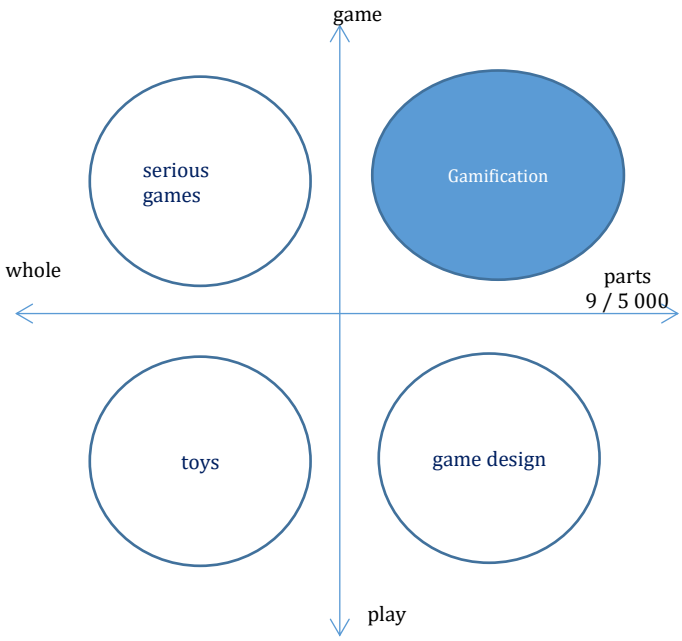

Figure 1 – Concept of gamification (According to S. Deterding et al. [4])

Table 1 lists the differences between gaming and gamification[5]: these two concepts are often confused, although some very important differences can be distinguished. This is probably due to the similarity of the term game and gamification in the original language (English): game (game) and gamification (gamification).

Table 1. Key differences between gaming and gamification

Game	*Gamification*
Specific rules and goals	A set of tasks, the completion of which involves a reward (points, badges)
Probability of losing	It is impossible to lose, the "level" can be repeated an infinite number of times: the main goal is to motivate people to perform certain actions.
Obtaining intrinsic reward (intrinsic reward) from the game process	Potential for intrinsic rewards
Creating a game is a complex and expensive process	Gamification is an easier and less expensive process to implement
The content usually changes according to the story of the game.	Added game elements without changing much content

Gamification in education is an educational approach that encourages students to learn by creating video games and game elements in the educational environment [6]. Its main purpose is to motivate students to continue their studies, to entertain them by "raising" their interest and to achieve maximum participation [5].

Gamification does not mean that learners must create their own games or play commercial video games. This is its main difference from learning through games [7]. Gamification is based on the assumption that the passion for the game experienced by the player can be transferred to the educational context in order to facilitate the process of learning the material and influence the learner's behavior [6].

The scheme of adaptation of gamification in the educational process proposed by the authors of A Practitioner's Guide to Gamification of Education is presented in Figure 2 [5].

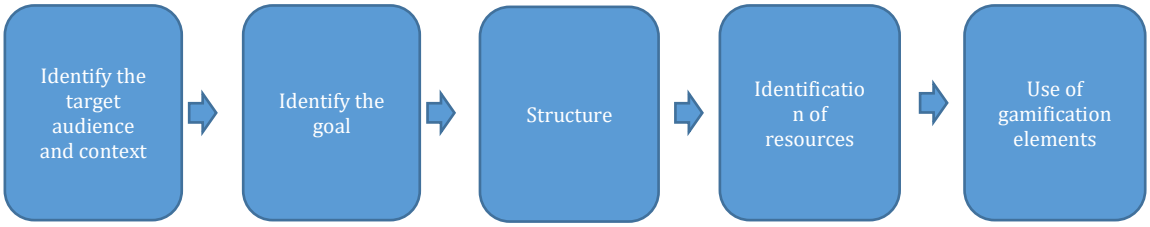

Figure 2 - Scheme of using gamification in education

Currently, gamification is one of the ways to increase motivation and encourage user participation, especially in the field of education, where teaching and learning are required to be interesting. There are many models of gamification in education. Next, let's analyze some gamification models.

PBL gamification model

The PBL model (from English points, badges, leaderboards) is the main gamification model. This model uses three of the most common game mechanics: points, badges, and leaderboards. Scores are a feedback mechanism that shows the player's progress in real time.

Badges are a visualization of the player's achievements. The leaderboard is a ranking of players based on various criteria such as level, number of achievements, number of items and so on. Each of the proposed mechanics is already used (often independently of each other). Likewise, individual elements of the PBL gamification model are used in education.

The goal of the PBL model is to use the proposed game mechanics together rather than separately, thus creating a synergistic effect. But this model does not take into account the scope of gamification, the needs of the target audience, the user experience or the goals of gamification

and can be implemented in any industry. Using points, badges, and leaderboards alone or in combination can increase learner motivation and engagement.

At the same time, it should be noted that points, symbols and leaderboards are effective game elements, but not enough [9]. In fact, gamification is not limited to the PBL model. According to Yu-Kai Chou, "experts" with limited experience in using this model do not take into account the moment of user participation, for which superficial use of this mechanic can be considered disrespectful[10]. The PBL model, in our opinion, has a number of disadvantages: first, the model deliberately limits the use of other game mechanics; secondly, it focuses only on external motivation, the main factor of which is reward, and not on internal motivation, which consists of free choice and enjoyment of the activity itself; third, the model is a mechanical use of the three main game mechanics without considering the features of the gamified environment and the needs of the users; fourthly, the model has no long-term effect [8].

Gamification model by K. Werbach and D. Hunter

K. Werbach and D. Hunter distinguish three types of gamification: external, internal and behavior-changing gamification [6]. Behavioral gamification is gamification aimed at creating new habits for healthy lifestyles, healthy eating, and more. This type of game is often used by public and state organizations.

K. Werbach and D. Hunter recommend the development of gamification projects using six D steps in business:

1. Define – to determine the goals.
2. Delineate- describe the desired behavior.
3. Describe - describe the players.
4. Devise - development of activity cycles.
5. Don't forget - do not forget about entertainment.
6. Deploy - use the right tools.

The authors of the model are liberal theorists of gamification, who propose to consider gamification as a way to develop and qualitatively improve the work of a commercial organization in a capitalist economy. In our opinion, the gamification model of K. Werbach and D. Hunter has a number of disadvantages: firstly, the model is aimed at commercial organizations; second, there is uncertainty in understanding the relationship between the stages of gamification; thirdly, the model service poorly takes into account the psychological needs of subjects subject to gamification[9].

Yu-Kai Chou Gamification Model

Yu-Kai Chou's gamification model is the Octalysis Framework based on eight needs or driving forces of human motivation (from the English Octalysis - octahedron and analysis - analysis). Unlike the model of K. Werbach and D. Hunter, where the emphasis is on the analysis of business goals and the gamified system, Yu-Kai Chow's model is more "personalized", that is, it takes into account the feelings, needs and motivation of people. In his view, gamification is the ability to produce entertainment, use game elements and use them thoughtfully in the real world or in productive activities. He suggests using the term "human-centered design" that stimulates people's feelings, motivation and participation in the system instead of the traditional "function-oriented design" (functional-oriented design), which only provides optimal conditions for functionality.

Yu-Kai Chow analyzes the motivation of people and explains their basic behavioral incentives [10]. According to Yu-Kai Chou, there are eight main driving forces of human motivation:

1. Meaning and recognition - demonstrated through inspiring mission-oriented tasks. People believe that they are useful, that their actions are valuable and important. Thus, they transcend themselves and satisfy their need to feel important.
2. Creativity and feedback - the more points you earn, the more awesome prizes you'll get later. In addition, in this way you will be more involved in the creative process, try

different combinations of activities, thus satisfying the need to express your creativity and receive feedback.

3. Social connections are reflected in our own eco-community and our ability to share resources.
4. Unpredictability and curiosity - you are always involved in the process, not knowing what the next gifts are waiting for you.
5. Avoidance and loss - manifested in the choice from small prizes to large prizes. But the points you earn are lost when you redeem them for prizes.
6. Neediness and Impatience – Realizing that you need to earn a lot of points for an exclusive prize, you continue to think about how to get it and try to earn points to satisfy your needs.
7. Possession - this need is manifested in the fact that you have a certain number of points that you can control yourself at once: spend or save as you wish.
8. Development and achievement - we have motivation, development, achievements, which is reflected by the accumulation of experience, the points you get.

These eight needs are divided into two groups: the left hemisphere (logic, analytical thinking, etc.) and the right hemisphere (creativity, curiosity, etc.), as well as "white" (which satisfies and satisfies us strongly) and "black" (which makes us anxious, addicted and obsessed). Each driving force of motivation is accompanied by game mechanics and techniques. For example, Octalyse Octahedron offers the use of mechanics like points, badges and leaderboards, progress indicators, quest lists, boss battles, and more to meet players' development needs and achieve success. Yu-Kai Chou's gamification model is to analyze the needs and motivations of the people whose activities are being gamified and use Octalize to create new user experiences within human-centered design. Octalysis can be used in two ways: firstly, to analyze (audit) existing products in order to determine their strengths and weaknesses in achieving the desired actions of the user; secondly, to develop a new, attractive user experience based on Octaliz.

Before you start gamification, you need to define five elements:

1. business indicators leading to termination of gamification goals;
2. the target audience of the gamified system, which becomes a player;
3. desired behavior of system participants leading to victory;
4. feedback mechanisms that initiate desired actions and behaviors of players;
5. Reward players for desired behavior and winning.

Thus, Yu-Kai Chow's gamification model pays much attention to the motivation of gamification subjects, however, in our opinion, questions remain unclear: by what criteria should game mechanics and techniques be selected, how users should connect business and gamification goals with their interests.

Gamification model for e-learning

Researchers from the University of Maribor in Slovenia (Marko Urh, Goran Vukovića, Eva Jereba, Rok Pintara) present a gamification model for e-learning in higher education [1]. From their point of view, the main goals of e-learning are to increase the enthusiasm and involvement of learners in the learning process, as well as to increase its efficiency. These goals can be achieved through the use of game mechanics and gamification. [11].

This gamification model consists of the following main elements: e-learning management; important factors in e-learning; user experience elements; stages of development (analysis, planning, development, application, evaluation); game mechanics; game dynamics; elements of gamification in e-learning and their impact on learners. The use of gamification in e-learning takes into account the interests and needs of learners, allows them to combine their personal goals with educational goals, and increases the understanding of the importance of learning for the future of learners. The implementation of gamification in the e-learning system helps to increase motivation, learner participation, greater satisfaction with the learning process, formation of a state of "flow" and much more. In our opinion, the disadvantage of the proposed gamification model is the lack of a description of a specific algorithm and specific actions for its practical application.

IV. CONCLUSION

There are several models of gamification that can be used as a method to increase motivation, achievement and engagement in learning activities. A critical analysis of the above gamification models showed that the considered models have a number of shortcomings (mainly focus on business, mechanical transfer of game mechanics and techniques, lack of a mechanism for choosing game mechanics, spread of business interests and goals) and can be improved.

Today, there is every reason to believe that in the future there will be an effective method of using gamification elements in the educational process, which will be developed in accordance with the requirements of the modern society. It can be concluded that knowledge of recent educational gamification models described in this article can help gamification professionals to develop new strategies in learning activities to increase learner motivation, achievement and engagement.

ACKNOWLEDGMENT

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CONSTRUCTION OF A MATHEMATICAL MODEL OF THE MOVEMENT OF A FOUR-WHEELED MOBILE ROBOT

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***Abstract*—** This article presents the process of creating and modeling a mathematical model of a mobile four-wheeled robot in the Simulink environment. Using detailed mathematical equations and algorithms, the article explains how the model calculates the position and orientation of the robot in space using its kinematics. Simulink simulation validates the accuracy and validity of the model. The article concludes by highlighting the next steps in development, which include enabling steering algorithms for the mobile robot to reach given waypoints.

***Keywords*—** kinematic scheme, mathematical model, mathematical modeling, modeling environment.

I. INTRODUCTION

In the modern world, there is a growing demand for intelligent robotic systems capable of autonomously performing various tasks. These systems can be used in a variety of applications, such as manufacturing, logistics, healthcare, and even space exploration. However, designing robot control systems is a difficult task, since it involves analyzing the complex dynamics of behavior in space. Mathematical modeling is a powerful tool that can help engineers and researchers gain an understanding of the dynamics of robotic systems, predict their behavior and optimize their control algorithms.

A mathematical model is a simplified representation of the object under study in the virtual world, which is described using mathematical equations or algorithms that interact and change over time. One of the purposes of modeling is to predict the behavior of the system under various conditions.

To develop a mathematical model, we will use the kinematics of the robot to determine the corresponding variables and their relationships. For example, the position and speed of the front and rear wheels can be used to describe the position and orientation of the robot in space. Once the relevant variables and interactions are determined, a set of mathematical equations or algorithms can be developed to describe the behavior of the system. These equations can then be used to predict the robot's movement under various operating conditions.

The purpose of the article is to build a mathematical model of a mobile four-wheeled robot and simulate its behavior using the Simulink simulation environment. This includes determining the appropriate kinematic variables, developing a set of mathematical equations or algorithms, implementing the model in Simulink, and analyzing the simulation results.

II. CONSTRUCTION OF A MATHEMATICAL MODEL OF A MOBILE ROBOT

To simplify the construction of a mathematical model of a four-wheeled mobile robot, let's imagine it as a two-wheeled one, where the front wheel changes its angle of rotation relative to the body. The rear wheels rotate at a certain speed ϑ_0; the position of the front wheel is determined by the coordinates x_{f0} and y_{f0}, the rear – x_{b0} and y_{b0}; the initial angle of rotation of the front wheel relative to the entire robot is φ_0; the angular rotation speed of the rotor, which is responsible for changing the angle of rotation of the front wheel, is equal to ω_r.

To build a mathematical model, we will construct a kinematic diagram of a mobile robot

(Fig. 1). To find the point relative to which the mobile robot rotates, we draw perpendiculars to the velocity vectors of the rear and front wheels (the perpendiculars pass through the edge points of the mobile robot A and B, or the central axes of rotation of the wheels); the intersection point of the perpendiculars (in the drawing, point P) is the point relative to which the mobile robot rotates, or instantaneous the center of rotation. Points G and K are projections of points A and B on the Oy axis, respectively, and points F and E on the Ox axis.

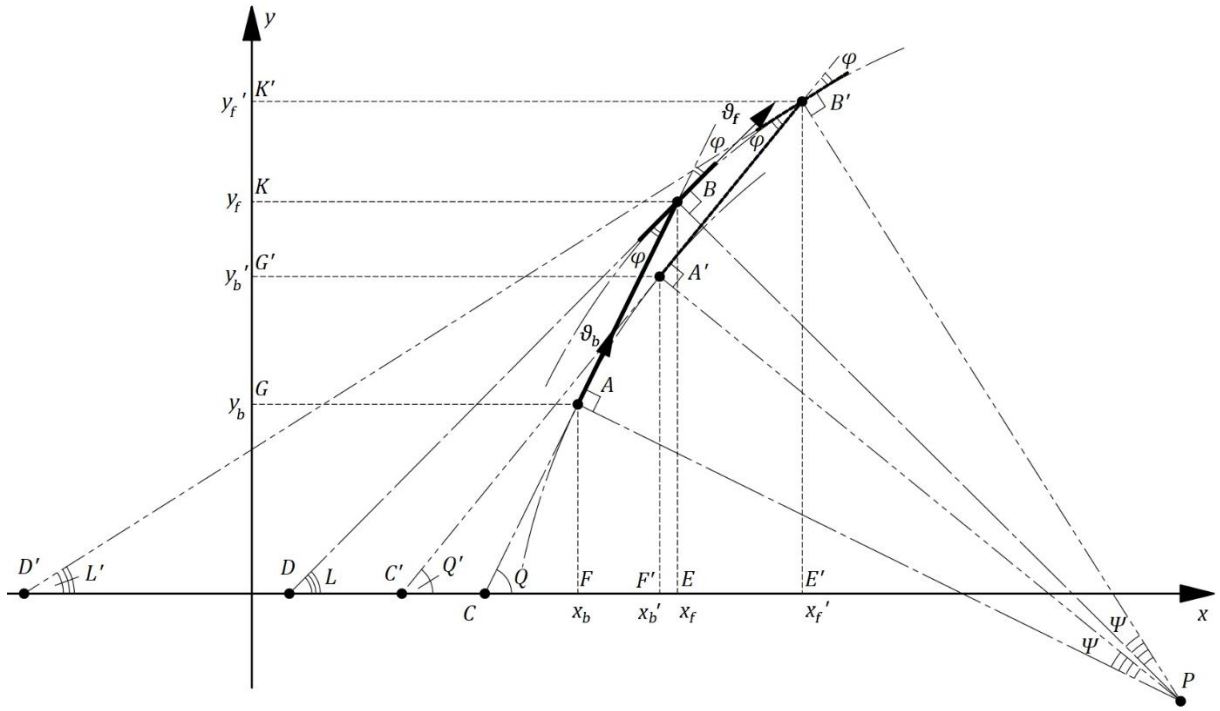

Fig. 1 Kinematic diagram of a mobile robot

To calculate the changes in the coordinates of a moving mobile robot, we will use a system of equations:

$$\begin{cases} x = x_0 + \vartheta\, cos(\alpha)\Delta t \\ y = y_0 + \vartheta\, sin(\alpha)\Delta t' \end{cases} \quad (1)$$

where x and y are the projection of the current position of the object on the Ox and Oy axes, respectively, x_0 and y_0 are the initial coordinates of the object, ϑ is the velocity of the object, α is the angle between the velocity vector v and the Ox axis.

The front and rear wheels have different angles between the velocity vector v and the Ox axis, since the front wheel, due to the rotor, can change the angle of rotation relative to the robot body, hence the angle between the velocity vector of the front wheel and the Ox axis will be different from the angle between the velocity vector of the rear wheel and the Ox axis. To find these angles, we will draw the axes collinear to the velocity vectors of the front and rear wheels. Point C is the intersection point of the Ox axis and the axis of the speed vector of the rear wheel, point D is the intersection point of the Ox axis and the axis of the speed vector of the front wheel. It is also worth noting that the angles themselves between the velocity vectors and the Ox axis will change due to the circular motion of the robot around the point P.

The angle between the axis of the velocity vector of the rear wheel and the axis Ox (angle $\angle BCE$) is found by the formula:

$$Q = arccos\left(\frac{x_{f0} - x_{b0}}{l}\right), \quad (2)$$

where l is the wheelbase of the mobile robot, which corresponds to the segment AB, calculated by the formula:

$$l = \sqrt{\left(x_{f0} - x_{b0}\right)^2 + \left(y_{f0} - y_{b0}\right)^2}. \quad (3)$$

To find the angle between the axis of the velocity vector of the front wheel and the axis Ox (angle $\angle CDB = L$), consider the triangle $\triangle DBC$ (Fig. 1). In this triangle, the angle $\angle DBC == \varphi$, since the angle $\angle DBC$ and the angle φ are vertical. The angle φ (the angle of rotation of the wheel at the moment) is found by the formula:

$$\varphi = \omega_r \Delta t + \varphi_0, \text{herewith} - 45° < \varphi < 45°. \quad (4)$$

The angle $\angle BCD$ is calculated by the formula:

$$\angle BCD = 180° - Q. \quad (5)$$

Then the angle $\angle CDB$ is equal to:

$$L = \angle CDB = 180° - \varphi - (180° - Q) = Q - \varphi. \quad (6)$$

The angular velocity ω is found by the formula 7:

$$\omega = \frac{\vartheta_f}{R_f} = \frac{\vartheta_b}{R_b}, \quad (7)$$

where ϑ_f is the speed of the front wheel, ϑ_b is the speed of the rear wheel, R_f is the radius of the circle of movement of the front wheel and is equal to the segment BP in the diagram (Fig. 1), R_b is the radius of the circle of movement of the rear wheel and is equal to the segment AP in the diagram (Fig. 1).

Next, we find the speeds of the front and rear wheels. Relative to point P, the rear and front wheels move in a circle with the same angular velocity ω, since point P is the point relative to which the mobile robot rotates.

The speed of the rear wheel from the condition is equal to the initial speed (formula 8):

$$\vartheta_b = \vartheta_0. \quad (8)$$

The radii of the circles of movement of the front and rear wheels can be connected geometrically. To do this, consider the triangle $\triangle ABP$ (Fig. 1). The angle $\angle BAP = 90°$, since the segment AP is normal to AB. The angle $\angle ABP$ is found by the formula 9:

$$\angle ABP = \angle DBP - \varphi. \quad (9)$$

The angle $\angle DBP = 90°$, since the segment BP normal to DB. Thus formula 9 can be converted to formula 10:

$$\angle ABP = 90° - \varphi. \quad (10)$$

Therefore, the angle $\angle BPA$ can be found by the formula 11:

$$\angle BPA = 180° - \angle BAP - \angle ABP = 180° - 90° - (90° - \varphi) = \varphi. \quad (11)$$

From formula 11 and the fact that R_f is equal to the segment BP, and R_b is equal to the segment AP, it follows (formula 12):

$$\frac{R_b}{R_f} = cos\,\varphi. \quad (12)$$

Formula 12 after conversion (Formula 13):

$$R_b = R_f\,cos\,\varphi. \quad (13)$$

Substituting formula 13 into formula 7 we get (formula 14):

$$\frac{\vartheta_f}{R_f} = \frac{\vartheta_b}{R_f\,cos\,\varphi}. \quad (14)$$

After converting formula 14, we get (formula 15):

$$\vartheta_f = \frac{\vartheta_b}{cos\,\varphi}. \quad (15)$$

Thus, the dependence of the speed of ϑ_f on the speed of ϑ_b was found, and consequently, the speed of the front wheel itself was found.

Fig. 1 shows the scheme of changing the position of the robot, where the angle Ψ, which corresponds to the angles $\angle APA'$and $\angle BPB'$, is the angle changes relative to the point P; point A' and $B'$are the points of change of the position of the front and rear wheels, respectively; the angles Q' and L' are changed angles Q and L, respectively; points $K'(y_f{}')$, $E'\left(x_f{}'\right)$, $G'(y_b{}')$ and $F'(x_b{}')$ are changed by the points of the projections of the points A' and B'respectively. The angle of change of the robot's position relative to the point P is calculated using the angular velocity ω.

R_b, based on Fig. 1, this segment corresponds to the segment AP, calculated by the formula 16:

$$R_b = \frac{l}{\tan\varphi}. \quad (16)$$

Thus, the angular velocity of change of the robot is calculated by the formula 17:

$$\omega = \frac{\vartheta_b \tan\varphi}{l}. \quad (17)$$

The angle of change of the robot 's position Ψ relative to the point P is calculated by the formula:

$$\Psi = \omega\,\Delta t \quad (18)$$

Therefore, formula 1 can be transformed into a system of equations:

$$\begin{cases} x_f = x_{f0} + \vartheta_f \cos(Q - \varphi - \Psi)\Delta t \\ y_f = y_{f0} + \vartheta_f \sin(Q - \varphi - \Psi)\Delta t \\ x_b = x_{b0} + \vartheta_b \cos(Q - \Psi)\Delta t \\ y_b = y_{b0} + \vartheta_b \sin(Q - \Psi)\Delta t \end{cases}. \quad (19)$$

Let 's supplement the system of equations 19 with the formula for changing the angle φ:

$$\begin{cases} x_f = x_{f0} + \vartheta_f \cos(Q - \varphi - \Psi)\Delta t \\ y_f = y_{f0} + \vartheta_f \sin(Q - \varphi - \Psi)\Delta t \\ x_b = x_{b0} + \vartheta_b \cos(Q - \Psi)\Delta t \\ y_b = y_{b0} + \vartheta_b \sin(Q - \Psi)\Delta t \\ \varphi = \omega_r \Delta t + \varphi_0 \end{cases}. \quad (20)$$

The system of equations 20 is a special case of describing the movement of the robot (due to the rotation of the wheel at a negative angle). The general system of equations is as follows (formula 21):

$$\begin{cases} x_f = x_{f0} + \vartheta_f \cos(Q + \varphi + \Psi)\Delta t \\ y_f = y_{f0} + \vartheta_f \sin(Q + \varphi + \Psi)\Delta t \\ x_b = x_{b0} + \vartheta_b \cos(Q + \Psi)\Delta t \\ y_b = y_{b0} + \vartheta_b \sin(Q + \Psi)\Delta t \\ \varphi = \omega_p \Delta t + \varphi_0 \end{cases}. \quad (21)$$

Thus, a mathematical model of a mobile four-wheeled robot was built (the four-wheeled robot was simplified to a two-wheeled one).

III. IMPLEMENTATION OF A MATHEMATICAL MODEL IN THE SIMULINK SIMULATION ENVIRONMENT

Let's build a mathematical model in the Simulink simulation environment. The general scheme is shown in Fig. 2.

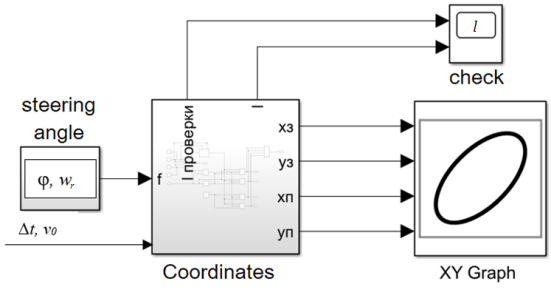

Fig. 2 Simulation diagram in the Simulink environment

The "Steering angle" block is responsible for entering angle data φ, ω_r. The "Coordinates" block calculates the coordinates of the front and rear wheels after a specified time interval Δt. The "Check" block is designed to check the correctness of calculations. The criterion for the adequacy of the result is the fact that the calculated coordinates of the front and rear wheels must correspond to the wheelbase l, according to formula 3. The "XY Graph" block is responsible for visualizing changes in the coordinates of the front and rear wheels.

An experiment was carried out when the angle of rotation of the wheel remains constant $\omega_{\text{p}} = 0$ and is equal to the value $\varphi_0 = \frac{\pi}{6}$. Initial conditions $\vartheta_0 = 10$, $x_{f0} = 0$, $y_{f0} = 5$, $x_{b0} = 0$, $y_{b0} = 0$, $\Delta t = \infty$.

The wheel movement graph, as expected, represents two circles, as shown in Fig. 3.

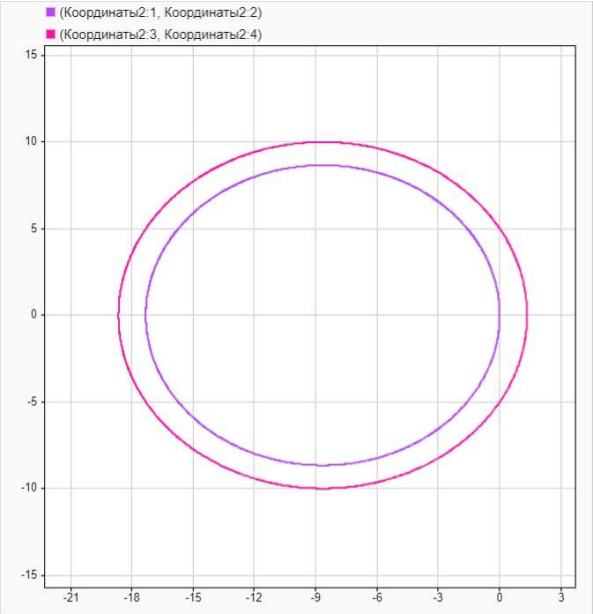

Fig. 3 Graph of the movement of the front and rear wheels (pink color – graph of the front wheel, purple – graph of the rear wheel)

The verification calculation of the wheelbase at each moment of the simulation is shown in Fig.4.

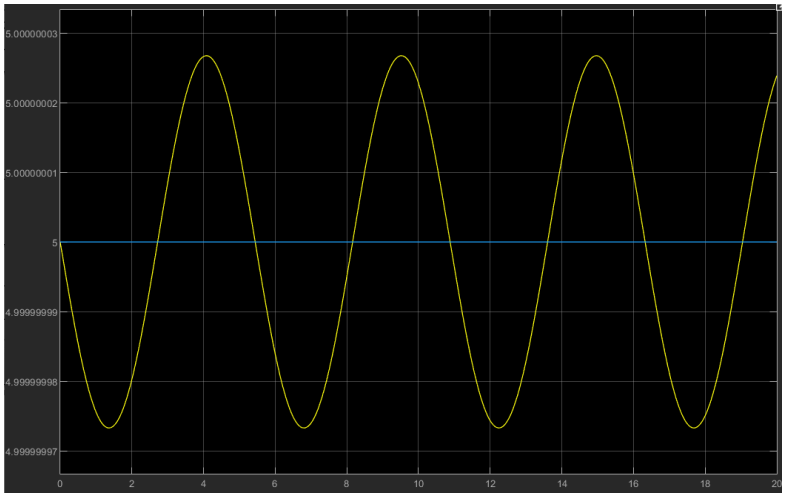

Fig. 4 Robot length graph (blue color is the actual value of the wheelbase of the mobile robot, yellow color is the calculated value)

As can be seen from the graphs, the error is less than 1%, which indicates the adequacy of the model.

IV. CONCLUSION

The article presents the process of developing a mathematical model of the movement of a mobile four-wheeled robot and modeling its movement using the Simulink simulation environment.

The simulation results demonstrate the correctness of the model when predicting the position of a mobile four-wheeled robot at a given model time.

The next step in the development of the model should be steering control algorithms:

$$\omega_r = f(x_f, y_f, x_b, y_b, x_i, y_i),$$

where x_i, y_i is the coordinate of the current route point that the mobile robot should reach.

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METHODOLOGY OF APPLICATION OF COMPLEX APPROACH IN DESIGNING OF MINI-TRACTOR WITH ELECTRIC DRIVE

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Abstract **-** In the article the problem of calculation and choice of electric drive of mini-tractor is considered. The methodology of application of complex approach at designing by means of solving the problem of calculation, determination of maximum load on the tractor taking into account the restrictions in the form of real characteristics of soils in essence of minimization of target function of resistance force for choice of optimum parameters of motor and traction battery is offered. As a result: a real calculation of these parameters was made in order to ensure the fulfillment of a set of tasks for a specific area of application of mini-tractor (application in greenhouses), to ensure the technological cycle on a single battery charge.

Keywords*:* integrated approach, system design, electric drive, mini-tractor, traction battery.

I. INTRODUCTION

The application area of a mini electric tractor is inextricably linked to the type and conditions of work, which can be specified by numerical or nominal values and constraints. For example: the type of soil and the method of cultivation with a certain tool (plow, cultivator or milling machine) with a given depth of cultivation determine the resistance force of the tool; the area of the cultivated area determines the required cultivation time, etc. The composition and mutual influence of such properties (and/or parameters) of the system can be represented as an undirected graph. Thus, by the example of solving the training problem of system design of a mini-tractor with an electric drive, the initial graph reflecting the complex approach to design can have the form as shown in Fig. 1.

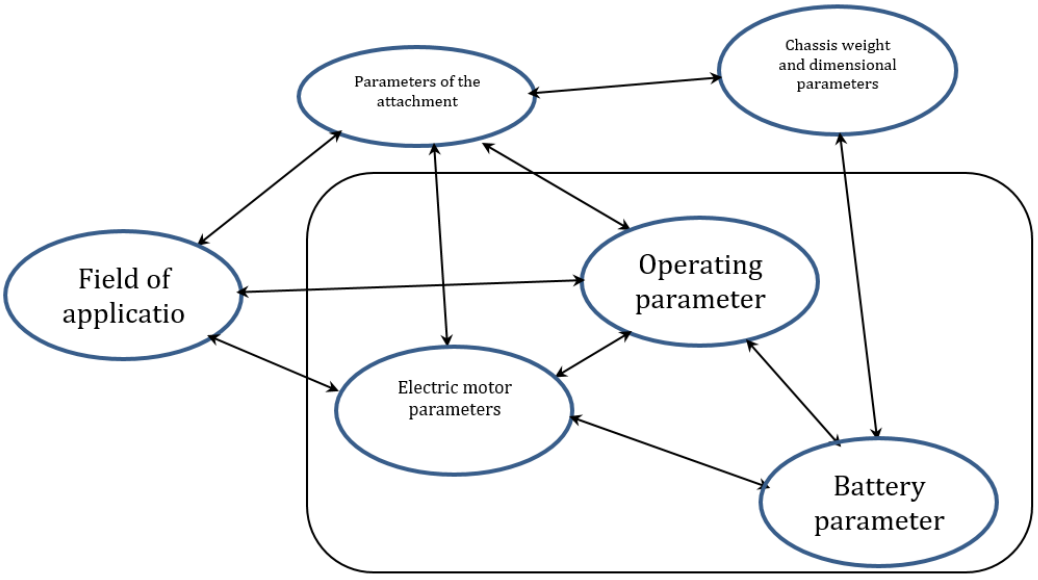

Fig. 1: Undirected graph reflects the subject area of system design

In this case, the graph reflects only qualitative dependencies. For example, for experts, in the selected fragment of the graph, it is obvious that the motor can have different power, a powerful motor consumes more energy, therefore, the battery must have a large capacity, otherwise, the operating time before charging will be small.

Even a cursory analysis of a fragment of the original graph shows the close interdependence of parameters in the system. Sometimes it is not difficult to visualize these dependencies in the form of known formulas (as will be shown below). However, this is not always the case. For example, it is difficult (and maybe even impossible) to specify the dependence of the mechanical layout of the battery on the chassis on its mass dimensions, although it is obvious to every designer that such a dependence exists. Also, it does not make sense to describe by formulas the restrictions on applicability of tractor with internal combustion engine in closed premises, in greenhouses.

This graph is of demonstration character, and, naturally, it can be supplemented with other parameters and links.

II. SYSTEM DESIGN PROBLEM STATEMENT

In general, the task of system design is to find such a conceptual solution, the parameters of which will be in acceptable, or, better, in optimal values. This formulation is difficult to refute, but it does not indicate possible ways of solution.

The problem statement of system design can be formulated as follows:

- to determine the values of input and output parameters, as well as the specification of internal parameters on the basis of a comprehensive approach;
- to find models (conceptual or system solutions) that provide such values of internal parameters to achieve the required output parameters.

III. SYSTEM DESIGN METHODOLOGY

The proposed system design methodology consists of the following.

1.1 The developer (or general designer, or system architect, depending on the subject area), makes an initial graph, similar to Fig. 1, reflecting the system design in a given subject area

1.2 Key parameters are identified in the graph as input, output and internal parameters. The initial graph is modified into an oriented graph, the number of mutual (less essential) links is reduced. Ideally, a chain of cause-and-effect relationships can be obtained.

Let us illustrate one of the variants of such problem formulation for our example (Fig. 1). Let the field of application of a mini-tractor with an electric motor - soil cultivation in greenhouses - be defined and its mechanical chassis - Belarus 132 - be defined. Let's take these initial data as "input parameters". On the chassis there is a possibility to install standard attachments (plow or tiller) to ensure the scope of application - soil cultivation in greenhouses. As output parameters - let's define "operation parameters". Then, as the main internal parameters with which the design calculations will be carried out will be "electric motor parameters" and "battery parameters". Thus, in an idealized version, one of the system design scenarios will look like an oriented graph as shown in Fig. 2.

1.3 Further, the found chain is supplemented (detailed) with the necessary (known) quantitative data and constraints. An express assessment of the possibility of achieving the final result is carried out using known theoretical dependencies, expert knowledge, as well as all kinds of heuristics.

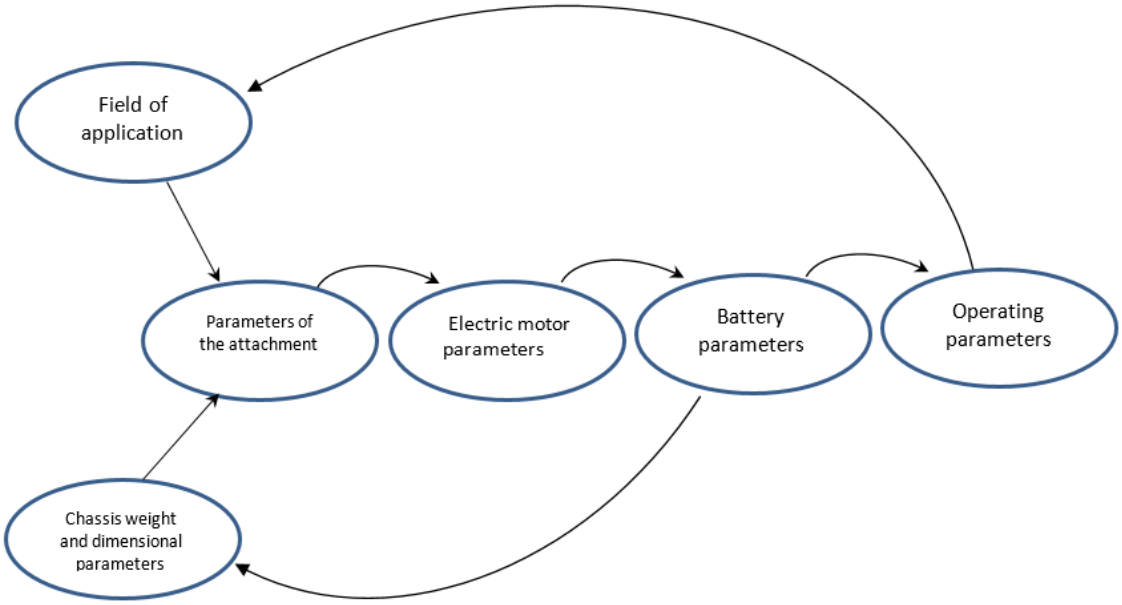

Fig.2. The oriented graph reflects one of the possible scenarios of system design

1.4 Very often parameters have implicit and mutually exclusive relationships. Therefore, it is important to "check the feedbacks" during system design, for example, it may be that the battery required for long term operation does not fit within the parameters of the mechanical chassis, or the performance parameters do not match the application. In this case, the system design process is iteratively repeated until an acceptable system solution is found.

IV. EXAMPLE OF PARAMETER CALCULATION IN SYSTEM ENGINEERING

Let us detail the chain of cause and effect relationships, according to the adopted scenario of system design. Thus, to perform a certain technological operation it is necessary to calculate the required engine power, then, based on the technologically justified operating time, to select the battery parameters. The final stage of development will be the tractor layout taking into account the mass-dimensional parameters of the battery, as a result of which the conceptual solution of the tractor design will be formed.

Let's start with the initial data (field of application): it is required to cultivate a greenhouse of the following dimensions: (length l=80 m and width s=30 m), the soil of the greenhouse has the following soil properties, and the technology of cultivation involves the following operations: plowing, milling, cultivation, transportation operations. To perform each technological operation it is required to expend a certain energy, to overcome the resistance force of the tool and the resistance force of the tractor movement. Let's consider the problem on the real example of a wheeled minitractor moving on the horizontal surface of peat mixture of normal moisture content in steady-state mode.

Proceeding from the above, we start the calculation by determining the force Pres, in which we take into account the parameters of the application area and attached equipment (in our example, the greatest resistance is when the tractor is working with a plow):

The total traction resistance for the general case of motion with passive technological equipment was determined by the dependence formula 3.1:

$$\sum P_{res} = P_t + P_{ob} = (G + Q_1)(f_1 + i) + G_{пр} i + P_{ob} \quad (3.1)$$

where P_t is the tractor rolling resistance force, N; P_{ob} is the resistance force to the movement of the working body (plow); G is the tractor own weight, N; Q_1 is the weight of the operator placed on the tractor, N; $G_{пр}$ is the weight of the trailed link, N; f_1 is the tractor rolling resistance coefficient; i is the slope coefficient of the driving surface (at small elevation angles i = tgα ≈ sinα=0, $\alpha=90^0$). In our example there is no trailed link, respectively $G_{пр}i=0$.

The main technological tool is the plow, the force of traction resistance of the plow Rob is a generalized indicator of all the resistances acting on the plow, serves as a criterion for its energy assessment and can be determined by the calculation formula of Acad. V.P. Goryachkin formula 3.2:

$$P_{ob} = fG + kabn + \varepsilon abnv^2 \quad (3.2)$$

where fG - part of traction resistance necessary for dragging the plow in the open furrow; kabn - part of traction resistance necessary for destroying (deforming) strata; $\varepsilon abnv^2$ - part of traction resistance necessary for transferring kinetic energy to the layers

Let's determine the acting adhesion force Pφ by formula 3.3:

$$P_\varphi = (G+Q_1)\ \varphi\ g \quad (3.3)$$

where φ is the coefficient of adhesion realized by the mover under the conditions of its interaction with the ground (road)

In the most severe case of movement Pφ = 3.428 kN, and the force of resistance to movement:

$$\sum P_{res} = P_t + P_{ob} = 2{,}458+0{,}65=3{,}108 \text{ kN}$$

The total resistance force P_{res} for the small-sized tractor in this case with the acting clutch force Pφ allows the designed small-sized tractor to perform full-fledged cultivation of greenhouse. soils.

Determine internal parameters of the engine:

Tangential traction force P_k (N), developed by the designed tractor, was determined by the dependence according to the formula 3.4:

$$Pk = \frac{M\ km\eta tr}{R} \quad (3.4)$$

where M - engine torque, η_{tr}- transmission efficiency, k_m - total transmission ratio in the corresponding gear, R - wheel radius.

Let's determine from this formula M.

The value of critical torque depends on the overload capacity of the electric motor λ and is determined according to formula 3.5.

$$M=9{,}55\frac{Nen}{n}\lambda M=9{,}55\frac{Nen}{n}\lambda \quad (3.5)$$

where n is the engine speed.

Let's determine from the given formula the motor power N_{em} =10 kW

The rated effective power of the motor is determined by formula 3.6

$$N_{em} = UI\ \eta m \cos\varphi \quad (3.6)$$

.

Based on the published power we calculate the parameters U and I, in this article we will not consider this calculation.

At a speed of about 8 km/h on plowing, the power consumption taking into account the transmission efficiency (0.73) will be 9.366 kW, which correspond s to the installed engine.

Intensity of the tractor's power load on plowing we will accept equal to 0.76, which slightly exceeds the values registered in greenhouse conditions (0.62 -0.66). In this case the hourly energy consumption of the battery when the tractor is working in the noted conditions will amount to 257,105 J or 7.15 kWh.

It should be noted that specific energy capacity of modern traction Li-ion batteries on average is 49.5 kWh/m3 Taking into account the standardized dimensions of supplying cells and housing, the average height of the battery composed of vertically arranged cells is 0.264 m. The surface area occupied by a 7.15 kWh battery will be 0.547 m2. With certain dimensional ratios, this allows the battery to be placed under the operator's seat. The mass of such a battery will be about 47 kg with a specific energy capacity by mass of 150 W-h / kg. The required processing time will be T=91 min.

If the capacity of the battery is sufficient as in our example, to perform the processing calculation is completed, if not we return to the beginning of the calculation.

All operations are supposed to enter a certain technological cycle "work-charging the battery - work".

As a result, the following results are obtained: the engine power is calculated under the condition that the tangential traction force is greater than the forces of resistance to the tractor and the implement; the energy required to cultivate the area is determined and an appropriate battery is selected that can provide a complete cycle on a single charge. The task is performed in the form of searching for the optimal value of the drag force taking into account the characteristics of the soil, minimizing this value.

V. CONCLUSION

System design is the "upper" stage in the classical (top-down) design methodology. At this stage, the basic principles of functioning, basic tactical-technical, technical-operational and economic characteristics are laid down, and the concept of the future system is formed. Despite the obvious importance of this stage in general, it should not be mixed with the subsequent stages of direct system development.

The integrated approach of complex objects is sometimes considered at an intuitive level, which reduces its effectiveness as a design methodology. Therefore, in this paper, the authors have tried to present one of the possible methods of applying the integrated approach on the example of system design of mini-tractor with electric drive.

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LEARNING ANALYTICS AS ADVANCED TOOLS FOR IMPROVING REMOTE EDUCATION

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Abstract **-** This article describes the trends and problems in online education caused by the COVID-19 pandemic. Authors show that learning analytics is an advanced tool to improve remote education. Article introduces learning analytics as a system for usage in university education management process and shows results of its implementation in universities listed in the top 150. Authors show pain points of remote education and offer ways of improving education process by implementing learning analytics.

Keywords*:* Remote education, learning analytics, education problems.

I. MASS REMOTE EDUCATION PROBLEMS DISCOVERED BY COVID-19

With the outbreak of the COVID-19 pandemic, educational institutions of all levels of education, around the world, have partially or completely transferred the learning process online. According to UNESCO, 109 states have already deployed national educational platforms for remote learning. At the same time, such teaching methods as blended, online learning and remote education are actively used. In addition, there is an explosive growth in interest in online courses hosted on the Massive Open Online Course (MOOC) platforms. According to a report published on the Class Central MOOC Report [1] the number of new users registered in April 2020 on the three most popular platforms (Coursera, edX, FutureLearn) exceeded the total number of new users for the entire 2019. The World Economic Forum experts C. Li, F. Lalani [2] note a dramatic change in the education system amid the COVID-19 pandemic, while recording a noticeable increase in e-learning, whereby teaching is undertaken remotely and on digital platforms.

According to World Bank experts, a sharp transition to remote education will cause a number of difficulties [3]: at the moment there are very few educational systems (even among the most high-class ones) that have good technical support to make a quick transition to remote education; the transition to remote learning is education; most students will have difficulty transitioning to remote education, which will affect learning outcomes; only a few educators are able to make the transition to an online learning model quickly and efficiently, as the methods of teaching online and in the classroom differ significantly from each other.

In addition, we can say that the transition to remote education will entail an increase in the number of expelled students. According to a study [4], completion rates for some groups of remote students may be 22% lower than for full-time students. At the same time, the average percentage of completion of MOOC courses is no more than 10% of the total number of people registered for the course [5]. Thus, one of the possible solutions to the difficulties associated with the adaptation of students and understanding of behavior during training in the online format and an increase in the number of successful students is the introduction of learning analytics into the learning process.

II. LEARNING ANALYTICS: DEFINITION, AIMS, METHODS AND TOOLS

Learning analytics is a relatively new area of scientific and practical activity. The professional community of scientists and practitioners Society of Learning Analytics Research (SoLAR) was founded in 2010, and the first conference under the auspices of the community was held in 2011.

According to the definition proposed by George Siemens at the first conference under the auspices SoLAR, learning analytics – is the measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs [6].

The purpose of learning analytics is to assess user behavior in the context of teaching and learning, with its subsequent analysis and interpretation, in order to obtain new information and its subsequent provision to participants in the educational process, along with new models for improving learning, teaching, effective organization of the educational process, decision-making [6]. The key is the fact of transferring the acquired knowledge to teachers and students in order to optimize their pedagogical and educational behavior, in order to develop appropriate skills in this area, to better understand the educational process and related areas, for example, university marketing and business. Learning analytics based on data collecting and analyzing [6].

Since the basis for learning analytics is data, the methods and tools used are characteristic of data analysis in general. According to Larusson, J.A., White, B. [7] the most common methods include:

Predictive models (classification, regression analysis, assessment of hidden knowledge), Structure detection (clustering, factor analysis), search for patterns (relationships: association rules, sequential, correlation analysis, search for causal relationships, discovery with a model).

Speaking about the tools most often used to implement learning analytics methods, based on a survey analysis [8] conducted on the Kaggle data analyst community platform in 2019, the two most popular programming languages for data mining are identified - Python and R . Survey found 64% of nearly 20,000 data science professionals use Python. Experts note that Python is better than R for data preprocessing. At the same time, R is better suited for ad hoc analysis and exploration of datasets than Python. It is an open source language and not an easy to learn. In loops that have more than 1000 iterations, R actually beats Python. At the moment the most popular language for implementing educational analytics methods is Python with a set of special libraries for data analysis and visualization.

Educational data analytics focuses on the educational process, with resultant goals for all key stakeholders [9]. C. Romero and S. Ventura from the University of Cordoba divided the main participants according to their main goals into four groups indicated in Table 1.

Table 1. Stakeholders and objectives of learning analytics [9].

User/Stakeholders	**Objectives**
Learners	To support a learner's reflections on the situation, to provide adaptive feedback or recommendations to learners, to respond to student needs, to improve learning performance
Educators	To understand their students' learning processes and reflect on their own teaching methods, to improve teaching performance, to understand social, cognitive and behavioral aspects
Researchers	To develop and compare analytics techniques to be able to recommend the most useful one for each specific educational task or problem, to evaluate learning effectiveness when using different settings and methods.
Administrators	To evaluate the best way to organize institutional resources (human and material) and their educational offer

Learning analytics is a data-driven approach, that affects all participants in the educational process and structural units of the HEI responsible for the educational process. Learning analytics process requires the integration of information flows from various sources related to the support and conduct it. Successful implementation that process requires an understanding of approaches to data analysis, the availability of resources for its implementation and setting goals for the organization of the process.

III. HOW LEARNING ANALYTICS INFLUENCE EDUCATION AND EDUCATION PROCESS: RESULT OF THE WORLD UNIVERSITY ANALYSIS

Authors [10] analyzes the experience of implementing learning analytics in universities in the USA, Australia, and Great Britain. The summarized results of the study are presented in Table 2.

The analysis revealed that the main goals of implementing learning analytics are usually: improving the quality of education, university efficiency and reducing costs, as well as student retention, especially at the initial stage of education. The instrument for the implementation of goals and objectives are working groups, services or institutions created within universities.

According to the results (table 2) we can conclude that for universities in the top 150 learning analytics is used to improve the quality and efficiency of the university, while for universities located from 224 to 1000 places, analytics is used for the task of student retention. In other words, top universities use analytics to solve global strategic tasks, and in less-rated universities to achieve tactically local tasks.

In addition, the result of the introduction of analytics for universities that are located at the top of the ranking in 3 out of 4 cases under consideration, was the introduction of a full-fledged analytical IT solution for the entire university.

IV. WHAT WE OFFER TO IMPROVE REMOTE EDUCATION BY IMPLEMENTING LEARNING ANALYTICS

Changes in the approach to the educational process caused by the coronavirus pandemic are contributing to the rapid transition to remote and online forms of education. This format, in turn, affects both the teaching methodology and the preparation of educational content. As mentioned above transition to remote education leads to an increase in the number of expelled students. The difficulty of obtaining feedback from students in the assimilation of educational content during the transition from classroom learning to online is one of the key factors affecting the quality of education. The development of tools for assessing the adequacy of a particular part of educational content and the form of its presentation to students, based on the data of interaction and student success, is an effective data driven solution to the problem. An analysis of the best practices for implementing educational analytics at universities showed that even before the pandemic, universities successfully applied analysis to solve this problem. Possible challenges for the implementation of the educational analytics strategy in the practice of online learning may be: lack of data analysis skills among teachers and students; lack of infrastructure solutions for handling and working with data within the organization; lack of understanding among the management of the importance of introducing the process of educational analytics in an educational institution.

Table 2. Generalized results of the study *Improving the Quality and Productivity of the Higher Education Sector*

University	The role of analysts	Strategy	Results	University Rank (QS World 2020)
University of Michigan. (USA)	Reducing costs, improving the quality of education	Creation of a working group to advise employees and management on educational analytics; Conducting regular forums on the topic of data analytics	Support for promising projects. An information platform has been created for discussion and exchange of titles in the field of educational analytics.	21
University of New South Wales (Australia)	Improving the quality of education and university efficiency	Creation of a data warehouse; Pilot project for the implementation of a self-developed tool "SAR" (Student at risk)	CRM and SAR integration; Scaling the solution; Launch of analytical projects based on LMS Moodle.	43
University of Wisconsin (USA)	Improving the quality of education and university efficiency	Professional development of employees; Support for projects in the field of learning analytics	Launching small targeted projects	56
University of Technology Sydney (Australia)	Achieving the vision of the world's leading university of technology	Research on teaching and learning, infrastructure, workforce planning, technology, processes based on learning analytics	Based on the BI solution, a dashboard has been developed for students to change their efforts and involvement and provide tools for independent work based on this data. Early identification of students at risk of failure and developed mechanisms for their retention	140
Queensland University of Technology (Australia)	Retention of students. Monitoring of activities related to the involvement of students in the learning process reports on progress.	Organizational Intelligence Capacity Building Project, incl. learning analytics: Collect process data and visualize learning; Development of predictive models; real-time analysis of at-risk students; monitoring student engagement characteristics	Significant improvements in student retention who were contacted based on the data obtained from the analysis.	224
Swinburne University of Technology (Australia)	Retention and adaptation of first-year students	Solving the problem of student retention, especially first year, by quickly connecting to support services	Increase in% retention of first year students	383

University	The role of analysts	Strategy	Results	University Rank (QS World 2020)
University of New England (Australia)	Retention of students; enhancing learning, teaching and knowledge assessment	Curriculum Improvement Project	A tool has been developed to analyze information about students based on 34 triggers with different weights.	800-1000
Open University (UK)	Retention of students	Ensuring: Data availability; Data access; Retrieving information from data	The university leadership participates in the implementation and development of an experimental ecosystem of learning analytics	800-1000

Based on this, we can conclude that:

- Learning analytics is a promising and rapidly developing scientific area, the results of the implementation of which can significantly change the approaches to managing the educational process.
- The development of models for the mining of educational data is an urgent and important task.
- The Python programming language can be used very effectively to quickly build data mining systems.

Implementation of learning analytics in remote education processes improves understanding between students and teachers, shows what methods work worse or better, and what certain lectures, workshops, topics and their parts lead to a higher level of remote education.

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AUTOMATED INFORMATION SYSTEM FOR AN ONLINE STORE OF COMPUTER EQUIPMENT

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Abstract **-** This research explores the dynamic landscape of online retail in the computer hardware industry, examining various aspects of e-commerce specific to this sector. It investigates the strategies employed by successful online computer hardware stores, encompassing aspects such as programming, design, and resource management. By shedding light on these areas, this article deepens our understanding of the online computer hardware market, offering valuable insights for businesses, entrepreneurs, and researchers in this field. Drawing from the fundamental principles of online retail in the computer hardware industry, the study proposes a prototype software solution designed to assist businesses specializing in computer hardware sales, following essential guidelines to create an efficient and user-friendly internet shopping system.

Keywords*:* online store, software system, automated system, e-commerce.

I. INTRODUCTION

In today's rapidly evolving digital landscape, the world of e-commerce has become an integral part of our daily lives. The convenience of online shopping has transformed the way consumers access and purchase products, and the realm of computer equipment is no exception. As the demand for cutting-edge technology and reliable hardware continues to surge, businesses specializing in computer equipment must adapt to this digital revolution. To thrive in this competitive environment, a robust and efficient automated information system for an online store of computer equipment is essential.

This system represents the backbone of a modern computer equipment retailer, streamlining various facets of the business, from inventory management to customer interactions. It not only enhances operational efficiency but also elevates the customer experience, providing seamless browsing, purchasing, and support options.

In this comprehensive exploration, we delve into the world of automated information systems for online stores of computer equipment. We will examine the critical components, functionalities, and benefits of such a system, shedding light on its transformative potential within the computer equipment retail industry. Additionally, we will explore the latest trends and innovations that are shaping the future of this technology-driven sector.

Whether you are a seasoned computer equipment retailer looking to optimize your operations or an entrepreneur venturing into the world of online sales, this guide will equip you with the knowledge and insights needed to harness the power of an automated information system for your success. Join us on this journey through the digital landscape of computer equipment retail and discover how automation can propel your business to new heights.

II. WHAT YOU'LL GAIN BY AUTOMATING YOUR ONLINE STORE

In the intricate landscape of e-commerce, automation emerges as a linchpin, revolutionizing the operational and strategic dimensions of online business. Leveraging state-of-the-art machine learning algorithms and complex data analytics, automation serves as a catalyst for exponential growth and efficiency. It's not just about automating routine tasks like order processing and inventory management; it's a paradigm shift that liberates

organizational bandwidth to focus on strategic imperatives.

The brilliance of automation manifests in multiple facets, beginning with an unprecedented increase in operational efficiency. Advanced algorithms execute tasks with a level of speed and precision that human operators cannot match. This computational prowess leads to quicker order fulfillment cycles, reduced error rates, and a profound optimization of workflow processes.

However, the impact of automation isn't confined solely to internal operations; it extends its transformative influence to the customer experience. Through the integration of Natural Language Processing (NLP) and machine learning algorithms, automation is capable of delivering hyper-responsive customer service, algorithmically optimized order processing, and personalized product suggestions. These capabilities culminate in elevated customer satisfaction indices, thereby engendering long-term brand loyalty.

In the domain of inventory management, automation is a game-changer. It employs real-time analytics and predictive modeling to maintain optimal stock levels, thereby mitigating the economic inefficiencies associated with overstocking and understocking. In doing so, it drives financial sustainability and primes the business for scalable growth.

From a marketing and sales perspective, automation is equally transformative. It integrates seamlessly with Customer Relationship Management (CRM) systems to deliver targeted, data-driven marketing initiatives. These range from programmatic advertising to personalized email campaigns, not only amplifying customer engagement but also driving revenue streams. Coupled with Big Data analytics, automation provides invaluable insights into customer behavior and purchasing trends, thereby empowering data-backed strategic decision-making.

Yet, the benefits of automation extend beyond efficiency and revenue generation; they touch upon risk mitigation as well. By integrating robust error-checking algorithms and data validation protocols, automation significantly reduces the scope for human error across business operations. This not only safeguards brand integrity but also enhances customer trust.

Adding another layer of complexity, automation frameworks are inherently scalable. Built on modular architectures, they adapt effortlessly to incremental transactional volumes and diversified operational demands. This ensures that as an e-commerce enterprise scales, its automation infrastructure evolves in tandem, without requiring a fundamental overhaul.

On the financial front, the return on investment (ROI) for automation is both quantifiable and substantial. Although the initial capital expenditure (CAPEX) may be significant, the long-term benefits manifest in the form of operational cost savings and increased revenue streams. This results in a favorable Total Cost of Ownership (TCO), making automation a financially prudent investment.

In the hyper-competitive landscape of e-commerce, automation serves as a pivotal differentiator. By enabling real-time analytics and facilitating agile responsiveness to market trends and consumer preferences, automation positions enterprises at the vanguard of industry innovation.

Moreover, automation has a role to play in enhancing cybersecurity. By constantly monitoring network traffic and system interactions, it preemptively identifies potential security threats, thereby serving as an added layer of defense.

Lastly, in the context of globalization, automation technologies facilitate seamless cross-border transactions. They intricately navigate the complexities of international tax codes and compliance requirements, thereby simplifying and enabling global business operations.

In essence, automation is not merely a technological tool but a comprehensive strategic enabler that has the potential to redefine the future landscape of online retailing.

III. BUILDING AND GROWING YOUR ONLINE STORE

In the ever-evolving ecosystem of online commerce, the roadmap to establishing and scaling an e-commerce operation transcends mere storefront creation. It's an intricate process guided by data-driven decision-making, strategic algorithmic interventions, and a keen focus on customer engagement. From market analytics to customer retention strategies, the orchestration involves multiple layers of technological and strategic complexities.

In the preliminary phase, market research takes precedence. Utilizing algorithms to analyze big data sets, the focus is on identifying target demographics and market niches. Competitive analysis algorithms dissect competitors' strategies, providing insights into their strengths and vulnerabilities. Concurrently, data analytics tools scrutinize market trends and customer preferences, thereby informing the definition of business objectives, mission statements, and vision.

Following market analysis, the next logical progression is product selection. At this juncture, machine learning algorithms curate a product catalog that synchronizes with the identified niche and target audience. The emphasis is not merely on quantity but on quality and uniqueness, often articulated through a compelling value proposition designed to captivate the intended market.

Transitioning to the customer experience, the role of automation and data analytics becomes palpable. Customer service channels integrate chatbots and AI-driven support systems to deliver real-time, responsive assistance. Additionally, logistical algorithms manage a seamless return and refund process, thereby minimizing friction in the customer journey. The system also aggregates customer reviews and testimonials, utilizing sentiment analysis algorithms to gauge customer satisfaction and identify areas for improvement.

When addressing customer retention, the incorporation of loyalty programs and incentive structures becomes crucial. These are often executed through automated marketing platforms that deploy targeted email campaigns and personalized product recommendations. By employing machine learning algorithms to analyze customer behavior, these platforms enable highly personalized and dynamic marketing strategies designed to maximize customer lifetime value.

IV. CHARACTERISTICS OF AN AUTOMATED ONLINE STORE SYSTEM

In the digital commerce ecosystem, the architecture of an automated online store system is intrinsically multifaceted. It's a confluence of interconnected modules, each designed to serve specific functionalities while contributing to an overarching seamless user experience. At its core lies the online product catalog, a sophisticated database layer that not only houses an array of products but also enriches them with metadata, ranging from descriptions and specifications to prices and visual assets. This database is often constructed using robust DBMS systems with optimized query mechanisms to facilitate quick and efficient data retrieval.

Complementing the product catalog is the shopping cart module. It serves as an intermediary transactional layer, where customers can curate their product selections. Designed with flexibility in mind, this module allows for real-time modifications—be it adjusting quantities, removing items, or saving selections for future consideration. Advanced algorithms manage the dynamic pricing and offer calculations within the cart.

Payment mechanisms represent another crucial characteristic, and these are commonly facilitated through secure API integrations with various payment gateways. The emphasis here is on cryptographic techniques and secure socket layers to ensure transactional integrity and customer confidentiality.

Beyond payments, the system extends its functionality to shipping logistics. Here, algorithms calculate delivery timelines and cost estimates based on geolocation data and

shipping provider APIs. This module works in tandem with the payment system to offer a comprehensive checkout experience.

Analytical reporting is another vital component, enabling businesses to derive actionable insights. Through advanced data analytics, the system offers a suite of reports covering sales tracking, inventory status, and product popularity, thereby acting as a strategic tool for business decision-making.

No system can be complete without robust customer support functionalities. Leveraging AI-powered chatbots and ticketing systems, this module provides real-time support and query resolutions, covering topics from order status to payment queries.

Last but not least, data protection mechanisms play a pivotal role. The architecture incorporates end-to-end encryption and complies with data protection regulations to ensure the secure handling of sensitive customer data.

V. SOLUTION ARCHITECTURE

The following technologies were chosen to build this system:

1. Frontend:
   - React.js with Redux Toolkit for state management
   - Axios for API communication
2. Backend:
   - Ruby on Rails for server-side logic
   - PostgreSQL for robust database management
3. Payment Gateway:
   - WayForPay for secure payment processing
4. Background Jobs:
   - Sidekiq for efficient background job processing
5. Shipping Integration:
   - Nova Poshta API 2 for seamless shipping and tracking
6. Admin Dashboard:
   - ActiveAdmin for an intuitive and powerful administrative interface

This refined solution architecture combines cutting-edge technologies and reliable components to deliver a high-performance and feature-rich e-commerce platform.

VI. THE MAIN REASON TO CHOOSE RUBY ON RAILS

The decision to utilize Ruby on Rails (RoR) as the backbone for an automated online store is underpinned by a multitude of strategic and technical considerations. A key attribute of RoR is its capacity for rapid development. The framework is renowned for its developer-centric syntax and conventions, which facilitate the expeditious deployment of web applications. This capability is especially pertinent in the hyper-competitive e-commerce sector, where time-to-market can be a critical determinant of success.

Complementing its agility is RoR's expansive ecosystem. The framework boasts a plethora of gems and plugins, which serve as extensible modules for a variety of complex tasks. Within the e-commerce context, gems like Spree Commerce and Solidus offer a robust foundation, simplifying the development process considerably.

Scalability is another dimension where RoR excels. The framework is not merely a tool for small-scale applications; it is employed by large e-commerce platforms, demonstrating its capability to handle high traffic volumes and extensive product inventories.

Furthermore, RoR is bolstered by an enthusiastic and active developer community. This provides a reservoir of communal knowledge, aiding in problem-solving, and

facilitating access to up-to-date resources and best practices.

In the realm of security, RoR is outfitted with intrinsic features designed to thwart common web vulnerabilities. The framework's gems also contribute to this, with libraries like Devise offering additional layers of authentication and authorization.

API integration stands as another forte of RoR. The framework is adept at interfacing with third-party services, ranging from payment gateways to shipping APIs and inventory management systems. This versatility is crucial for a fully functional online store.

From a financial perspective, RoR's open-source nature offers cost-efficiency, eliminating the burden of licensing fees. This makes it particularly appealing for startups and small businesses operating on a constrained budget. RoR's Object-Relational Mapping (ORM), known as ActiveRecord, is another noteworthy feature. It serves to simplify database interactions, thereby streamlining data management processes within the store.

Finally, the maturity of the RoR ecosystem cannot be overstated. Its longstanding presence in the technology landscape has endowed it with a track record of stability and reliability.

VII. THE MAIN REASON TO CHOOSE REACT

When contemplating the technology stack for an automated e-commerce platform, React emerges as an immensely compelling choice. One of its foremost strengths is its capacity to deliver an unparalleled User Interface (UI) performance. The framework is engineered to facilitate highly responsive and interactive interfaces, a prerequisite for a seamless shopping experience.

Another distinguishing feature of React is its component-based architecture. This paradigm promotes both modularity and reusability, enabling developers to craft and repurpose UI elements such as product cards and checkout forms. This not only streamlines the development cycle but also fosters maintainability in the long run. The potency of React's Virtual DOM is yet another salient aspect. Unlike the traditional DOM, the Virtual DOM selectively updates only the requisite components, mitigating the need for resource-intensive page reloads. This results in an optimized page rendering speed, further enhancing the user experience. Complementing its core capabilities is React's extensive ecosystem. It offers a myriad of third-party libraries and design components, such as Material-UI and Ant Design, which expedite the development process while enriching the platform's aesthetics.

React's innovation extends to state management as well, with the introduction of React Hooks like useState and useEffect. These hooks offer a more straightforward, cleaner methodology for managing application state and orchestrating side effects.

The framework's vibrant developer community is another invaluable asset. It serves as a repository of shared knowledge, open-source projects, and tutorials, thereby providing a robust support network for developers. From an SEO perspective, React's compatibility with server-side rendering (SSR) and static site generation (SSG) frameworks like Next.js is noteworthy. This facilitates more effective crawling and indexing by search engines, optimizing the platform's search visibility. Moreover, React's adaptability to real-time technologies like WebSockets and GraphQL is worth highlighting. These integrations enable dynamic features, including live product updates and real-time customer support, thereby elevating the platform's interactive capabilities.

In the realm of security, React offers seamless integrations with community authentication solutions like Firebase Authentication and Auth0, thereby fortifying the user accounts within the store.

In closing, it's worth mentioning that React's focus on testing and debugging is not to be overlooked. The framework offers a comprehensive suite of developer tools designed to safeguard the application's reliability and quality.

CONCLUSIONS

Whether you're selling computer equipment or any other products. We've explored the importance of strategic planning, the choice of technology stack, and the significance of user experience in the e-commerce landscape.

By carefully selecting the right tools, such as Ruby on Rails for backend development and React for frontend interactivity, businesses can create a dynamic and efficient online store. These technologies offer scalability, performance, and a vibrant developer community to support your goals.

Furthermore, we've underscored the significance of staying attuned to emerging trends, including AI-driven recommendations, virtual reality shopping experiences, sustainability efforts, voice commerce, and blockchain applications. These innovations can play pivotal roles in the future of e-commerce and should be considered in your long-term strategy.

By embracing automation, optimizing user interfaces, and providing a seamless shopping experience, online stores can cater to the needs of both sellers and customers. Craftsmen can expand their reach, connect with a broader audience, and boost their sales, while customers can enjoy the convenience of discovering and purchasing unique products online.

In summary, building a successful online store is a dynamic and evolving endeavor, and the right combination of technology, strategy, and customer-centric design can pave the way for growth and success in the competitive e-commerce landscape.

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THE IMPORTANCE OF CYBERSECURITY POLICIES IN TODAY'S SOCIETY

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Abstract – With the increasing reliance on the Internet and technology, the need for effective cybersecurity policies has become more critical than ever. Implementing an effective cyber security policy reduces losses and increases customer trust. This article highlights the importance of cyber security policies and their role in protecting personal and confidential data. The report also provides examples of countries implementing cyber security policies and their success in reducing cyber-attacks and improving cyber security.

Keywords – Cybersecurity, Data breach, Policy, Regulation.

I. INTRODUCTION

In today's highly digital age, the Internet and ICT have profoundly changed how we live and do business. People rely more on the Internet for communication, data storage and transactions. It means that individuals, organizations and companies store much information, privacy and financial data in the online cloud. While this brings us convenience, it also gives hackers a more accessible space to steal information. If a hacker succeeds in stealing this personal information or confidential documents, it could lead to a significant breach of information, loss of property or even damage to reputation, which could be devastating for any user, company or country. To protect this critical privacy, cyber security becomes essential. Cybersecurity protects computer systems, networks and data from unauthorized access, malware and other cyber threats. We must have cybersecurity-related policies and laws to regulate cyber behavior and enhance protection measures concerning the Internet.

II. WHAT IS CYBER SECURITY POLICY

In this context, it becomes imperative to have an effective cyber security policy and to take appropriate measures. A *cyber security policy* is a regulation set by a country, company or government to ensure cyber security. It sets standards and measures for regulation, prevention, response and disposal to ensure cyber security. Its purpose is to guarantee the network's security and stability and maintain national and social stability. Furthermore, it protects citizens' privacy, prevents malicious attacks, ensures the stable operation of critical information infrastructures, and prevents cybercrime and information leakage.

III. DAMAGE FROM CYBER ATTACKS

Because there are no proper security policies and measures, large data storage servers have become a significant target for hackers, such as companies, organizations and even countries. According to news reports, a data breach at Target supermarkets in 2013 resulted in the loss of credit card information for more than 40 million people and 70 million addresses, phone numbers and other personal information. Hackers installed malware that targeted security and payment systems, then stored credit card information and uploaded it to the hackers' servers each time a card was swiped. The attack resulted in a loss of nearly US$200 million, a 46% drop in revenue, and a significant reduction in customer purchasing power and demand due to the breach. Not only companies but even governments have

suffered significant losses as a result of the hack. In May 2018, hackers broke into and took control of approximately 10,000 government computers in Baltimore, Maryland, USA, and demanded a payment of approximately $100,000 in Bitcoin to free their systems. The hackers used RobbinHoo ransomware to break in quietly, making it impossible for government departments to access servers without a specific digital key. The ransomware uses a publicly available algorithm called RSA to encrypt data. The city would have had to rebuild its servers from scratch without the key. However, the city has refused to deliver the ransom, government emails are inaccessible, utility parking fees cannot be paid, and property transactions cannot be made. This paralysis of the municipality's systems has occurred for three weeks. The attack damaged all markets and was finally fixed in September at a cost to the city of $18 million. Their severe lag in cyber security capabilities, staffing needs and infrastructure have led to these crises.

Despite the increase in cyber security threats and the associated hacking cases, many organizations and institutions still have significant vulnerabilities and weaknesses. These vulnerabilities and weaknesses may be due to inadequate security policies, technical safeguards, or employee security awareness. Therefore, this study aims to explore and improve existing cyber security policies and measures in response to the hacking cases mentioned above to improve the cyber security of organizations and institutions and protect the data we need to preserve.

IV. WHAT WE CAN IMPROVE

The first point is access control. This means that only authorized users, programs and computer systems can access the resources in the design, and unauthorized access is not possible to keep systems and data secure. Therefore, it is one of the essential means of protecting information and technology security. We can implement access control by determining whether a user's identity is legitimate, granting appropriate permissions, and monitoring and logging user access behavior. These methods are good at eliminating intrusion by unknown users and preventing data leakage.

The second point is to conduct regular security assessments. It means that the security of systems and networks needs to be checked regularly to confirm compliance with security requirements and policies and to take appropriate measures to improve them. Three aspects need to be taken into account when carrying out these checks: the assessment methods and techniques used, a clear definition of the scope of the assessment and the generation of a detailed assessment report. This allows us to identify and clarify issues that need to be addressed more quickly and, finally, to track and monitor the implementation of improvements. This ensures that recommended measures are addressed and fixed promptly and that the security situation is regularly reviewed and reassessed.

The third point is safety awareness training. Employees are an integral part of the country and the company, and human factors are the leading cause of information security incidents. Therefore, provide employees with knowledge and skills on cyber security, such as identifying suspicious emails, phone calls or fake web links. It is vital that employees are made aware of the importance of information security and that their active involvement and responsibility in protecting it is emphasized. Encourage employees to report security issues and suspicious activity and establish effective communication channels to promptly identify and address potential security threats.

The fourth point is to innovate technology and keep it up to date. As hacking techniques evolve and new security threats emerge, organizations and institutions must constantly innovate and update their security measures to meet these challenges. For example, we can adopt advanced security technologies such as intrusion detection systems (IDS), intrusion prevention systems (IPS), firewalls, data encryption, and multi-factor

authentication. These technologies can provide more robust security protection and help organizations quickly detect and block potential attacks. Automated and intelligent security measures can also be tried to enhance cyber defense and response capabilities using automated and intelligent security measures. For example, use machine learning and artificial intelligence technologies to detect anomalous behavior and threats, respond in real-time and automate responses to attack incidents.

The fifth point is to establish an incident response plan. Organizations and institutions need to have an effective incident response plan in place. An organization can respond and deal with a security incident or attack in a quick and orderly manner to minimize damage and restore normal operations. The plan should clearly define the various responsible roles and processes, including incident reporting channels, emergency contacts, post-incident analysis and remediation measures. By establishing a well-defined incident response plan, organizations and institutions can better respond to security incidents, limit the impact of attacks promptly, and take the necessary steps to repair and enhance systems to prevent the recurrence of similar incidents in the future.

In summary, by strengthening access controls, conducting regular security assessments, security awareness training, technical innovation and keeping up to date, and establishing effective incident response plans, organizations and institutions can more comprehensively and systematically improve their cyber security, reduce potential risks and vulnerabilities, and better protect critical data and assets.

V. THE CHANGES THAT COME WHEN CYBER SECURITY POLICIES IMPROVE

The implementation of robust cybersecurity measures has resulted in substantial progress in improving the security of organizations and institutions. One notable example is the European Union's General Data Protection Regulation (GDPR) introduced in 2018. Designed to safeguard personal data's confidentiality, integrity, and availability, the GDPR has had a profound impact on businesses worldwide, setting higher standards for data protection and privacy. Companies are required to undertake a range of measures to ensure the security of personal data, as evidenced by the severe penalties imposed for non-compliance. The tables below show some of the significant fines already imposed under the GDPR, totaling approximately €1.6 billion through 2023.

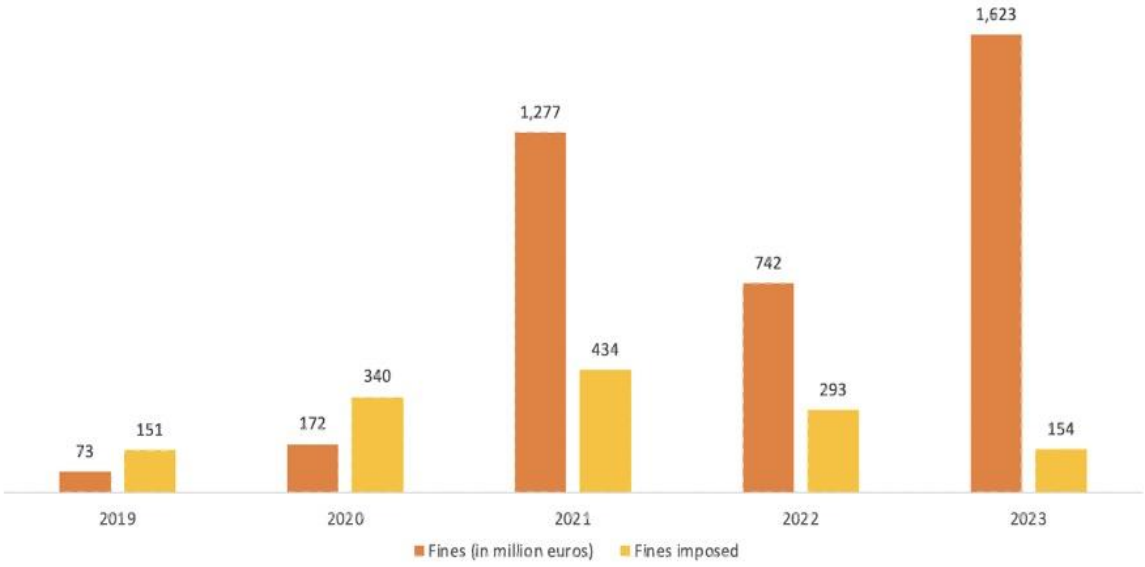

Fig. 1 Fines imposed in the EU as a result of General Data Protection Regulation (GDPR) violations

Companies fined under the GDPR include Amazon, which faced a penalty of 746 million Euros for non-compliance with the basic principles of data processing. WhatsApp (Ireland) received a fine of 225 million Euros for inadequate compliance with information obligations. Google has faced fines multiple times, including 90 million Euros and 60 million Euros for insufficient legal basis for data processing. Facebook (Ireland) and Google (Ireland) also received penalties of 60 million Euros each for the same reason. Additionally, there have been fines imposed on H&M (35.26 million Euros), TIM (Telecom Italia Mobile) (27.80 million Euros), Enel Green Power (26.50 million Euros), and British Airways (22.05 million Euros) for various violations under the GDPR.

These penalties demonstrate the importance the GDPR (Table 1) places on protecting personal data and underline the need for businesses to strengthen their data processing processes, enhance data security measures, and ensure compliance when sharing data with third-party partners. Adhering to the GDPR not only fulfills compliance requirements but also enhances a company's competitiveness by improving stock performance, brand value, and customer loyalty. Companies that prioritize GDPR compliance signal their commitment to privacy and data protection, earning the trust and confidence of customers. This, in turn, helps build a positive market reputation, attracting more customers and fostering new business opportunities. The GDPR exemplifies the remarkable outcomes achievable through enhanced cybersecurity policies and measures, showcasing the significant benefits organizations and institutions can reap from prioritizing data security and privacy.

TABLE 1
information about companies that have been fined under the General Data Protection Regulation (GDPR)

16-Jul-2021	Amazon	746 million	Non-compliance with the basic principles of data processing	Business
2-Sep-2021	WhatsApp (Ireland)	225 million	Inadequate compliance with information obligations	Media, telecommunications
31-Dec-2021	Google	90 million	Insufficient legal basis for data processing	Media, telecommunications
31-Dec-2021	Facebook (Ireland)	60 million	Insufficient legal basis for data processing	Media, telecommunications
31-Dec-2021	Google (Ireland)	60 million	Insufficient legal basis for data processing	Media, telecommunications
21-Jan-2019	Google	50 million	Insufficient legal basis for data processing	Media, telecommunications
1-Oct-2020	H&M	35.26 million	Insufficient legal basis for data processing	Costumes
15-Jan-2020	TIM (Telecom Italia Mobile)	27,80 million	Insufficient legal basis for data processing	Media, telecommunications
16-Dec-2021	Enel Green power	26,50 million	Insufficient legal basis for data processing	Transport and Energy
16-Oct-2020	British Airways	22,05 million	Inadequate measures to ensure information security safeguards	Transport and Energy

Another relevant case is the *Cyber Shield* programme in Kazakhstan. Launched in 2013 by former President Nursultan Nazarbayev, this programme addresses Kazakhstan's cyber security challenges. Kazakhstan is one of the most attractive countries for hackers, as

the country's low computer security is the main reason why nearly 74% of software is downloaded from illegal sources. As a result, computers running pirated software are highly vulnerable to hacking, theft of confidential information, fraud and other forms of cybercrime attacks. The government has taken several measures to address the cyber security challenge through the Cyber Shield programmer. Among other things, the government has increased surveillance and proactive response to protect cyberspace and introduced a range of security measures to improve critical infrastructure security systems such as banks, government agencies, businesses and manufacturing industries. In addition, they have focused on training cybersecurity experts and raising public awareness of information security.

Furthermore, the government offers cyber-focused scholarships for university students to attract more professionals. At the same time, extensive education campaigns have been conducted for the public to ensure that they have basic knowledge of computer and communications technology protection to avoid becoming victims of cyber fraud. In addition, the government has provided free online cyber security training courses for civil servants to enhance their cyber technical skills. According to the 2014 Global Cybersecurity Index published by the International Telecommunication Union, a United Nations information and communications technology initiative, Kazakhstan was ranked at 111th place with an overall score of 0.176. However, following the government's efforts to combat and improve cybercrime, Kazakhstan has improved its ranking by 80 places by 2020, surpassing countries such as Denmark, China and Croatia to rank 31st, with an overall score reaching a score of 0.9315. This change in ranking demonstrates the efforts made by the Government of Kazakhstan in cyber security and the significant returns achieved.

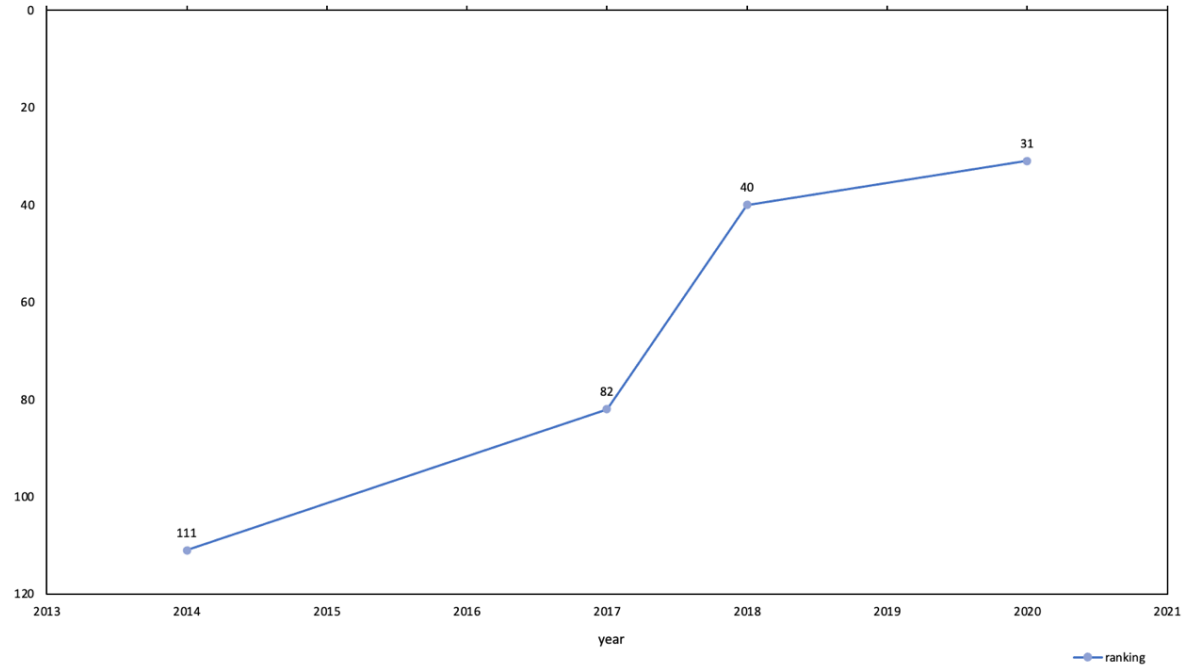

Fig. 2 Kazakhstan's ranking in the Global Cybersecurity Index from 2014 to 2020

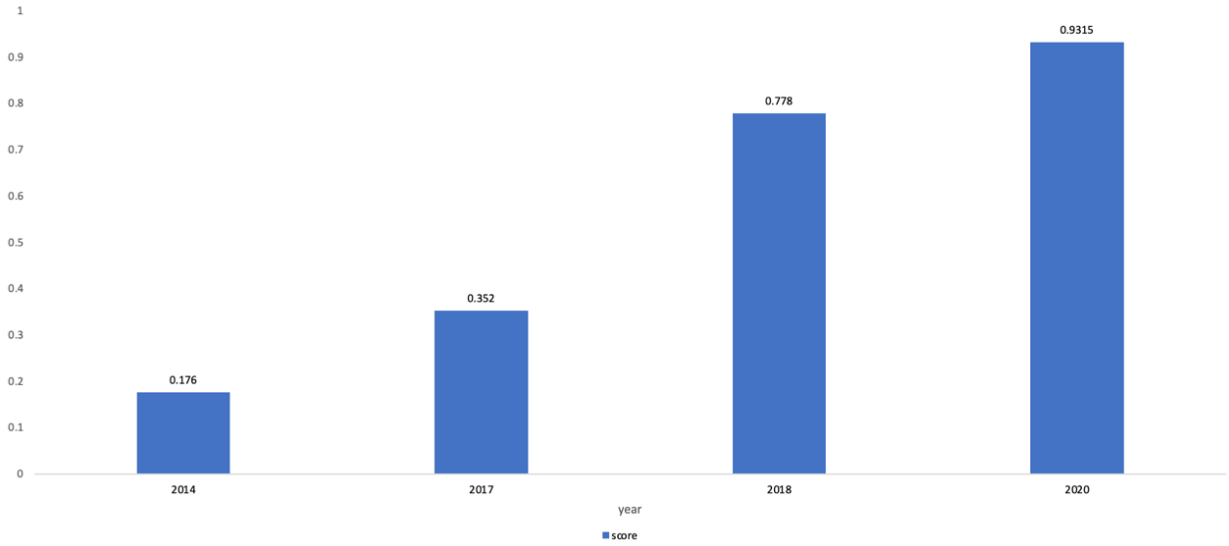

Fig. 3 Kazakhstan's score in the Global Cybersecurity Index from 2014 to 2020

VI. CONCLUSION

In conclusion, as information technology continues to evolve and cyber security threats increase to protect individuals and organizations from the devastating effects of these attacks, the importance and significance of cyber security policies will become more prominent and significant. A successful cyber security policy must fully account for the realities of the individual, business, or government agency and continuously improve and enhance cyber security through regular evaluation and feedback mechanisms. This is why today's security policies still require relentless improvement and progress. Although implementing a cyber security policy is costly and requires effort, it is crucial for long-term success.

ACKNOWLEDGMENT

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PROGRAM SYSTEM OF ELECTRONIC TRADE OF ECOGOODS

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Abstract— This research explores the dynamic realm of online sales of eco-friendly products, delving into various aspects of e-commerce, including opportunities and challenges characteristic of the digital eco-products market. The publication examines the strategies and tactics employed by successful online store owners of eco-friendly products. Drawing upon fundamental principles of online eco-product retail, the study proposes a prototype software based on a three-tier client-server architecture utilizing a non-relational database MongoDB.

Keywords— e-commerce, e-store, eco-friendly products, web application.

I. INTRODUCTION

E-commerce is one of the key components of e-business and plays a significant role in the modern business world. The core essence and concept of electronic commerce encompass the following aspects: e-transactions, a large variety of e-commerce websites. E-commerce involves conducting business operations over the Internet. This includes buying and selling goods and services, financial transactions, information exchange, etc., using electronic systems and technologies [1].

It is a website or platform where a company showcases its products or services, ideally with interactive features for ordering and payment [2]. Customers can browse the product range, add items to their cart, and make purchases online. Electronic payment systems are systems that allow customers to make payments for goods and services online. These can include credit cards, electronic wallets, mobile payments, and other electronic payment methods. E-commerce also involves using the Internet for marketing and advertising products and services. This may include search engine optimization (SEO), content marketing, social media advertising, and other tools to attract and retain customers. Effective electronic commerce requires a well-organized logistics and delivery system to ensure timely delivery of orders to customers. However, providing high-quality online customer service is a crucial aspect of electronic commerce. Communication with customers, resolving their issues, and providing information are key elements. Security issues will remain important. Ensuring the security and confidentiality of customer information and transactions is a mandatory aspect of electronic commerce [3].

E-commerce enables companies to expand their digital market and conduct international business, depending on their readiness and ability to adapt to local peculiarities. In summary, e-commerce is a vital component of e-business that enhances convenience for customers, increases market accessibility, and allows companies to improve their operational efficiency.

II. OPPORTUNITIES AND CHALLENGES IN THE ELECTRONIC SALE OF ECOGOODS

The main trends in the field of e-commerce in 2022 may include the following aspects. The role of social media and online communities in commerce is growing. More brands and retailers are partnering with social media platforms to engage customers, interact with them more, and offer products and services directly in these environments. The popularity of marketplaces continues to rise. This gives consumers more choice and the

ability to compare prices and product features. Manufacturers and sellers are striving to engage customers through interactive content such as videos, virtual reality (VR), and augmented reality (AR) to help customers better understand and interact with products before purchasing.

There is a growing demand for products and brands that actively demonstrate their environmental responsibility. More companies are focusing on using renewable materials, reducing CO_2 emissions, and other sustainable practices. Retailers are trying to enhance convenience for consumers by offering integrated online and offline experiences. This may include online purchasing and in-store pickup, among other omnichannel offerings. With the increased circulation of consumer personal data, companies are becoming more cautious in preserving and protecting this data from security breaches. Many companies are looking to expand their presence in the international market through exports and collaborations with international markets.

E-commerce can take the form of e-shops, where consumers can browse product assortments, place orders, and make payments online. An e-shop is a website or platform where goods and services are sold over the Internet. This term describes an interactive environment where customers can choose products, learn more about their characteristics, and make purchases online.

Eco-friendly products, also known as eco-products, are goods that are produced or consumed with minimal negative impact on the environment. This may include products made from renewable materials, low-carbon-emission products, as well as products that contribute to the conservation of natural resources and waste reduction.

Opportunities and challenges in the electronic sale of eco-friendly or "ecogoods" encompass a wide range of factors. Let's consider some of the factors of the spread of sales through electronic stores of eco-goods.

There is a rising consumer demand for eco-friendly products. As awareness of environmental issues increases, more consumers are seeking sustainable and green alternatives. E-commerce platforms offer access to a global customer base. Selling eco-friendly products online allows businesses to reach a wider audience, including environmentally conscious consumers in different regions. Online sales can be cost-effective. Businesses can reduce overhead costs associated with physical stores, warehousing, and traditional marketing. E-commerce platforms provide an opportunity to educate consumers about the environmental benefits of eco-friendly products, helping them make informed choices. Online platforms allow businesses to offer a diverse range of eco-friendly products, from clothing and home goods to electronics and food items. E-commerce platforms provide valuable data on customer preferences and behavior, allowing businesses to tailor their offerings and marketing strategies.

There are also certain challenges. The eco-friendly market can be highly competitive. Many businesses are offering similar products, making it challenging to stand out. Consumers are becoming more discerning and may question the authenticity of eco-friendly claims. Sourcing sustainable materials, manufacturing processes, and transportation can be complex and costly. While e-commerce can educate consumers, it can also lead to information overload. It's essential to effectively communicate the eco-friendly benefits of products without overwhelming customers. The environmental impact of shipping and packaging can be a concern. Balancing convenience with sustainability in packaging and shipping methods is vital. Compliance with environmental regulations and obtaining eco-certifications can be time-consuming and costly. Building and maintaining customer trust is crucial. If customers perceive a lack of transparency or discover inconsistencies in eco-friendly claims, it can damage a company's reputation. Handling returns of eco-friendly products and managing waste responsibly can be challenging. Businesses need efficient processes for managing returned items and recycling or disposing of them properly.

In summary, while there are significant opportunities in the electronic sale of ecogoods due to growing consumer demand and the global reach of e-commerce, businesses must navigate various challenges related to competition, authenticity, supply chain sustainability, consumer education, logistics, regulations, and customer trust to succeed in this market.

III. STRATEGIES AND TACTICS FOR THE SUCCESS OF ECOGOODS ONLINE STORES

Developing a successful online store specializing in eco-products requires a thoughtful and comprehensive strategy.

Need for market research to identify niche, determine the specific eco-products you want to sell and your target audience. Consider which products are in demand and align with your values. Also need to study competitors in the eco-products space to understand their strengths and weaknesses. Identify gaps in the market that you can fill. Ensure that products are genuinely eco-friendly, sustainable, and meet relevant certifications. Consider offering a diverse range of products to appeal to a broader customer base. Ensure the quality of your products is high, as this will help build trust with customers.

Website of ecogoods online stores must be user-friendly. Create an easy-to-navigate website with a clean design that emphasizes your eco-friendly mission. Ensure your website is mobile-responsive, as many customers shop from mobile devices. Provide secure and convenient payment options to build trust. Share your brand's eco-friendly mission and values through compelling storytelling. Use your website and social media channels to create a connection with customers. Provide information on the environmental benefits of your products. Blog posts, videos, and infographics can help educate and engage customers. Use sustainable packaging materials and practices to minimize your environmental footprint. Clearly communicate your commitment to eco-friendly packaging to customers. Leverage social media platforms to showcase your products, engage with your audience, and build a community around your brand. Produce informative and engaging content related to eco-products and sustainability to attract and retain customers. Optimize your website for search engines to improve visibility in search results. Use analytics tools to monitor website traffic, sales, and customer behavior. Adjust your strategy based on data-driven insights. Stay up-to-date with evolving trends in eco-products and sustainability and adapt your product range accordingly. Success in the online eco-products market requires a long-term commitment to sustainability, a strong online presence, and a customer-centric approach. Building trust and delivering value to eco-conscious consumers will be key to your store's success.

The coronavirus pandemic influenced the global economy in many different ways. Due to coronavirus restrictions and social distancing, consumers all over the world were looking for efficient and convenient ways to buy products. As a result, there is an increasing demand for purchasing products online which causes global e-commerce growth over the past few years. In particular, customers tend to prioritize sustainable ecological products and shopping formats that don’t require physical presence. The solution can be found in the program system for the e-trade of ecological products.

IV. IMPLEMENTATION, TESTING OF ECO-GOODS ELECTRONIC TRADE SYSTEM

The developed system is based on a client-server architecture and interacts with users following a B2C (business-to-consumer) model. A three-tier client-server architecture using a non-relational database is shown in Figure 1.

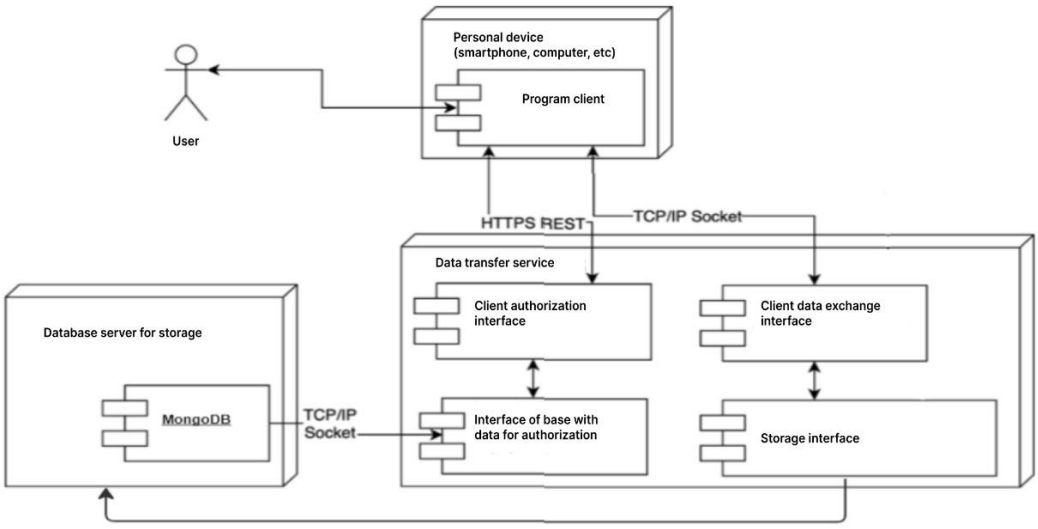

Fig. 1 A three-tier client-server architecture of electronic trade of ecogoods program system

To accomplish the stated task, the following objectives need to be addressed:

- Identify the advantages and disadvantages of similar resources.
- Develop a user-friendly client-oriented interface for interacting with users.
- Create a data access resource (database server) using non-relational databases.
- Ensure the data security principles for user data.

Fulfill the main requirements for an e-commerce system on the website and implement the necessary functionality. The task of developing an e-commerce system involves creating software that enables efficient and secure online trading of eco-friendly products over the Internet.

The system represents an online store of eco products with an intuitive and user-friendly interface based on B2C business model. Implemented functionality includes a wide range of features, such as translation, authorization/registration, search, filter, sort, cart, order, and payment. The list of products can be updated in real time by the administrator. The system was developed based on three-tier client-server architecture. The server-side rendering technique used in this system provides faster load time and improved search engine optimization. Technologies in frontend include HTML, Tailwind CSS, Javascript, React, and Next.js frameworks [4]. As to the backend, users' and products' data is securely stored in a non-relational MongoDB database with the cloud environment. The Bcrypt library has been employed for secure password storage. Bcrypt is a hash function used to protect passwords through hashing. Bcrypt provides a built-in comparison function that compares the hash of the input password with the stored password hash. This ensures proper password verification during authentication [5].

The developed system can be applied not only for sales of eco products but also can be widely used by any business owner who decided to transform the trade from a physical to digital market.

V. CONCLUSION

The research resulted in the development of an electronic commerce software system for eco-friendly products, including the following key steps: examination of the general theoretical foundations of electronic commerce; analysis of software and technical solutions for constructing electronic commerce systems for eco-friendly products; design,

implementation, testing, and deployment of the electronic commerce system for eco-friendly products, taking into consideration engineering requirements. The future of eco-goods e-commerce is likely to be influenced by several trends and developments that are shaping the broader e-commerce and sustainability landscapes. As people become more conscious of environmental issues such as climate change, deforestation, plastic pollution, and biodiversity loss, there is a growing demand for eco-friendly products. This heightened awareness is likely to drive the demand for eco-goods. Governments and international organizations are increasingly implementing regulations and standards to promote sustainability. This could impact the production, labeling, and marketing of eco-goods, potentially creating opportunities for e-commerce platforms that adhere to these standards. E-commerce platforms will continue to leverage technology to improve the shopping experience for customers. This may include advanced search and recommendation algorithms to help customers find eco-friendly products, augmented reality for virtual product try-ons, and more efficient supply chain management to reduce the carbon footprint of deliveries. Consumers are becoming more interested in the origins and supply chain of products, especially when it comes to eco-friendly and sustainable goods. E-commerce platforms that can provide transparent information about the sourcing and production of their eco-products may gain a competitive edge. E-commerce platforms may collaborate with eco-friendly brands, NGOs, and sustainability organizations to expand their offerings and promote sustainable practices. Such partnerships can help build trust with environmentally conscious consumers. The concept of a circular economy, where products are designed to be reused, recycled, or repurposed, is gaining traction. E-commerce platforms may play a role in facilitating the buying and selling of refurbished or recycled products. Also e-commerce platforms are likely to offer more personalized and customizable eco-product options to cater to individual preferences and values. Many consumers are still unfamiliar with eco-friendly options and may require education on their benefits. E-commerce platforms can provide educational resources, such as blogs, videos, and guides, to inform customers about sustainable choices. Eco-goods e-commerce platforms may expand globally, connecting eco-conscious consumers with sustainable products from around the world. This could lead to increased trade of eco-friendly products. As the demand for eco-goods grows, more players may enter the market, leading to increased competition. In summary, the future of eco-goods e-commerce is likely to be shaped by a combination of environmental concerns, technological advancements, regulatory changes, and consumer preferences. E-commerce platforms that can adapt to these evolving trends and offer a compelling shopping experience while promoting sustainability are likely to thrive in this growing digital market.

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INTERNET SHOP FOR TRADE IN HANDMADE GOODS

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***Abstract*—** This study explores the dynamic realm of online sales for handmade products, delving into various facets of e-commerce, including the opportunities and challenges specific to the handmade goods market. It investigates the strategies employed by successful online store owners, encompassing programming, design, and resource management. Additionally, it traces the historical evolution of online shopping and offers insights into the creation and enhancement of online retail platforms. Drawing from the foundational principles of online handmade goods trading, the study proposes a prototype software for small businesses specializing in handmade product sales, adhering to essential guidelines to ensure an efficient and user-friendly internet shopping system**.**

***Keywords*—** handmade goods, online shopping, e-commerce, online store.

I. INTRODUCTION

The development of e-commerce has opened up a new era of opportunities for artisans and craftspeople, which has impacted the landscape of handmade goods. As traditional markets are being digitized, artisans are gaining a new platform to showcase their unique creations to a global audience. This shift opens up many opportunities, from reaching a wider customer base to navigating the complexities of online marketing and customer acquisition.

With this in mind, the purpose of this article is to comprehensively explore the field of selling handmade goods in online stores. The complexities of this digital marketplace will be examined and strategies, challenges, and innovative approaches used by artisans to succeed in the digital sphere will be identified [1].

II. THE EVOLUTION OF HANDMADE GOODS IN E-COMMERCE

The online marketplace offers many opportunities for artisans, but it also comes with some challenges. Among the opportunities it should be noted that selling handmade goods online offers artisans the opportunity to reach a global audience that was previously inaccessible through traditional retail channels. This means that artisans can connect with buyers from all over the world, potentially increasing sales and brand awareness; online platforms allow artisans to serve niche markets that share a passion for unique handmade products. This precise targeting can lead to a loyal customer base that appreciates the authenticity of artisanal products; online environments enable direct communication between artisans and customers, fostering a sense of community and allowing artisans to gather feedback and ideas for product improvement. The main challenges are that with the proliferation of online shopping, it is becoming increasingly difficult to stand out from the competition. Artisans need to find creative ways to differentiate themselves and their products to attract the attention of potential customers; shoppers may be wary of buying handmade goods online because of concerns about their authenticity; ensuring the quality of handmade products and creating a positive customer experience is paramount. Any problems related to product defects, delivery delays, or customer service can affect the reputation of an online artisan store [2].

For any Internet project to be successful, a lot of time and effort must be devoted to

maximizing the results in specific aspects such as successful artisans often use e-commerce platforms that offer customization, flexibility, and scalability. They optimize their websites for speed, security, and mobile responsiveness, ensuring a seamless browsing experience; the design of an online store is critical to creating a visually appealing and cohesive brand image; effective resource management involves optimizing inventory to prevent shortages or overstocking. Optimizing order fulfillment processes, responding promptly to customer inquiries, and improving customer support contribute to a positive customer experience [3].

The e-commerce industry is constantly evolving, and to successfully set up and maintain an online store, you need to know all aspects of its evolution. First of all, the evolution of online shopping is closely linked to the development of Internet connectivity, secure payment gateways, and encryption technologies that enable secure online transactions. Also, the growth of online shopping is driven by changes in consumer behavior, such as convenience, access to a wide range of products, the ability to compare prices and read reviews before making a purchase. And at last the evolution of online marketplaces-from simple platforms to complex ecosystems-has allowed artisans to join larger communities and benefit from built-in traffic and customer trust [4].

An important stage in creating a successful online store for the sale of handmade goods is the choice of methods and technologies. Selecting the appropriate technology and methodology involves the following steps: artisans have a range of e-commerce platforms available to them, each with its own advantages. Some platforms offer simplicity and ready-made templates (e.g. Shopify and WooCommerce), while others offer more customization and control (Magento or standalone solutions). The choice depends on the technical level of the master and the desired level of control; Creating a responsive website ensures that the online store adapts smoothly to different screen sizes and devices. This is very important as customers are increasingly shopping on mobile devices; a user-friendly CMS allows artisans to manage their online stores efficiently. Systems like WordPress with WooCommerce provide intuitive interfaces for managing products, processing orders, and updating content, iintegration of secure payment gateways is essential to ensure the security of online transactions. Technologies such as SSL encryption and two-factor authentication increase the security of both artisans and customers, effective SEO strategies increase the visibility of handmade online stores in search results. This involves optimizing product descriptions, meta tags, and other elements to increase search engine rankings [5].

When an e-commerce store owner chooses a development methodology and technology stack, he should consider that artisans must create a strong brand identity that resonates with their target audience. This involves choosing a unique brand name, creating a memorable logo, and designing packaging that reflects the brand's values; high-quality images are essential to showcase the intricacies of handcrafted products. Detailed product descriptions, including materials used, dimensions, and care instructions, help customers make informed purchasing decisions; user experience is crucial for conversion. User-friendly interfaces, intuitive navigation, clear calls to action, and simplified checkout processes contribute to a positive shopping experience; artisans can use data analytics to gain insights into customer preferences, popular products, and shopping patterns. This data-driven approach helps optimize inventory, pricing strategies, and marketing efforts [6].

At the end of this section, we will pay attention to the issue of prospects and electronic commerce and online shopping. As technology advances, personalized shopping experiences will become more common. AI-powered recommendation engines will analyze customer preferences and suggest products to improve the shopping experience. Virtual and augmented reality (VR) technologies will allow customers to virtually experience goods before purchasing, enabling them to tactilely evaluate handmade goods. In the future, e-commerce is likely to pay more attention to sustainability and ethical practices. Consumers are becoming more conscious about their purchases, leading to a demand for

environmentally friendly and ethically produced products. With the emergence of virtual assistants such as Amazon's Alexa and Google Assistant, voice commerce is expected to grow. Artisans will need to optimize their online stores to accommodate voice search and purchase. Blockchain can increase the transparency and authentication of supply chains. This will be especially true for handmade goods, where provenance and authenticity are important factors [7], [8].

III. DESIGN AND IMPLEMENTATION OF AN INTERNET STORE TRADE IN HANDMADE GOODS

After analyzing the above main theoretical principles of designing online store systems, highlighting the key principles that should be followed, as well as realizing the shortcomings that should be avoided, the main goal of this work was formulated: the creation of a prototype of an online store software system for a small business, specializing in on trade in handmade goods. When building an online store system, follow the basic requirements and recommendations given in the previous sections of the work in order to ensure the most effective and convenient system for making purchases via the Internet.

As a result of the Ukrainian market study, three main online stores for trade in handmade goods were selected: Crafta.ua, Zrk.ua and Pacorky.ua. Table 1 shows the comparative characteristics of the functionality of the selected online stores.

TABLE I
COMPARISON OF THE FUNCTIONALITY OF UKRAINIAN ONLINE STORES SELLING HANDMADE GOODS

Name of the online store	Crafta.ua	Zrk.ua	Pacorky.ua
Navigation menu	Present, attractive, easy to use	Present, simple	Present, attractive, easy to use
Sorting of goods	Present, complex	Present, simple	Present, primitive
Interface	Complex	Simple	Simple
Product catalog	Large, easy to view	Large, very easy to view	Medium, easy to view
Search engine	Present, simple	Present, primitive	Present, simple
Registration/Login	Present, complex	Present, simple	Present, simple
Change of language	Present	Present	None
Change of currency	None	Present	None
User reviews	Present, many	Present, many	None
Description of the store	Present, brief and informative	Present, medium	Present, small
Contact information	Present, informative, understandable	Present, clear	Present, uninformative
Social networks	Present	Present	Present
Product basket	Present, convenient	Present, convenient	Present
Separate product page	Present, informative	Present, informative	Present, informative
Preferences	Present	Present	None
Ask a question about the product	Possible	Impossible	Impossible
Payment methods	Many	Not much	Not much
Delivery methods	Various	Various	Various
The ability to share a product	Present	Present	None

During the design of the system, the advantages and shortcomings of the characteristics that were discovered during the analysis of the selected systems for the sale of handmade goods according to their nature and subject matter were taken into account.

The program system is designed to be a user-friendly and intuitive online store specifically tailored for handmade products. It follows a business-to-consumer (B2C) model, allowing individual artisans and sellers to showcase their creations and reach a broader customer base.

The system incorporates essential features necessary for an online store, including user registration and authentication, product browsing and search functionality, shopping cart management, order placement, secure payment processing etc. The interaction between the main functions of the online store is shown on Figure 1.

To ensure a seamless and enjoyable user experience, the system utilizes a responsive web design that adapts to different devices and screen sizes. This allows customers to browse and purchase handmade products from anywhere using their preferred devices, be it a computer, tablet, or smartphone.

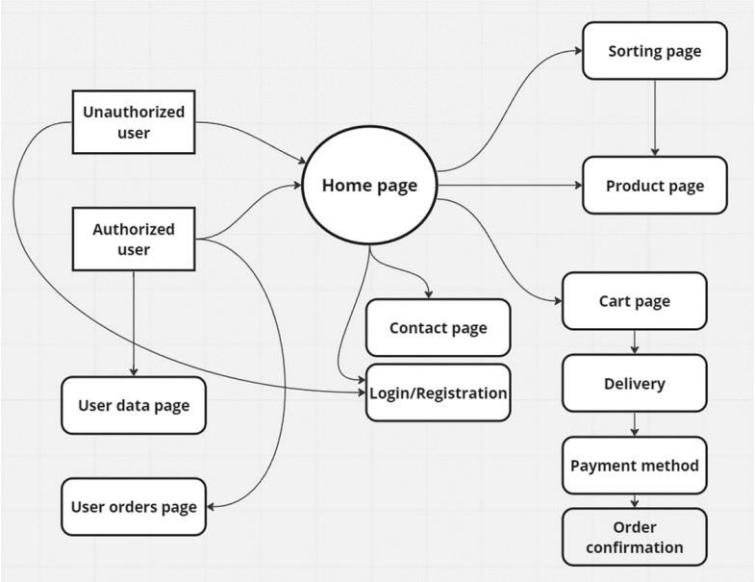

Fig 1. Flowchart of building an online store selling handmade goods

The system was designed on a monolithic architecture. To design the front-end was used React framework, HTML, CSS, JS, Bootstrap. For the backend technologies, Node.js was chosen to write the server part of the application, Express.js to create custom APIs of the application, Mongo DB as a database to store products and user information (Fig. 2) [9]-[11].

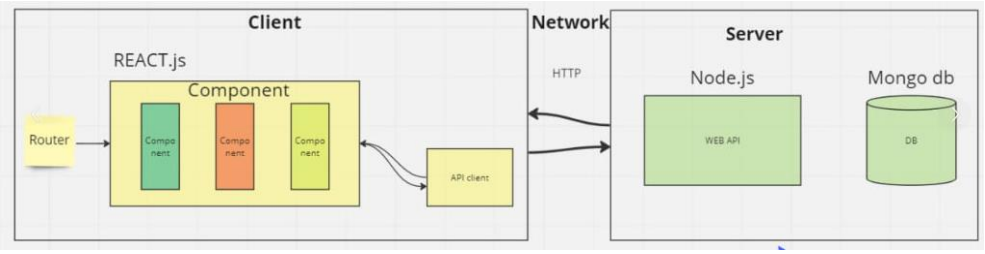

Fig 2. Client-server architecture of the application

IV. CONCLUSIONS

This article outlines the opportunities and challenges faced by artisans in the online sale of handmade goods. It emphasizes the need for effective strategies in programming, design, and resource management for online stores. Adapting to evolving online shopping trends, selecting the right technologies, and considering future developments like AI recommendations, virtual reality, sustainability, voice commerce, and blockchain are vital to the growth of this industry.

Based on the conducted research, the development and implementation of a convenient online store system for handmade goods, aimed at improving the shopping experience for both craftsmen and customers, is discussed.

By implementing this program system, sellers of handmade products can expand their market reach, connect with a larger customer base, and increase their sales. Likewise, customers can enjoy the convenience of browsing and purchasing unique handmade items from the comfort of their homes, supporting independent artisans and promoting the appreciation of handmade craftsmanship.

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MULTI-AGENT INTELLIGENT SYSTEMS BASED ON EXTENDED QUEUEING MODELS AND SPECIAL EXTENSIONS OF KOLMOGOROV SPACES FOR THE ENERGY INDUSTRY

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***Abstract*—**The article researches the question of centralized energy supply systems in terms of queueing systems with negative requests, special probability spaces and intelligent agents. The main part of the article describes mathematical essence of energy supply systems and demonstrates mathematical approach with role of intelligent agents.

***Keywords*—** energy supply, intelligent agent, negative request, queueing system, probability space.

I. INTRODUCTION

The task of power supply networks managing from smart city concept point of view is on object of practical and research interest [1-5]. This is primarily due to the fact that energy systems, despite the abundance of regulatory documents and standards, are very diverse in their architecture. First of all, the architectural differences of power supply networks are due to the peculiarities of the region and electricity producers. Secondly, the architectural features of the energy supply items are determined by the structure of energy consumption, types of consumers and energy distribution loss. In this paper, a project of a centralized regional power system management system using intelligent agents is proposed. A distinctive feature of this work is the use of rarely encountered models of queuing systems with negative requirements [6-9], as well as special extensions of Kolmogorov's axiomatics for probabilistic systems. The role of intelligent agents and their functioning fully inherit these features.

II. PROBLEM STATEMENT

There is a regional monopolist company that is a supplier of electric and thermal energy (set G) and regional power supply network consisting of a limited number of distribution substations (set N), and power lines connected to them. Consumers are united in set C. The regional energy supply network is a part of unified republican energy system, in which surplus energy is sold, as well as in which the missing energy is requested (with Tax(out) and Tax(in) tariffs, respectively).

The production and consumption of electricity are defined as piecewise random processes with different properties, but defined on the same probability space. A positive or negative balance of energy (depending on the sign) hence either the sale of energy to the republican network, or the request for energy from the republican network, according to the approved tariffs.

The task is to minimize financial and energy losses.

III. MODEL AND SOLUTION

The problem is solved as follows:

1. Using specialized queueing systems with negative requests;
2. Defenition of probability space with special features;
3. Using intelligent agents.

The above provisions are discussed in detail below.

Queueing systems with negative requests

The following model is based on following sets:

1. Set “Consumers”;
2. Set ”Generators”.

Both of them generate random processes of the form:

C: {U, Fr, Tax, T[Tb;Te], Q};

G: {U, Fr, Tax, T[Tb;Te], Q},

where

U – voltage;

Fr – frequency;

Tax – the price;

T[Tb;Te] – time of entrance and time of exiting the queue;

Q – the quantity of energy (produced of consumed). For G flow Q variable aquires Q<=0, For C >=0.

Regional energy supply system is described as a hierarchical set of consumers and a set of energy producers. Both of them connected by hierarchical structure of wires. The whole system defines as a set (E), with two subsets: Consumers (C) and Generators (G). Every consumer produces a flow of requests which can be summed up as a collective request, indexed either by a geographical scope, or by the criteria of connectivity with special feeder.

$$\lambda C = \sum_{n}^{1} \lambda c \{U, Fr, Tax, T[Tb; Te], Q\} \quad (1),$$

where

U – voltage;

Fr – frequency;

Tax – the price;

T[Tb;Te] – time of entrance and time of exiting the queue;

Q – the quantity of energy (produced of consumped). For G flow Q variable aquires Q<=0, For C >=0.

The same situation with G subset, where

$$\lambda G = \sum_{n}^{1} \lambda g \{U, Fr, Tax, T[Tb; Te], Q\} \quad (2),$$

with the same variables.

Beginning with request’s flows begins the statistical difference, henced by the nature of the subject:

The nature of λC fundamentally differs from λG, especially in a mode of generation and it’s features. As random processes the prior difference consists of:

The feature of stationarity:

The flow λG is stationary but the flow λC has a piecewise assignment and is not stationary over the entire range of values of the function. The feature of regularity:

λG is regular.

The feature of ordinariness: λG is ordinary, but λC has a piecewise assignment and is not ordinary on the entire range of values of the function.

The feature of aftereffect presence:

λG as a aftereffect presence, due to energy generating equipment (usually the function is continuous and smooth), but the presence aftereffect for λC has the form of a piecewise set saturation function.

There is also difference in time modes.

To sum up, basic features to apply useful and stable model for both of flows has to be filtered, not to sophisticate already complicated highly loaded models.

The probability space, it's features and attributes

Axiomatically, the probability space may have different features, but always consists of:

- Ω – the space of elementary events;
- P – the value of probability;
- Ƒ – sigma algebra of events (filtration mode for all the probability space).

To specialize the probability space for our task there are also defined λG and λC, hence:

- Defined set of variables (according to a structure of request);
- Intervals for every variable to make piecewise setting easier;
- Defined operations with multidimensional vectors;
- Filtration for every variable saving probability qualities and joint distribution possible.
- Time has to be also defined, because of using intervals.

To define a probability (P) as a basic measure of the space which inherits the features of subspace, there is also needs a filtration.

- PλG = (P|G), where P and G are subsets of probability space with appropriate index.
- PQGn = (P|Q ∈G), it's also possible PGn = (P|G, G|n).
- It's also possible to filtrate probability by T as variable, (P|TGn ∈ Ti-Tj).

Requests, their structure and operations

The request is a basic category in this model. To make request and it's operations more clear it is useful to define following conclusions:

Requests are multidimensional vectors, with defined operations of summing up, multiplication, substraction and so on only in following dimensions (T, Q, U). The requests marked by G the structure is the same, but Q is always ≤0. The satisfaction of requests in general case is defined as:

$$\sum G + \sum C \to 0 \tag{3}$$

where g and c are vectors of requests.

Actually, the energy cannot be saved, so it's needed to limit the request's lifetime. To avoid mistakes there has to be filtration by T dimension. There is also needed a request's lifetime limitation. This case non-satisfied request leaves the system, but may be renewed with another T-dimension meanings.

IV. INTELLIGENT AGENTS

Intelligent agents are a set of subagents – agents solving homogeneous and relatively simple tasks – data collection, training based on collected data, decision making, etc [10-13]. To solve this problem, the use of intelligent agents is due to a large amount of homogeneous data. The main data source is a random process initiated by set C. This agent can be classified as a data mining agent, the which main functions are:

1. Collecting information about the quantitative and qualitative parameters of the energy consumption, as well as the duration of use.
2. Formation of the so–called consumer profile - collection of consumption statistics for a certain period (daily, monthly, annual), as well as estimates of the most likely periods of downtime or minimum energy consumption, as well as the most likely periods of the socalled peak load.
3. Formation of the so-called collective profile of the consumer. Namely, the formation of a forecast of consumption in the context of the energy district.

Thus, it is worth defining the status and concept of agent and subagent. The subagent will be considered a software and hardware complex that collects and generates statistics on the energy consumption of a particular user. We will consider the software and hardware complex for collecting information within the energy district as an agent.

Decision-making agent:

This agent is supposed to be used on the set G.

1. Based on the information received from the agents of the set C, a predicative sequence of actions is formed that allows minimizing the energy balance.
2. An agent is a set of instructions for maintaining the necessary, and taken from agents With, production parameters.

The proposed agents are assumed to be intelligent systems built on the basis of neural networks, where the network is trained based on a set of the following parameters:

1. Date;
2. Usage time;
3. Amount of energy consumed;
4. Current parameters (voltage, frequency, amperage, etc.).

V. CONCLUSIONS

In this paper, the problem of power system management is considered, based on the application of a queuing system model with negative requirements and intelligent agents. The proposed model is based on extensions of the classical theory of queuing systems, as well as on the expanded Kolmogorov space. The solution of the main management tasks is reduced to the use of intelligent agents.

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ENHANCING FACE RECOGNITION IN NOISY ENVIRONMENTS: A STUDY ON ROBUSTNESS AND PERFORMANCE

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***Abstract*—**This paper explores the critical need for robust face recognition systems capable of handling image corruption. We focus on assessing the performance of machine learning algorithms, specifically the K-Nearest Neighbors (KNN) algorithm, in noisy face recognition tasks. Our experiments involve pristine and noiseintroduced datasets, with salt-and-pepper noise and median filtering as key elements. The findings emphasize the importance of robust face recognition systems in real-world scenarios and their potential to mitigate image corruption's impact on system performance.

***Keywords*—**Face recognition, denoising, K-Nearest Neighbors (KNN), salt-pepper-noise.

I. INTRODUCTION

Face recognition technology has emerged as a pivotal facet of our increasingly digital and interconnected world, heralding a new era of security, convenience, and personalized experiences. With applications spanning across numerous domains, face recognition systems have garnered substantial importance and have become indispensable in various aspects of contemporary society. One of the foremost applications of face recognition is in security and access control. This technology has revolutionized the way organizations safeguard their facilities and data. By employing biometric authentication through facial recognition, institutions ensure that only authorized personnel gain access, thus bolstering security levels [1]. Law enforcement agencies have harnessed the power of face recognition for criminal investigations and public safety. The capability to identify and apprehend criminals, locate missing persons, and enhance overall security has been significantly enhanced through the integration of facial recognition systems into surveillance and investigative processes [2]. In the realm of financial services, face recognition has redefined customer authentication. Many banks and financial institutions utilize this technology to secure online and mobile banking transactions, making it more convenient and secure for users to access their accounts [3]. Modern smartphones and consumer electronics now incorporate face recognition for user authentication, granting individuals secure and convenient access to their devices and personal data [4].

As we delve deeper into the myriad applications and implications of face recognition systems, it becomes evident that this technology has permeated virtually every facet of our lives, from the way we secure our digital identities to the manner in which we interact with our devices. However, it is crucial to acknowledge that the widespread adoption of facial recognition also raises pertinent concerns regarding privacy, ethics, and potential biases. This paper will delve into these intricate facets while exploring the advancements and implications of face recognition technology.

A reliable face recognition system that can tolerate image corruption is crucial because it ensures the technology's effectiveness in real-world conditions. This robustness enhances security, accuracy, and user experience in applications ranging from security and law enforcement to consumer electronics and healthcare. It minimizes false positives and

negatives, accommodates diverse appearances, and fosters trust and acceptance, making it a vital component in today's technological landscape. The reliable face recognition system can improve the accuracy [5], increase the reliability and display better performance [6],

In this paper, we delve into the reliability of machine learning algorithms, particularly the KNearest Neighbors (KNN) algorithm, when applied to the Yale Face Database B dataset under noisy image conditions. Our investigation aims to assess the performance and robustness of these algorithms in face recognition tasks, shedding light on their effectiveness in the presence of image corruption and noise.

The paper is organized as follows: In the second chapter, we will talk about the data used in the study. Then, in the next chapter, we will cover the methodology, experiments, and results. Finally, we will conclude the paper**.**

II. DATASET

The Yale Face Dataset [7] is one of the most widely used datasets of faces in the field of face recognition. It was created in the early 1990s and contains 165 grayscale images in GIF format of 15 individuals. There are 11 images per subject, one per different facial expression or configuration. The dataset was created to provide a standard set of images for researchers to use in developing and testing face recognition algorithms. The Yale Face Dataset has been used in a wide range of research studies and has contributed significantly to the development of face recognition technology.

The Extended Yale Face Database B is an extension of the Yale Face Dataset and contains 16128 images of 28 human subjects under 9 poses and 64 illumination conditions. The data format of this database is the same as the Yale Face Database B. The Extended Yale B database contains 2414 frontal-face images with size 192×168 over 38 subjects and about 64 images per subject. The images were captured under different lighting conditions and various facial expressions.

In this research, we conducted a comprehensive study of the reliability of machine learning algorithms, with a particular focus on the K-Nearest Neighbors (KNN) algorithm, in the context of face recognition tasks. To thoroughly assess the performance and robustness of these algorithms, we employed two distinct datasets: the original Yale Faces Dataset and a modified version referred to as the 'Noise-Introduced Yale Faces Dataset.'

The original Yale Faces Dataset serves as our baseline, representing clean and unaltered facial images. This dataset provides us with a reference point to evaluate the algorithms' performance under ideal conditions, where the facial images are free from any noise or corruption.

To simulate real-world scenarios and challenges, we introduced controlled levels of noise into the Yale Faces Dataset, resulting in the 'Noise-Introduced Yale Faces Dataset.' This dataset contains facial images deliberately subjected to various types of noise, including Gaussian noise, occlusions, blurriness, and illumination variations. These noise-induced images replicate the conditions often encountered in practical applications, where image quality may be compromised due to environmental factors or image acquisition limitations.

By conducting experiments on both datasets, we aim to provide a comprehensive assessment of how the algorithms, particularly the KNN algorithm, perform in face recognition tasks when faced with image corruption and noise. Our analysis will shed light on the algorithms' adaptability and effectiveness in challenging real-world scenarios, where the quality of facial images cannot be guaranteed.

III. METHODOLOGY AND EXPERIMENTS

A. Methodology

To simulate real-world image corruption, we introduced salt-and-pepper noise into the original Yale Faces Dataset, resulting in the 'Noise-Introduced Yale Faces Dataset.' Salt-andpepper noise is a common type of noise characterized by random, isolated pixels being either completely black (salt) or completely white (pepper). This type of noise can emulate various image corruption scenarios, including sensor or transmission errors.

For denoising in this research, we applied the median filter, a well-established image processing technique known for its efficacy in noise reduction. The median filter functions by employing a sliding window or kernel across the image, wherein pixel values within the window are collected, sorted, and then replaced by the median value of the sorted list. In cases of noise, especially salt-and-pepper noise or impulse noise characterized by sporadic extreme pixel values, the median filter excels in noise removal while preserving critical image features and edges.

The algorithm operates [8] as follows, Let S_{xy} is the (m×n) sized window that is centered at point (x, y), and g(x, y) is the value of the corrupted image centered at (x, y)

$$\hat{f}(x,y) = \underset{(s,t)\in S_{x,y}}{median}\{g(s,t)\} \tag{1.1}$$

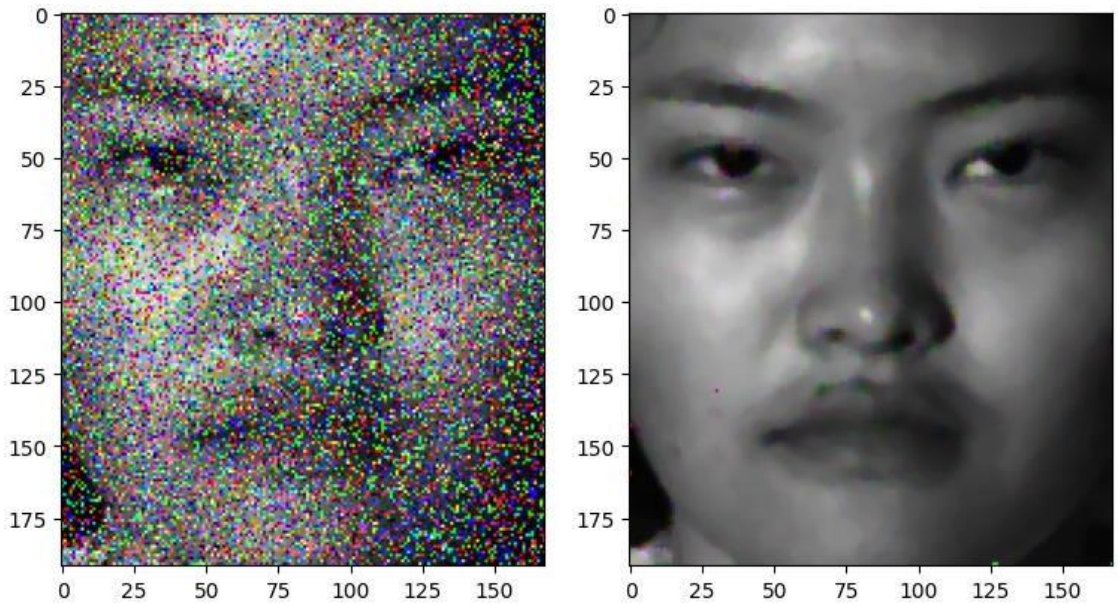

Fig. 1 (a) Salt-pepper-noise corrupted image (b) Denoised image

The impact of noise on data and performance of the algorithm is evaluated with KNN machine learning algorithm. The K-Nearest Neighbors (KNN) algorithm is a versatile supervised machine learning technique used for both classification and regression tasks. It operates on the principle of assigning a label or predicting a value for a new data point based on the majority class or average value among its K nearest neighbors in the feature space. KNN identifies these neighbors by measuring the distance, typically using metrics like Euclidean distance or Manhattan distance, between data points. The algorithm then assigns the class label or predicts the value based on what the majority of the closest neighbors exhibit.

B. Experiment

The experimentation was executed within the Google Colab computing environment. To assess the proficiency of the Facial Recognition (FR) system on pristine data, the model underwent training on unadulterated datasets, from which accuracy are computed. Subsequently, salt-and-pepper noise was deliberately introduced into the images contained in the Yale dataset, and the FR system's performance was reevaluated. Following this, the noise corrupted dataset underwent denoising using the median filter, and the consequential impact on performance was meticulously documented.

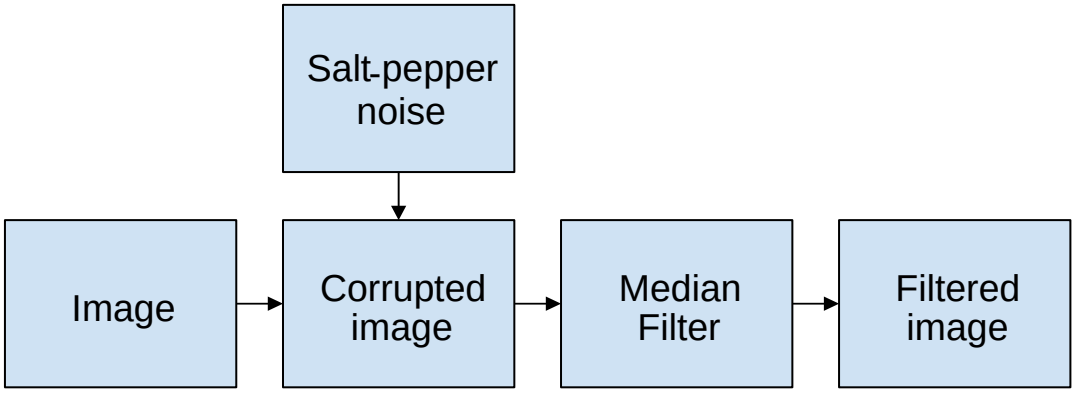

Fig. 2 Schematics of the experiment

The performance of the system is evaluated according to accuracy

$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN} \quad (1.2)$$

C. Results

Table 1 presents the system's performance metrics, revealing that the introduced noise exerted a substantial influence on the model's performance.

Algorithm and dataset	Accuracy, %
KNN on original data	74.94
KNN on noisy data	65.29
KNN on filtered data	71.66

Nevertheless, it is noteworthy that the denoising procedure effectively alleviated the deleterious effects of the noise, resulting in an improved performance.

IV. CONCLUSION

In our exploration of face recognition technology, we have recognized its pivotal role in security, convenience, and personalization across various domains. It has revolutionized access control, law enforcement, finance, and even our everyday devices.

However, widespread adoption has raised important concerns about privacy, ethics, and biases. This paper focused on the need for a reliable face recognition system that can handle image corruption, emphasizing its importance in enhancing security and user trust.

Our research centered on assessing machine learning algorithms, particularly K-Nearest Neighbors (KNN), in the context of face recognition under noisy conditions. We conducted experiments using the original Yale Faces Dataset and a noise-introduced version, simulating real-world scenarios with controlled noise levels.

In summary, our study underscores the necessity of robust face recognition systems to address real-world challenges. It contributes to our understanding of how algorithms like KNN perform in noisy environments, highlighting their potential in practical applications.

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SONN NETWORK IN CLASSIFICATION OF REAL VALUED CLIMATOLOGICAL DATA

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***Abstract*—**In the presented paper, we show the application of the Self-Optimizing Neural Network (SONN). SONN can be in principle understood as a form of decision network with the reduced number of paths corresponding to every possible set of discretized values obtained by the special procedure from the real-valued data measured by the experimental setup. In the paper, we use the dataset obtained during the meteorological study in the wetlands in Poland. Such data are burdened with the significant measurement error. In the paper, we want to deal with a complex dataset burdened with significant experimental errors, and we hope that the proposed technique can be useful for such a dataset. The analysis, performed with various methods of determining of final signal as well as various metrics defined in the discretized space of solutions, shows that the proposed method can lead to visible improvement when compared to typical classification methods like SVM or Artificial Neural Networks.

***Keywords*—**data analysis, data classification, experimental data, self-optimizing network, SONN, SVM.

I. INTRODUCTION

Almost in every live experiment, there is used special measurement equipment. Experimental measurements maybe be real-valued, whereas they are only the approximation of the true value. In the paper, we consider the data acquired in a continuous meteorological experiment collected in the wetlands of Biebrza National Park, northeastern Poland [3,4]. We focus on the time series of CO_2 which represents the net exchange of this greenhouse gas between the surface and the atmosphere. In the paper, we present the classification method for geographical data analysis. For our research, we choose an approach that takes into account only discrete signals.

We use the Self-Optimizing Neural Networks [8,9] whose main idea is to minimize the size of the neural network by retrenching connections that are not needed. In the first stage, the dataset is discretized, and then the values of discrimination coefficients are calculated. We obtain the system which deterministically builds the network based on the learning set and classifies the items from the test set.

The presented results show that the proposed method can give better results than the SVM method and the climate researchers' approach (fCO_2NN), which we use for comparison.

The paper is organized as follows. In Section 2, we present the formalism of the method, defining the discriminants, weights, and output values. In Section 3, the results of the calculations are described. In Section 4, the conclusions are presented.

II. SELF-OPTIMIZING NEURAL NETWORK

This paper describes the use of the Self-Optimizing Neural Network, which structure is related to the adaptation process based on learning data. The construction process distinguishes the most general and discriminating features of the data. This network can adapt the topology and its weights in the deterministic process [8,9].

A. SONN formalism

The idea of Self-Optimizing Neural Networks was originally introduced by Horzyk and Tadeusiewicz in [8,9]. The crucial property of SONN is that it operates on discrete values. This assumption seems very limiting for the computational possibilities of the method, and it seems to be why it did not achieve popularity similar to other techniques. The form of discretization is also not obvious. When working on a specific set of patterns (elements) with discrete values, we consider a vector of values representing each of them individually. It means that, instead of representing each parameter by one variable of the real vector, we obtain the discrete value vector corresponding to the division of real parameter into intervals. We have, for every real parameter, several discrete variables. The number of these variables is connected with the division of the parameter range into intervals, and it can contain only one of three values from the set $\{-1,0,1\}$. Value -1 means that a feature does not appear in a given pattern (so the value of a particular parameter does not belong to the interval corresponding to the interval represented by this variable); by 0 we denote an undefined feature, and 1 means that the pattern has values in a given feature.

Let us shortly recapitulate the basics of the approach and our modifications. Let $\boldsymbol{U}$ be a set of the form $\boldsymbol{U}=\{(\boldsymbol{u}^n, c^n)\}$, where $\mathbf{u}^n = [u_1{}^n, u^n{}_2 \cdots u_N{}^n]$, $u_f{}^n$ is the value of the f-th feature for n-th pattern and $u_f{}^n \in \{-1,0,1\}$, n=1,2,...,N_p, N_p is the total number of patterns, f=1,2,..., N_f, N_f is the number of features, c^n is the class for the n-th pattern and $c^n \in N_c$, where N_c is the set of classes. As a pattern, we understand every vector of discrete data described above, and as a feature, every single variable of this vector.

Let $P_f{}^c$ denote the number of patterns with values greater than 0 in f-th features in c-th class and M_f^c denote the number of patterns features with values less than 0 as noted

$$P_f{}^c = \sum_{u^i_f \in \{u^i_f > 0, i=1,2,\ldots,Q^c\}} u_f{}^i \tag{1}$$

$$M_f^c = \sum_{u^i_f \in \{u^i_f < 0, i=1,2,\ldots,Q^c\}} -u_f^i \tag{2}$$

where Q^c is the number of patterns in the given c class.

Having unknown values in a particular feature in the discrete value vector (marked with 0), we can estimate the probability of the occurrence of the feature with a value 1 or -1. We use the values of this feature in other patterns from the class under consideration. Even though SONN allows the use of indefinite values and the special masking procedure has been proposed [8,9], we do not deal with such data in our work.

B. Fundamental coefficient of discrimination

The discriminant (discrimination coefficient) concept in SONN is used to calculate the power to differentiate individual classes by particular features. The bigger the discriminant, the more essential and distinguishing the feature in view of classification is [9]. We should point out that the positive, as well as the negative value of the discriminant is meaningful. A big positive value corresponds to the observation that the given feature often exists for the considered class. On the other hand, a big negative value means that the feature is rarely present for a particular class. Horzyk [9] proposed the following formula for the discriminants

$$d_f^{c+} = \frac{P_f^c}{(N_c-1)Q^c} \sum_{h=1,h\neq c}^{N_c} \left(1 - \frac{P_f^h}{Q^h}\right) \tag{3}$$

$$d_f^{c-} = \frac{M_f^c}{(N_c-1)Q^c} \sum_{h=1,h\neq c}^{N_c} \left(1 - \frac{M_f^h}{Q^h}\right) \tag{4}$$

where $d^{c}{}_{f}{}^{+}$ and $d^{c}{}_{f}{}^{-}$ mean the coefficient of determination calculated for a given feature of a pattern in the appropriate class, taking into account the values of positive or negative features, respectively. Moreover c denotes the class, c=1,2,..., N_c and Q^c is the number of patterns in the given class c.

C. Structure of the network and the weight factor

The network structure is related to the described discretization. This method bases on division into subranges and then maps the real value attributes to the discrete values vector. Firstly, when constructing the network, we have to rank the features of each pattern according to the chosen ordering related to the assumed strength of its influence on the final response.

Horzyk proposed a method of network construction consisting of the iterative addition of successive layers of the network based on features that best distinguish patterns from a given class among all other patterns from other classes [9].

In our paper, we propose modification of this approach by replacing them with a set of unique (on the training set scale) pairs consisting of the discrete values vector (features) and the corresponding class. Therefore this pair is of the form $(\boldsymbol{u}^{s}, c^{s})$, where $\mathbf{u}^{s}$ is the discrete vector and c^{s} is the corresponding class. From now on, we will call each such vector a path, and all paths will be a set denoted by S. We will call a neuron for each vector element used to create a path. There are situations where one path is associated with many classes and vice versa, that one class is related to several paths.

Even though it does not have a typical network structure, the connections between neurons have a certain weight factor. The coefficient is calculated based on the properly organized network (in our case, identified by the set of paths S).

The weight factor for a neuron j of a given path s is calculated as follows

$$w_j^s = u_j \frac{d_j^s}{\sum_{i \leq j} d_i^s} \tag{5}$$

where u_j is the value of the feature on the basis of which the neuron j is created, d_j^s is the value of the discriminant on the basis of which this neuron is created. Moreover, d_i^s specifies the value of the discriminant on the path under consideration $s \in S$, for $i \leq j$ neurons, i.e. all those neurons (with appropriate discriminants), which were considered before together with the current one.

D. Network response

During our work, we introduce some modifications of the ordering features of each pattern and calculating the weight factor. We choose two methods of calculating the response from the network for a given pattern.

Algorithm version v1- The order of the features is consistent with the decreasing value of the discriminants, firstly considering the feature set 1, and then -1. The chosen ordering features with appropriate discriminants are related to the fact that we consider the value 1, i.e., the existence of a given feature, to be more important. The standard formula for calculating the response (the output of a given path s) from the network is as follows

$$out_s^{base} = f(\sum_{i=1}^{N_F} w_i^s c_i)$$

(6) where $d_i{}^s$ stands for the weight factor for the given neuron i on path s, $s \in S$ and f is the activation function.

Algorithm version v2- We use the decreasing ordering of discriminants. The response from the network for a given pattern is with an additional factor, and it looks like this

$$out_s = f(d_{max}^s \sum_{i=1}^{N_F} w_i^s c_i) \tag{7}$$

where d^s_{max} is the highest value of the discriminant on path s, $s \in S$, w^s_i is the weight factor for a given neuron i on the s path and f is the linear function.
The use of d^s_{max} may change the relative strength of the individual paths depending on the discriminants. The low value of the discriminants shows that there is little impact. The greater the value, we can assume that it becomes a certain component that allows strengthening the impact of the result for a given path.

The introduced path joins the feature vector with the corresponding class. When calculating the answer from the network for a certain test pattern, we use a defined neighborhood describing paths located at a certain distance from the test pattern and having an impact on the obtained result. We use two different metrics: Chebyshev and Manhattan. Each of them is responsible for determining which paths contribute to the network's response.

$$out_s = out_s^{base} 2^{-\mu(\mathbf{u}^i - \mathbf{u}^s)} \tag{8}$$

where μ is the well-known Manhattan or Chebyshev metric to calculate distance between paths, N_A is the number of real attributes, $\mathbf{u}^i$ and $\mathbf{u}^s$ are the feature vectors from the i-th pattern, and the s-th path, respectively.
Despite of the used modification, the evaluation of the winning class, for each element in the test set, is as follows

$$\sigma = arg \max_{s \in S} \{ out_s \} \tag{8}$$

The finding path $\sigma \in S$, gives the highest network response, and its class is the winning one.

III. EXPERIMENT AND RESULTS

A. Dataset

We use raw, real data from experiments conducted at the Biebrza National Park in the years 2013-2017 [3]. Our dataset has fourteen attributes represented as real numbers describing different meteorological properties like humidity, temperature, wind, or insolation. The result which is subject to classification is the total stream of carbon dioxide measured with the method of eddy-covariance technique. In Table 1, we show some exemplary measurements under consideration (the whole dataset has over forty-three thousand patterns). The form is abbreviated without units and detailed description due to a lack of place, but our other papers present them [3,11].

Table 1. The real geographical attributes.

	attributes														
	real values vector														
pattern	*Water level*	*T50cm*	*T2m*	*Kd*	*Ku*	*Ld*	*Lu*	*ppp*	*v*	*vdir*	*Tgrunt*	*vwc*	*PARd*	*PARu*	CO_2
1	-0.2	20.3	19.9	725.8	117.5	335.2	435.1	1005.2	3.6	278	17.6	0.761	1482.4	59.7	-22.03
2	4.6	21.2	20.4	754.2	124.4	345.5	424.7	1003.5	1.4	307.2	18.5	0.761	1524.2	70.2	-21.92
3	-2.6	20.8	20	794.8	139.6	354.5	443.3	1000.5	3.9	279.1	17.2	0.754	1629.5	75.2	-21.83
4	-8.4	23.5	22.6	842	145.4	356.6	458.8	997.9	3.6	231.7	11.6	0.795	1765.3	57	-17.45
5	5	23.6	23.5	843	118.3	331.1	439.7	1005.8	0.1	197.4	18.5	0.765	1795.7	74.4	-17.43

The problem with the data comes from the significant measurement uncertainty and errors. They are related to different factors, from the delicacy of particular devices to the results of permanent and often uncontrolled exposition to the conditions of the environment.

Therefore, some records in the dataset have higher quality than others, thus they are more reliable. The mentioned above, the data's quality level is specified with three

stationarity tests and the friction velocity threshold criterion. As a result, the data is divided into three classes that define the quality of the result, High-quality (HQ), Medium-quality (MQ), and Low-quality (LQ). These groups describe the credibility of the raw data. The HQ data (accepted by all three additional tests) passed more rigorous criteria than usually used in eddy-covariance data analysis. The MQ data (accepted by at least one of the three additional tests) are similar to those usually analyzed.

B. Data preparation

Each of p-th patterns in a dataset is described by a real attributes vector $\mathbf{v}^{\mathrm{n}} = \left[v_1^{\mathrm{n}}, v_2^{\mathrm{n}}, \dots, v_{N_a}^{\mathrm{n}}\right]$, where $1 \leq n \leq N_P$, N_P is the total number of patterns and v_a^n is the value of a-th attribute for n-th pattern, a=1,2,... N_A, N_A is the total number of attributes.

The range of variability of every of N_A attributes can be discretized arbitrarily. We can use any clustering procedure like k-means or apply some data-independent, statistical division like clustering the assumed centiles. The analysis of the influence of the clustering method on the results exceeds the range of the paper, and we decided to present data for the simple decile division.

In this way, for all attributes, we obtained a sequence of one hundred and forty discrete features representing the pattern (Table 2). Those features we call a discrete feature vector or discrete value vector. We distinguish attributes (real dataset features) from features (pattern discrete features).

Described discrete feature vector we denote as $\mathbf{u}^{\mathrm{n}} = [u_1{}^{\mathrm{n}}, u_2{}^{\mathrm{n}}, \dots, u_{N^{\mathrm{n}}{}_F}]$, where u_f^n is the value of the f-th feature for n-th pattern.

Table 2. Discrete features vector for two extremely located attributes from Table 1.

features vector / discrete values vector																						
	Water level											*PARu*										
pattern	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	…	*131*	*132*	*133*	*134*	*135*	*136*	*137*	*138*	*139*	*140*	**CO_2 → class CO_2**
u^1	-1	-1	-1	-1	-1	1	-1	-1	-1	-1		-1	-1	-1	-1	-1	-1	1	-1	-1	-1	-22.03 → 0

The discretization of the real value of CO_2 is not considered on the basis of belonging or not belonging to a particular subrange, but it delivers an index (class CO_2) of the subrange to which it belongs (classical classification).

C. Classification

We use our version (v1 or v2) of SONN with different versions of discriminant modification and neighborhood metrics: Manhattan ($\mu 1$) or Chebyshev ($\mu 2$). The training set consists of all HQ data and test set contains MQ data in the first approach and LQ data in another one. The evaluation of the network's performance was carried out on a test dataset, which was not used in training and indicated in how many cases a good answer was obtained. By the good answers, we mean those answers that match the expected output (expected class), signified by the discretization of the MQ and LQ values on which the tests are performed. In addition, for each of the possible configurations of parameters (version, metric), we perform thirty tests, and we present the averaged results.

The first problem was to choose one of the many classification methods [7] which could provide a result of high quality and comparable to the ones obtained in our calculations for the data of high level of uncertainty [1]. As it was mentioned, instead of using the specially designed methods for a particular problem [2,10,13,14], we decided to use the known, out-ofthe-box solutions first. In the presented calculations, we compare our

classification results with the results from the SVM method, which we consider the best for comparison (the most effective among these techniques).

When analyzing the results of classification, we use three basic, well-known measures:
precision, recall and f1-score [6,12]. These values are listed in Table 3. In the case of binary classifications w use the definition presented, for example, in [5]. To evaluate nonbinary classifications and compare them, we use pairwise confusion matrices.

In Table 3, we present the results obtained for different approaches and testing sets. With bold font, we mark the best results in particular columns, i.e., the best result for a given dataset and measure. We can observe that the results obtained for the presented SONN technique are better than those for the method used earlier in these calculations and by the SVM technique. We can also observe that the crucial factor when evaluating the results is the approach's version rather than the metric used to describe the neighborhood.
Another conclusion comes from the different meanings of the measures used in the evaluation. We can see that precision and f1-score are better for v1 method while recall is higher for v2. Precision describes the number of correct results in the classified ones, so it is rather related to the result of classification, while recall corresponds to a rate of correctly recognized items in a particular class.

Table 3. Precision, recall, and f1-score measures for different pairs of classifications.

classifier	*testing set 1*	*precision*	*recall*	*f1-score*	*testing set 2*	*precision*	*recall*	*f1-score*
$(v1, \mu1)$	MQ	**0.614**	0.633	**0.619**	LQ	**0.461**	0.496	**0.464**
$(v1, \mu2)$	MQ	**0.614**	0.633	**0.619**	LQ	**0.461**	0.496	**0.464**
$(v2, \mu1)$	MQ	0.598	**0.642**	0.597	LQ	0.443	**0.518**	0.445
$(v2, \mu2)$	MQ	0.598	**0.642**	0.597	LQ	0.443	**0.518**	0.445
$fCO_2\ NN$	MQ	0.553	0.566	0.557	LQ	0.426	0.460	0.430
SVM	MQ	0.394	0.413	0.391	LQ	0.304	0.350	0.305

IV. CONCLUSION

This paper discusses the problem of experimental data classification. This type of data is usually strictly connected with measurement uncertainty, noise, statistical and systematical errors, which are hard to identify in the data analysis phase and are problematic for many classification methods. We propose to use a classification scheme based on Self-Optimizing Neural Networks. Some modifications of SONN proposed in the paper allowed us to classify data taken from environmental experiments much better than it was possible by SVM or the ``Neural Network tree" (fCO_2NN), used in original papers on these data. It is a very interesting observation that this improvement was achieved despite the potential loss of information during the discretization process.

Our future works should go in several directions. First of all, the SONN method itself: the formulas for discriminants, the way of their modification according to different properties of particular patterns. On the other hand, to generalize the conclusions, especially those about the value of modifications (v1 and v2), we are going to use other datasets, selecting especially those that present high dimensionality and for which the reduction of dimensionality is hard. The third direction is connected with the indication (recreation) the value of CO_2 from the class index. The fourth direction is connected with the clustering of the dataset. Here we presented only the most simple and obvious division into deciles. Some attempts to use different techniques, like k-means or, so far unpublished, recursive k-means with Savitzky-Golay smoothing, have already been made.

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TRANSFER LEARNING IN BANKNOTE CLASSIFICATION: A COMPARATIVE ANALYSIS OF FINE-TUNED CNNS ALEXNET, GOOGLENET, AND VGG16 ON THE KAZAKHSTAN BANKNOTES DATASET

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***Abstract*—** Transfer learning has become an influential technique in the realm of deep learning, particularly when faced with the challenge of limited datasets. Within this framework, the study aims to provide a comprehensive analysis of the performance metrics of three widely-acknowledged Convolutional Neural Networks (CNNs)—AlexNet, GoogLeNet, and VGG16. The chosen domain for this comparison is banknote classification using the Kazakhstan Banknotes (KZB) dataset. This dataset is intricately curated, comprising 14 distinct classes with each class encompassing 20 images, all captured with the ubiquity of a mobile phone camera, ensuring practical relevance. Preliminary observations denote AlexNet's efficiency, as it displayed the fastest training time. However, in the pivotal realm of accuracy, VGG16 emerged as the front-runner, registering a flawless 100%, whereas AlexNet trailed closely with 95.24%. In contrast, GoogLeNet recorded a modest accuracy of 88.65%. Beyond the comparative performance, this study serves as a testament to the adaptability and variability of modern CNNs, especially in niche fields like banknote classification. The findings herein can significantly influence the choice of architecture for researchers and industry professionals alike when grappling with dataset constraints

***Keywords*—**AlexNet, Banknote Classification, Fine-tuned CNNs, GoogLeNet, Transfer Learning, VGG16

I. INTRODUCTION

Banknote classification remains a crucial task for various applications in banking, finance, and security. With the rise of digital finance and the continuous introduction of new banknote designs worldwide, an efficient and automated classification system is increasingly vital. Traditional methods, often relying on simple image processing techniques, have been progressively overshadowed by advancements in deep learning, particularly the utilisation of Convolutional Neural Networks (CNNs). CNNs have revolutionised the realm of image recognition, bringing remarkable accuracy and adaptability.

However, one significant challenge faced in the application of these sophisticated models to niche tasks like banknote classification is the scarcity of large and diverse datasets. It's here that transfer learning comes to the fore. By leveraging knowledge from pre-trained models on new, smaller datasets, transfer learning offers a promising solution to the data insufficiency problem. This approach not only reduces the need for extensive data but also curtails the computational cost and time associated with training deep neural networks from scratch.

In this paper, our focus narrows down to the comparative analysis of three iconic CNN architectures—AlexNet, GoogLeNet, and VGG16—as they are fine-tuned using transfer learning on the Kazakhstan Banknotes (KZB) dataset. Each model, with its unique architectural nuances and history of success in image classification tasks, provides an

exciting dimension to this study. Through this investigation, we aim to unearth the capabilities, strengths, and potential limitations of these models in the domain of banknote classification, hoping to offer guidance for future applications and research in similar constrained-data scenarios.

II. RELATED WORK

The field of banknote classification has received a lot of attention in recent years, owing to the growing demand for automated, efficient, and secure currency management systems. Several studies have looked into various methodologies to achieve this goal.

A. Banknote Classification Approaches

Earlier studies relied heavily on traditional image processing techniques. In [1] extracted colour and texture-based features from banknote images, followed by classification using Support Vector Machines (SVM). In [2] investigated the use of wavelet transforms in conjunction with neural networks for banknote recognition, demonstrating acceptable accuracy with older generation banknotes.

B. CNN Architectures for Image Classification

With the introduction of Convolutional Neural Networks (CNNs), the evolution of image classification experienced a paradigm shift. AlexNet was introduced by [3], marking a watershed moment with its deep architecture and use of rectified linear units (ReLU) for activation. The inception module was incorporated into GoogLeNet, optimising computational efficiency. VGG16, described in detail, emphasised the importance of depth in CNNs, achieving remarkable performance on the ImageNet dataset by employing multiple 3x3 convolutional layers.

C. Transfer Learning in Image Classification

Transfer learning has emerged as a dominant strategy, particularly for tasks with limited data. In [4] demonstrated that CNN features, even from intermediate layers, can outperform traditional methods when applied to new tasks. In the field of banknote classification, In [5] successfully used transfer learning by leveraging pre-trained models, demonstrating its superiority over traditional machine learning approaches.

D. CNNs in Banknote Classification

With CNNs' success in various image recognition tasks, researchers have recently begun to investigate their potential in banknote classification. In [5], for example, used a modified AlexNet architecture to classify banknotes from multiple countries, achieving superior results when compared to traditional methods.

III. MATERIALS AND METHODS

A. Dataset: Kazakhstan Banknotes (KZB)

The study makes use of the KZB dataset, which contains images of 14 different Kazakhstan banknotes. Each class contains 20 images, for a total dataset size of 280 images. To introduce realistic challenges, all images were captured using a mobile phone camera in varying light conditions.

Pre-processing: Given the diverse lighting conditions and potential background noise, each image underwent several pre-processing steps:

- **Size Normalisation:** Images were systematically rescaled to keep the aspect ratio intact by maintaining a consistent size of 224x224 pixels.

- **Data Augmentation:** Encompassing transformations such as rotations, zooming, and horizontal flipping to enhance dataset volume and variation.
- **Normalisation:** Standardisation of pixel values into a [0, 1] range to facilitate efficient training.

B. CNN Architectures

The three CNN models delineated for this study encompass:

- **AlexNet:** This eight-layer deep model has been modified to adjust its last fully connected layer to accommodate the 14 classes of the KZB dataset instead of the native 1000 classes from ImageNet.
- **GoogLeNet:** Identified by its inception modules, this model's output layer was tailored to recognise 14 distinct classes.
- **VGG16:** Renowned for its profound architecture, this model's terminal fully connected layer was fine-tuned to be attuned to the 14 banknote classes specific to the KZB dataset.

C. Transfer Learning Approach

- **Pre-trained Models:** All three CNNs were initialised with weights pre-trained on the ImageNet dataset. This aids in leveraging the generic features learned by these models on a diverse and extensive dataset.
- **Fine-tuning:** Only the last few layers of each network were made trainable to adapt to the specific features of the KZB dataset, while the initial layers, capturing generic image features, remained frozen.

D. Training Procedure

The KZB dataset was divided into 70% for training, 15% for validation, and the remaining 15% for testing. The Adam optimizer was used in the training, with a learning rate of 0.0001 set over 50 epochs and batch sizes of 32. The categorical cross-entropy was chosen as the loss function due to the dataset's multi-class nature.

E. Evaluation Metrics

- **Accuracy** is the primary metric for evaluating model performance.
- **Confusion Matrix:** Empowered visualisation of classification results and identification of potential misclassifications.
- **Complementary Metrics:** Metrics such as the F1-Score, Precision, and Recall were harnessed to offer a multi-faceted evaluation perspective, especially beneficial when contending with underrepresented or challenging classes.

IV. RESULTS

This section examines the performance of three distinct CNN architectures, namely AlexNet, GoogLeNet, and VGG16, on the Kazakhstan Banknotes (KZB) dataset. The centrepiece is a tabulated elucidation of performance metrics, which is supported by analytical commentary.

A. Quantitative Analysis

Table I: Performance metrics overview for CNN architectures on the KZB dataset.

Model	Accuracy (%)	Precision (%)	Recall (%)	Training Time (min)
AlexNet	95.24	95.5	95.2	30
GoogLeNet	88.65	88.7	88.6	45
VGG16	100	100	100	60

B. Interpretative Analysis

AlexNet

Accuracy: Demonstrating a commendable accuracy of 95.24%, AlexNet substantiates its prowess for such datasets.

Precision and Recall: These metrics further reinforce the robustness of AlexNet's classification competence.

Efficiency: A salient feature of AlexNet was its expedited training duration, suggesting a pragmatic choice for applications necessitating swift deployment.

GoogLeNet

Accuracy: With 88.65%, the performance is noteworthy yet lags behind its counterparts.

Precision and Recall: The nearly identical values intimate a harmonized classification behavior. **Training Duration:** The inception modules, emblematic of GoogLeNet, contribute to the protracted training interval, signaling its architectural intricacy.

VGG16

Accuracy: VGG16's performance is unparalleled, evidenced by its impeccable 100% accuracy. **Precision and Recall:** The congruence of these metrics with the accuracy underscores the model's categorical supremacy.

Training Duration: The intricate architecture, although culminating in superior accuracy, necessitated an elongated training phase.

In summation, the interplay between architectural profundity and computational efficiency emerges as a central theme. VGG16, with its profound structure, yields unparalleled accuracy but demands extended training durations. Conversely, AlexNet, while marginally compromising on accuracy, offers enhanced efficiency. The trade-offs highlighted herein are pivotal for practical implementations where both precision and expediency are of essence.

V. DISCUSSION

The results delineated in the preceding sections, achieved through the meticulous application of CNN architectures – AlexNet, GoogLeNet, and VGG16 on the Kazakhstan Banknotes (KZB) dataset, offer profound insights and pave the way for further discussions on their implications.

A. Performance Evaluation

AlexNet has displayed resilience despite its age and relatively simplistic architecture. The efficiency it offers, especially with the KZB dataset, underscores the assertion that sometimes, efficiency can rival depth.

GoogLeNet, with its inception modules, provides an interesting performance pattern. While it achieved respectable accuracy, there's an inkling that the complexities of its inception layers could benefit from further optimization, especially for specialized datasets like KZB.

In contrast, VGG16 stands as a testament to the prowess of deep networks. Its performance accentuates that, given enough computational resources, deeper networks can achieve unparalleled accuracies, particularly for intricate classification tasks like banknote recognition.

B. Influencing Factors

Various elements have influenced the divergent performance trajectories of these architectures:

- The nature of the KZB dataset, with its intricate design variations, underscores the need for models capable of discerning these nuances. Herein, VGG16's architectural depth has manifested as a boon.
- Utilizing pre-trained weights from vast datasets like ImageNet equipped the models with an initial advantage, potentially aiding in quicker convergence and superior performance.
- Training dynamics, including factors like learning rates, batch sizes, and epochs, played a pivotal role, underscoring the importance of their judicious selection and fine-tuning.

C. Comparative Perspective

When juxtaposed against contemporary state-of-the-art models prevalent in image classification, the studied architectures, despite being relatively older, reiterate their continued pertinence. While newer models might usher in incremental performance enhancements, the trio of AlexNet, GoogLeNet, and VGG16 remains formidable, chiefly due to their simplicity, modifiability, and interpretability.

D. Real-world Deployments

These architectures beckon a myriad of real-world applications:

- With its sterling performance, VGG16 emerges as an ideal candidate for detecting counterfeit banknotes – an extant challenge that plagues the financial realm.
- Models epitomizing efficiency, such as AlexNet, could revolutionize ATMs, empowering them with enhanced banknote discrimination capabilities.
- As automation permeates the banking sector, incorporating these models could streamline myriad processes, minimize human-induced discrepancies, and bolster operational efficacy.

In summation, this exploration into CNN architectures paints a vivid tapestry of the vast avenues they unlock. The nuances in their performance shed light on the imperative of judicious model selection, underscored by the perennial tug-of-war between accuracy and efficiency. As the deep learning domain burgeons, the scope for refining these stalwarts and tailoring them to evolving challenges brims with promise.

VI. CONCLUSION

In the rapidly evolving landscape of image classification, the deployment of Convolutional Neural Networks (CNNs) has ushered in a paradigm shift, enabling unprecedented accuracies and groundbreaking applications. This study embarked on a journey to unravel the intricacies of three quintessential architectures – AlexNet, GoogLeNet, and VGG16 – and their efficacy on the Kazakhstan Banknotes (KZB) dataset. Our exploration unearthed several pivotal findings:

- **Depth vs. Efficiency:** VGG16, emblematic of deeper architectures, exhibited unparalleled accuracy, reiterating the oft-cited virtue of depth in CNNs. Conversely, AlexNet, a relatively more straightforward model, showcased the benefits of efficiency, especially in applications where time is of the essence.
- **Optimization Nuances:** GoogLeNet, with its innovative inception modules, underscored the necessity of bespoke optimizations, especially when grappling with niche datasets like KZB.
- **Real-world Implications:** The performance matrix of these architectures delineated their potential applications, from counterfeit banknote detection to modernizing ATM operations and catalyzing banking automation.

This study not only accentuates the salience of these seminal CNN architectures but also lays the groundwork for their future adaptations. Several avenues beckon exploration:

- **Hyperparameter Tuning:** While the present study leveraged conventional settings, a more exhaustive search into the hyperparameter space might unlock superior performances.
- **Incorporating Regularization Techniques:** Methods like dropout and batch normalization could further bolster the models' robustness, especially when dealing with overfitting.
- **Exploration of Newer Architectures:** While the triad studied herein remains foundational, the deep learning realm is rife with newer architectures that could be juxtaposed against these stalwarts.

In essence, the endeavor to classify Kazakhstan banknotes using CNNs has underscored the myriad facets of deep learning. As we stand on the cusp of further advancements, it becomes imperative to continually re-evaluate, refine, and reimagine these models in the context of ever-evolving challenges and opportunities.

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Our gratitude extends to our peers and fellow researchers who provided feedback, suggestions, and invaluable critiques, enabling us to refine our methodologies and approaches.

This study stands as a testament to the collective efforts, encouragement, and unwavering support of the aforementioned entities and individuals. Their contributions, both overt and covert, have been the bedrock upon which this research was constructed.

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TOWARDS GRAPH REPRESENTATION OF PHYSICS KNOWLEDGE

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***Abstract*—** In times of rapid increase of machine intelligence and information overload among computer users, causing us not to be as smart as we can be, the question is: will we, humans, meet machines in the middle? To address this issue, an approach of visualization of physical knowledge in the form of a graph is considered. Simple learning application based on knowledge graph of physics is shortly presented and discussed.

***Keywords*—** Knowledge Graphs, Semantic Networks, Online Education, Physics, Ontologies

I. INTRODUCTION

The traditional way of learning from books starts with opening the book, looking at the linear structure of Table of Contents. After some time spent on this page, the Reader goes to the introduction and the first chapter. If the Reader would like to learn, for example, what is the concept of ‘energy’ from a physics book, the diligence of reading precise definitions is advised. Then the Reader needs to solve some physics problems which lead to the understanding of concept of energy. After confrontation with other concepts, the Reader becomes gradually aware of the role of the given concept in the landscape of physics. This "awareness" means usually knowledge and understanding of relations between the concept of energy and other concepts of physics. But it takes a lot of time, effort and mental agility to »just« understand basic concepts. What is important, the learning process is usually based on the content delivered through standard student's textbooks and online courses which usually have very similar structure: text and graphics consists of rectangular elements: text sections, paragraphs, images, drawings etc. During learning process from all this elements the knowledge of relations between concepts in the domain gradually "emerges". It can be said that this knowledge is the culmination of the learning process.

In this paper, we consider a slightly different approach in which the graph of relationships between concepts in a domain is given explicitly and is a fundamental component of the learning process. Namely, we propose to enrich online learning through drawing graphs, consisting of circular nodes representing concepts and links between them representing relations. Such graphs may contain additional information in form of text or graphics in vicinity of nodes and links, describing their characteristics. We apply this approach to learning physics and present an application based on the knowledge graph. The application is still work-inprogress but its current status allows us to present its main functionalities. We limit ourselves to physics but this approach is equally applicable to STEM (Science, Technology, Engineering and

Mathematics) education. In all these domains it is generally possible to draw a graph of concepts and relations among them.

II. RELATED WORKS

There are a lot of publications related to representing knowledge as graphs. We refer the reader to an interesting review paper on the subject published a year ago (Chaudhri, 2022). Regarding graph representations of knowledge in physics, it is worth mentioning the paper that considered the possibility of obtaining linked data based on physics publications

(Skulimowski, 2013). Attempts have already been made to apply knowledge graphs in teaching nuclear power engineering (Telnov, 2019). It worth to mention also about an interesting paper proposing a new way for helping students grasp the logical relation between the physics knowledge points based on neural networks and knowledge graph technology (Shang, 2022). When it comes to online web applications related to our idea, two are worth mentioning.

A. Khan Academy

One of them is Khan Academy, a free-to-use website that teaches various subjects, from music and history to mathematics and physics. In STEM (Science, Technology, Engineering and Mathematics) part of Khan Academy's system, a student is taught theory through video lectures, and then solves exercises and problems provided by course authors. Checking of student's solutions is automated and instantaneous.

Khan Academy also offers a possibility to see the entire plan of learning, in a form of a graph (see Fig. 1). However, the nodes in this graph correspond to parts of the course and not to concepts in the field, as in our application.

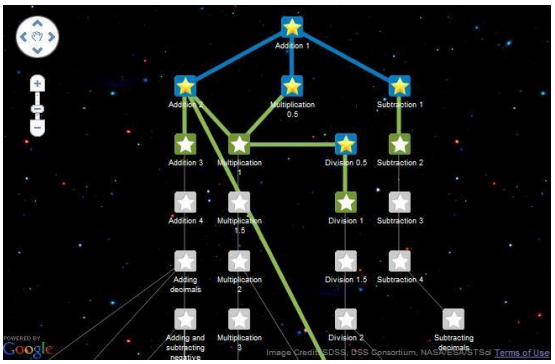

Figure 1: Khan Academy's skill/lesson tree

B. Wikipedia

Another project worth mentioning in context of graphs relating concepts is Wikidata4, a child project of Wikipedia. Wikidata gathers and processes data to be used by encyclopaedia, but not only. Information housed by Wikidata is freely available through the API, accessible over the Internet. It gives perfect granularity, breaking down the structure of knowledge to distinct entities (concepts), which are and relations with learning paths, but this is not the goal for this project.

As we can see, there is some space for a web application with teaching purpose, based on the graph of concepts and relations between them, something between Wikidata and Khan Academy.

III. KNOWLEDGE GRAPHS AND LEARNING GRAPHS

The content delivered through textbooks and today's media with graphical screens has common structure: text and graphics consists of rectangular elements: text sections, paragraphs, images, drawings etc. In this paper, we propose to enrich text and imagery

through creating *knowledge graphs*, consisting of circular nodes representing concepts and links between nodes representing relations. Such graphs may contain additional information in form of text or graphics in vicinity of nodes and links, describing their characteristics. If we model concepts as graph's nodes and relations as edges, usually lines or arrows, it is possible to depict the structure of knowledge from given branch of science, for example physics.

Concepts in physics are linked to each other with relations. Let us consider for example the concept of *velocity*, which is related to two other concepts: *position* and *time*. In terms of mathematical analysis, velocity is a derivative of position of a body with respect to time, simply: the rate of change of position in time. Such *relation* provides us a link between *velocity* and *position*, and also between *velocity* and *time*. If we want to be mathematically accurate, *velocity* is also linked to the concept of *derivative*. It is possible to contain these relations in few or just one knowledge graph, according to current needs.

Applications with user interfaces using such knowledge graphs have obvious benefits for the Reader. Even a brief look at such graph might result in better understanding of core ideas and relations of a given branch of knowledge. Knowledge graphs allows us easily to visualize, search and synthesize information from a given domain. What is very important, we can use such knowledge graphs for a given domain to create learning courses in the domain e.g. in physics.

Learning is a process with an almost linear structure i.e. a student learns concepts sequentially from the simplest to difficult ones, and of course the relations between them. During this process, the order of learned concepts is very important. To denote the order, in which the student should learn some group of concepts, we use the '*relation of precedence*'. This is a directed relation, and can be denoted on a graph with use of arrows (see Fig. 2).

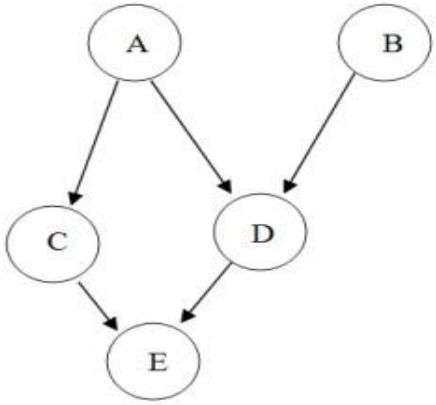

Figure 2: Relation of precedence. Concepts A and B precede D, concept A precedes C, and concept E is preceded by C and D.

Starting point of an arrow means that given concept is a *source*, and the concept which the arrow points at is a *target*. Sources precede targets, in other words *sources* are required to understand firstly, giving possibility to understand the *target* concept. To understand the target, all of precedents are required. A graph containing *concepts* from some domain and created with only the *relation of precedence* is of course acyclic. We call it the *learning graph*.

IV. SEMANTIC DATA AND ONTOLOGIES

To generate aforementioned knowledge and learning graphs, we need to create and retain data that will have the structure suitable for encompassing concepts, their relations

and other properties. Databases seem to be first natural option. But there is another possible choice: semantic data stored in ontologies and semantic repositories.

What is crucial from our point of view, semantic data consists of triples, forming a statement: C1 R C2. In this pattern, C1 is a subject of the RDF (Resource Description Framework) statement, R is a relation, and C2 is an object of the statement. Such construction is naturally adequate to represent relations between concepts. Concepts can be represented formally as classes in ontologies ($_{owl:Class}$) and relations between concepts as object properties (owl:ObjectPropert$_y$) in ontologies. In the application presented in the next section we use two kinds of ontologies:

1. *Domain ontologies* – contain knowledge from a domain, in our case knowledge from a branch of physics (see also Skulimowski, 2010, 2019). We can use them to create *knowledge graphs*.
2. *Learning ontologies* – contain information about precedence of concepts during the learning process. We can use them to create *learning graphs*.

V. ATLAS – VISUALIZATION AND LEARNING OF PHYSICS KNOWLEDGE

In this chapter, an application using our idea of graph visualization of knowledge for STEM domains is presented. The application is still work-in-progress but their current status allows us to present their main functionalities.

The general approach of Atlas application is to create a visualization tool to browse through the knowledge graph, created from few different *domain ontologies*, based on different branches of physics e.g. mechanics, electromagnetism and particle physics. The knowledge graph for Atlas is constructed from OWL *classes* (see Fig. 3), that represent concepts and OWL *object* properties, that represent graph relations. Additional data is gathered as OWL *datatype properties*, and include comments and labels for concepts and relations. The main purpose of exploration of these graphs is to support learning from undergraduate entry level up to the understanding of the Standard Model, a theory underlying modern particle physics. This is the reason why the application also uses a *learning ontology* related to physics. The ontology treats concepts as instances, and introduces directed relations, which denote the order of learning. To create ontologies, Protégé editor was used[1]. After creation of XML files, they have been added to the RDF repository, into a graph database GraphDB [2] . Further operations to extract information from the repository use SPARQL queries.

[1] https://protege.stanford.edu
[2] https://graphdb.ontotext.com

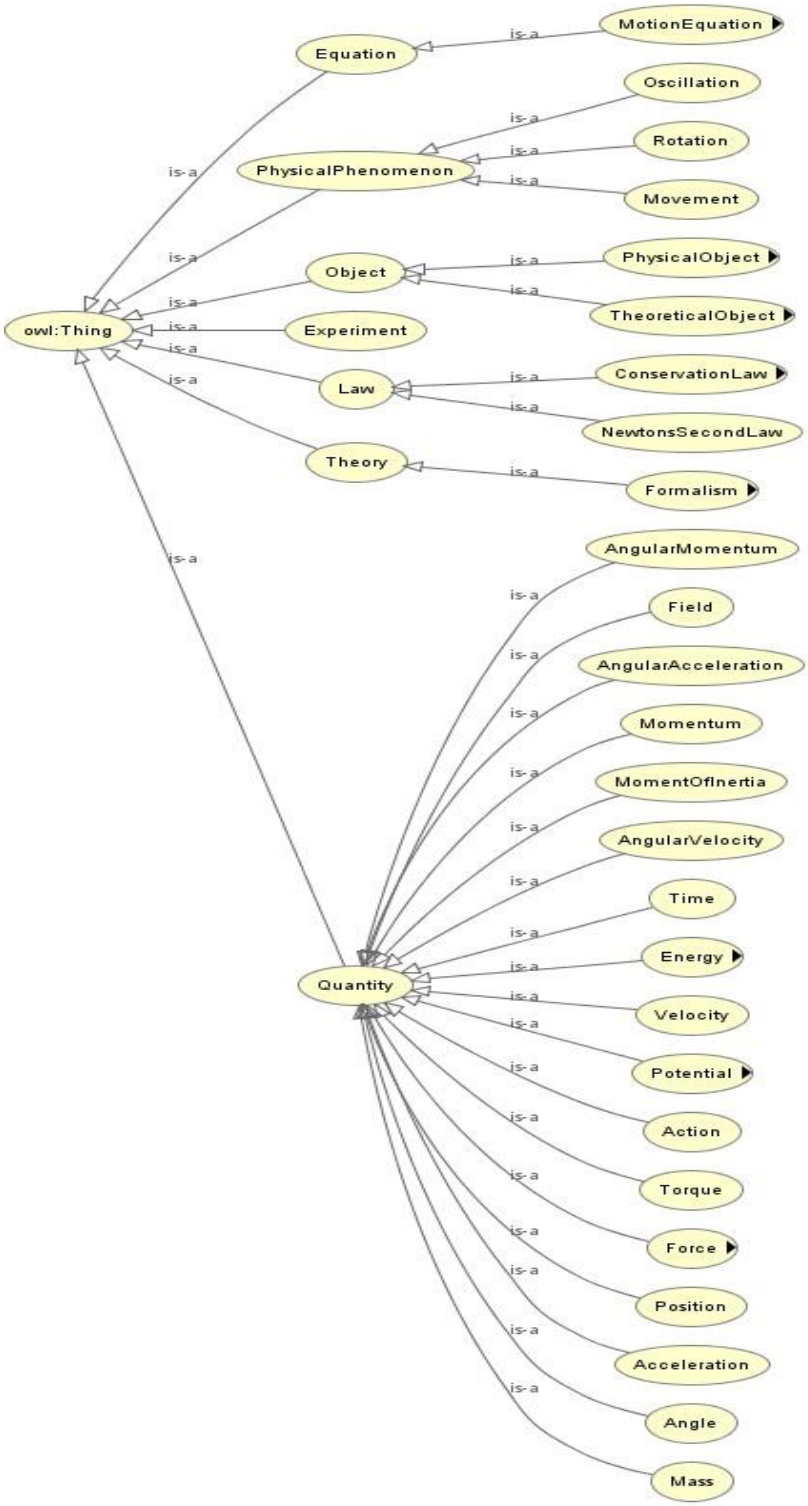

Figure 3: Graph structure of OWL classes. Visualization created in ontology editor Protégé

Atlas application, has been created in Meteor (a JavaScript framework) [3] . It consists of two parts: back-end and front-end, both programmed in JavaScript. The back-end part uses MongoDB NoSQL database. The backend part directs simple SPARQL queries to extract data from RDF Repository (Ontotext GraphDB). Then simple operations on data are

[3] https://www.meteor.com

performed to make it ready for front-end. The front-end part of the application creates SVG (Scalable Vector Graphics), graphically representing nodes (concepts) as circles and relations as arrows. Library used to manage graphics according to the data is D3.js[4]. Graph is interactive, user can alter positions of nodes, and the behaviour of the graph is governed by so-called "Force-Layout" (see Fig. 4).

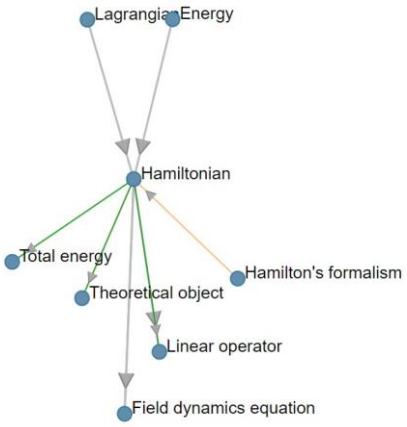

Figure 4: Links to the concept of Hamiltonian. Different relation types have been marked by different edge colours. The resulting picture has been produced by search command, selecting only the vicinity of searched keyword.

It means that nodes move according to physical forces between them: connected nodes are attracting each other like physical springs. Moreover, all nodes are also repelling each other. These properties cause the graph to disentangle itself, which is very useful in complex cases. A few graphs from the Atlas application are presented in Figures 4, 5 and 7.

In Fig. 4, the result of search for the concept *Hamiltonian* is presented. Relations with other concepts are shown. *Hamiltonian* in physics is a function or an operator equal the sum of kinetic and potential energy. It can be also obtained from *Lagrangian* of the system. It is of course a discussable topic if such semantic relations are correct and complete, however, creation of such platform is giving us the possibility to start such discussions, that may bring some new views on the known topics. This functionality is planned to be introduced in next versions of the application. In Fig. 5, the global *learning graph*, leading from the most basic concepts to the Standard Model is shown.

The learning path is not linear; it consists of many edges, forming an acyclic graph. This *learning graph* provides information about different directions which student may follow, according to his own needs and desires. There's a possibility to mark known and target topics and show paths leading to the targets. Cherry-picking topics, or rather: concepts is possible.

There's also a possibility to draw a sum of all knowledge graphs (Fig. 6), whether talking about relational knowledge graphs or learning graphs, showing the order of learning. In the future, there is a possibility of creation of a system handling graph creation of many independent people, and in such cases addition of many graphs into a one sum may become important.

[4] https://d3js.org

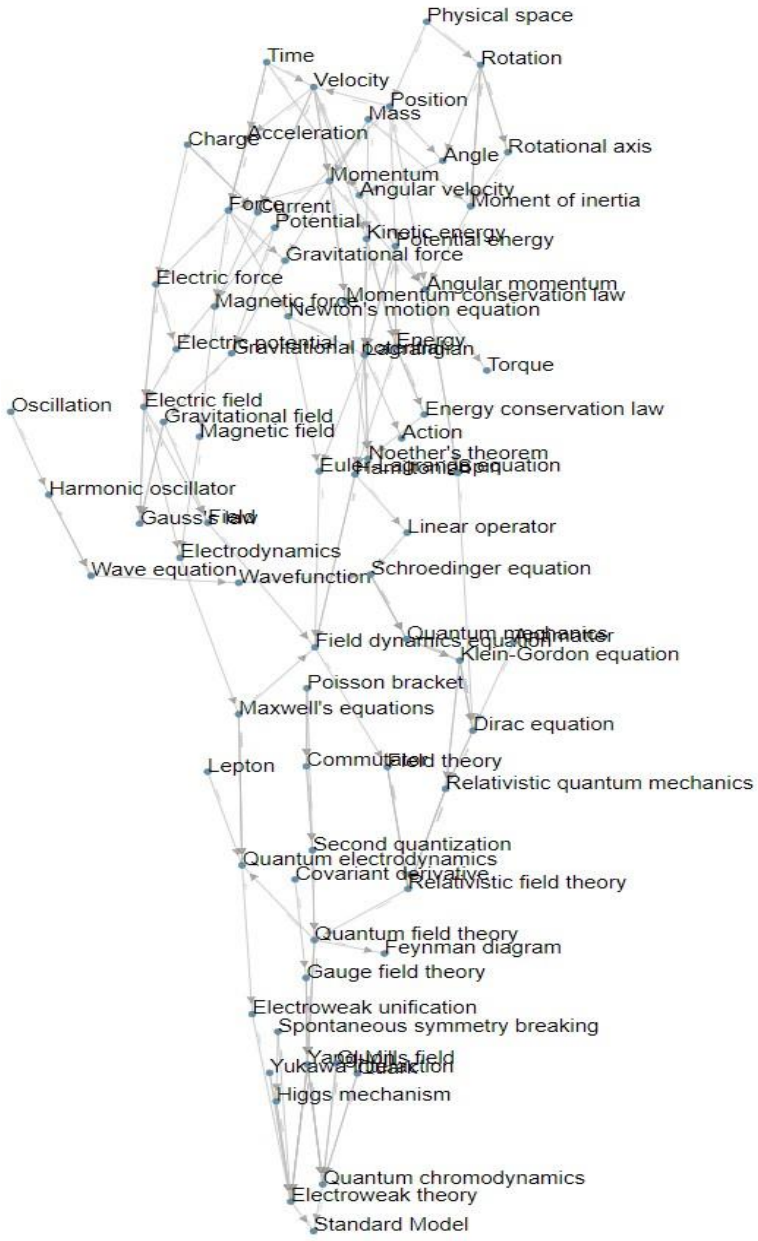

Figure 5: Global learning path, constructed with relation of precedence. The last concept, at the bottom of the graph is 'Standard Model'

VI. DISCUSSION AND FUTURE WORK

In this preliminary paper we consider knowledge graphs and learning graphs in physics and describe shortly the application using these graphs that helps learners understand physical knowledge. We are of the opinion that there is a room for further research and development in the niche of graph visualization of distinct concepts and relations particularly in STEM education, most notably as a web and/or mobile application. Moreover, it seems that knowledge graphs and learning graphs can be also generated and used in the learning for non-STEM fields.

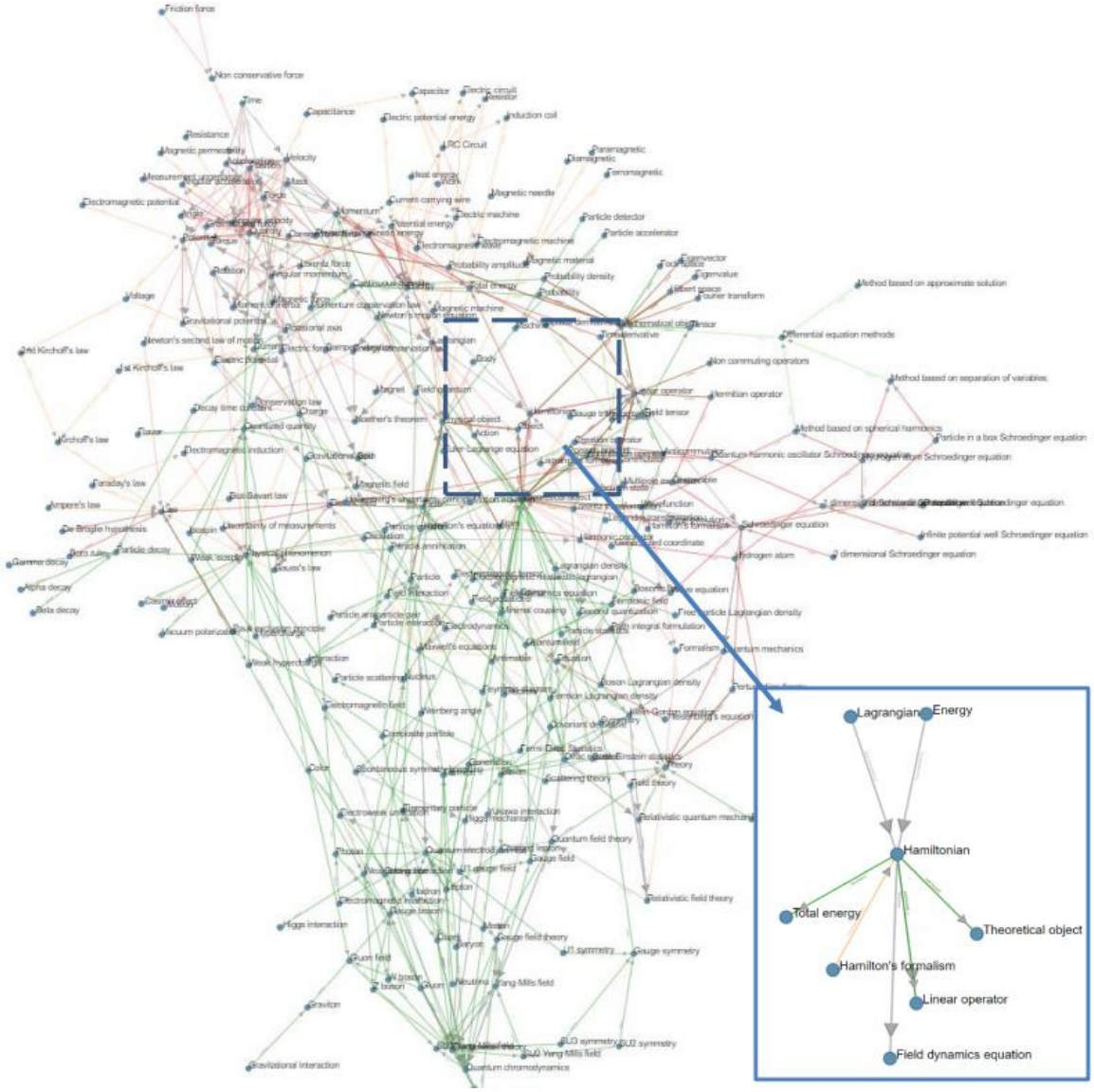

Figure 6: Sum of all graphs, containing both domain relations and learning graph. Graph vicinity of the concept 'Hamiltonian' is marked with dashed rectangle. Result of search of concept 'Hamiltonian' shown on the bottom-right, in blue rectangle.

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GEOINFORMATION EDUCATION IN THE TRAINING OF SPECIALISTS OF VARIOUS PROFILES

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***Abstract*—** In this article, the monitoring of the current situation in the field of geoinformation education (GIS education) in the Republic of Kazakhstan is carried out; difficulties appearing in this area are identified and ways of their settlement based on world experience are presented. Today geoinformation systems (GIS) are a resource for the formation of socially useful and economically constructive solutions that respond to the challenges of modern life in the interests of the entire community. The need to use GIS in the settlement of diverse tasks is a source of demand for professionals in the field of geoinformation technologies (GIS technologies). Training in GIS technologies, the development of educational and training GIS, professionals in various fields of the national economy seems to be the most important direction today

***Keywords*—** geoinformation systems, geoinformation education, highly qualified specialist, cartographic literacy, cartographic worldview

I. INTRODUCTION

The use of GIS technologies is limited only by the imagination of the person who uses them Jack Dangermond, CEO of ESRI, an American company that manufactures geographic information systems Knowledge-power. Today, the more information we have, the easier it becomes to make the necessary decisions and implement effective actions. A huge part of the information that a person deals with is spatial or geographical. But it is not enough just to collect information, you need a tool that will ensure its full application. GIS technology is a similar multifunctional tool. All this causes the unavoidable introduction of GIS technologies in training, professional training of specialists and determines the relevance of the topic of this study [1]. Improving the quality of education is the subject of special attention not only for Kazakhstan, but also for the whole world. This is not just one of the methods of society's response to the current social situation, but also a way to change this situation, to influence it not only in the present, but also in the future [2]. The ability to work with maps and get the necessary data from them becomes an important element of mass cartographic literacy and culture, which develops the individual [3]. GIS technologies represent modern effective approaches to the study and settlement of territorial problems. They are becoming more widely recognized and officially recognized in Kazakhstan. Digital spatial information plays an important role in the tasks of socio-economic and political development and management of natural, industrial and labor potential in the national interest.

Geographic information technologies are used with great success in numerous industries, some of which are shown in Figure 1.

Figure 1. Areas of application of geoinformation technologies

At the present stage of GIS evolution, their enticing capabilities are needed both by specialists of various profiles and by the vast masses of ordinary people. Today, cartographic literacy is not the prerogative of a researcher, it has become necessary for any person in everyday life: a diplomat, a tourist, a manager and an engineer, an astronaut and a driver of personal transport, and ultimately, a modern person needs cartographic literacy no less than a computer one [3]. In general, there are no restrictions on the use of geoinformation technologies, and they can be used for research and optimization in a variety of areas. According to forecasts, in the near future, GIS will also be an integral part of a specialist's workplace, along with text, image editors, spreadsheets, and databases. A specialist in the field of geographic information systems must know the sources of spatial data and have the skills to correctly select the material for work, based primarily on the project objectives. Here are some important skills that are a valuable part of the cartographic literacy of future professionals:

– improvement of geographical and spatial thinking; - development of thinking and creative skills for cartographic modeling and comprehension of the figurative language of the map;
- development of a unique, "cartographic" worldview;
- ability to solve ideological problems, research and creative tasks in the field of cartography;
- developing the ability to organize work and research activities in cartography in a reasonable way [2].

At the international level, GIS and related geospatial savings are estimated at more than two hundred and fifty billion dollars each year. The geospatial section is considered by the US Department of Labor as one of the technological areas where the largest number of new jobs will be formedin the nearfuture [4]. Recently, Kazakhstan has seen a steady increase in the need of the job market for professionals who have GIS skills. First of all, this is due to the introduction of automated information processing technologies in all branches of production and research work in various areas [5]. However, now there is a discrepancy between the scale of tasks for mastering and operating GIS technologies and the existing degree of development of professional geoinformation education in Kazakhstan. проблемнымTechnical and software solutions remain problematic due to their

cost unavailability. There are no decent training materials on geoinformaticsthat would take into account the essence of training in various specialties. The need to apply GIS technologies in the system of Kazakhstan's geographical education is indisputable. Rational standardization of all activities in the field of GIS education is required: from the introduction of technologies in school geographical education to the training of teaching staff in higher education institutions [6]. Monitoring of the current experience of using GIS technologies in education revealed a lack of theoretical and methodological developments in the field of using GIS technologies as a tool for solving applied problems.

There is a personnel problem — there are certainly few qualified employees specializing in working with GIS in Kazakhstanбезусловно. These above-mentioned problems create difficulties in GIS education that hinder its progress. This state of affairs cannot be called normal and corresponds to the current level and importance of GIS technologies. Detailed information on the problems that hinder the progress of GIS education in Kazakhstan and on the opportunities that favor its evolution is presented in Table 1.

Table 1. Challenges that hinder the progress of geoinformation education and opportunities that favor its evolution in Kazakhstan

	Problems that hinder the progress of geoinformation education	Opportunities that favor the evolution of geoinformation education
1.	There is no coordinated work in the field of geoinformatics development at the national level, which took into account the needs of all organizations and individuals involved in the creation, collection, promotion and operation of digital geodata, restricts the flow of investment in GIS education, does not allow achieving the proper level of information security all kinds of educational tasks in the field of GIS.	Modern republican policy in the field of informatization has identified GIS as one of the most important information technologies, thereby creating republican assistance to the evolution of geoinformatics in the country in all divisions of the state, public and business segments and stimulating the open exchange of geospatial data in various branches of management, science and education.
2.	Different degrees, needs, opportunities, and technological policies for promoting GIS technologies in line ministries and departments serve as a source for creating industry-specific requests for training specialists. This, in turn, hinders the formation and standardization of an integral core system of continuous and professional GIS education.	Modern regional policy, which is based on a unified approach to accounting, assessment and management of environmental management, production opportunities and labor resources of territories, has increased interest in GISspecialists as a separate group of professions that have geoinformation training based on a problem-based method for developing the basic educational level.
3.	The discrepancy has become even more obvious in the hardware and software equipment of educational organizations that are related to GIS-related topics, in comparison with institutions of other branches of activity that are engaged in GIS-related technologies, due to the lack of targeted funds intended for GIS education.	The creation of a highly developed market of hardware and software tools in the field of GIS technologies will eventually lead to the special (sponsorship) connection of manufacturing firms and large users established in developed countries to the complexity of GIS education and its material equipment.
4.	The creation and approval of the national educational standard for higher professional GIS education is still a mandatory requirement for budget financing of training specialists in the field of geoinformatics and official recognition of the corresponding qualifications of graduates by republican bodies, industries and departments.	The transformation of higher education in Kazakhstan to a multi-level system of training professional personnel, which is approved in developed countries, provides a chance for universities to establish special training in the field of geoinformatics sooner and more effectively. in the system of continuous education, to resort to the world educational potential for this purpose, involving a system of netting, internships.

5.	The lack of GIS education equipment with teaching materials is critical today. Based on the global trends in the technological and informational development of GIS, this problem can become an insurmountable challenge for Kazakhstan.	The development of telecommunications and network technologies in Kazakhstan, the formation of access and comprehension of educational GIS resources collected and continuously replenished in the world's Internet networks, the use of modern information educational technologies makes it possible to establish an effective information exchange of educational materials, go to the creation and implementation of distance GIS education programs, and the distribution of electronic training tools.
6.	Dual (geographical and engineering) principles are characteristic of geoinformatics. Due to the development and comprehension of GIS technologies, it has become a fundamental difficulty for both geographical and engineering cartography. It needs close attention, consideration and a national decision regarding educational standards and curricula, otherwise everything can serve as a source of groundless "technologization" of geoinformatics as a training area and educational discipline.	The emergence and development of modern areas of application of GIS technologies for Kazakhstan: geography of business and finance, real estate activity, natural and urban cadastres, geography of disasters, geopolitics, world tourism and much more complement geoinformatics with new ideas, methodological approaches and technological solutions, strengthening the problem-subject component of geoinformatics at the expense of socio-economic disciplines and strengthening the knowledge base of geographic information systems. its geographical origin [7].

The resolution of the above-mentioned difficulties and the use of opportunities that favor the further progress of GIS education in Kazakhstan will provide an opportunity to stimulate the movement to raise the level of GIS education. GIS is a social activity.

GIS is designed to engage the public. GIS users interact through communities. It is clear that isolated activities are unacceptable when creating solutions to important social and economic problems. Of course, this will be a public project. The digital revolution is happening right before our eyes. Today, in developing countries, the Internet economy is growing by up to 25% annually. No segment of the economy can come close to this indicator. There are new requirements for people's education and work skills. More than 15 countries are currently implementing national digitalization programs [8]. The digital revolution is happening right before our eyes. Every year, the Internet economy is growing by up to 25 % in developing countries. No segment of the economy can come close to this indicator. There are new demands for people's education and working abilities. More than 15 countries are currently implementing national digitalization programs.

The leading countries for digitalization of national economies are China, Singapore, New Zealand, South Korea and Denmark. In China, a similar program is called "Internet+" and it combines digital industries with traditional ones, Singapore has a "Smart Economy" program, South Korea with its "Creative Economy" program aims to improve human capital and entrepreneurship, and Denmark, in turn, focuses on digitalization of the public sector [8]. The State program " Digital Kazakhstan "was the basis for the development of the Presidential Address" Third Modernization of Kazakhstan: global Competitiveness " dated January 31, 2017. The deadline for its implementation is 2018-2022.

The goal of the program is to increase the level of development of the economy of Kazakhstan and modernize the quality of life of people through the use of digital technologies in the near future.

The objectives of this program are: digitalization of industry and electric power industry; digitalization of transport and logistics; digitalization of agriculture; improvement of e-commerce; digitalization of internal activities of state bodies; "Smart" cities; increasing digital literacy in secondary, technical and professional, higher education [8].

In the world ranking of information and communication technologies development, which is calculated under the guidance of the UN-ICT Development Index, Kazakhstan ranked 52nd out of 175 countries in 2016, the same indicator was in 2015. As a result of the implementation of the Program and other strategic directions, Kazakhstan will take the 30th place in this rating by 2022, the 30th place by 2025, and finally the 15th place by 2050 [8].

International experience shows that when training programmers, it is not necessary to teach them four years of bachelor's degree, and six months are enough for them to learn basic things and in the future, by collaborating and attending seminars, accumulate knowledge. It is necessary to form short-term courses, and programmers will hone the skills required in their work in the future in practice [9].

The list of modern GIS software products is very diverse. There are approximately 20 programs that are related to professional or desktop GIS. These programs are particularly well — known: GIS MapInfo Pro, Arc/INFO, ArcView GIS, GeoMedia, GeoGraph/GeoDraw, GIS "Panorama" [6].

ESRI promotes GIS technologies and introduces geographic thinking to the educational process. ESRI software in the education industry holds the top spot. The company's Distance Learning center provides more than 100 courses on a variety of topics with sample training data, and students can purchase a temporary license for software products that are required for completing tasks. A significant number of universities use these Internet-accessible materials as teaching aids in their applied courses and in distance learning [1].

ESRI is implementing a long-term program of assistance to educational institutions, which focuses on improving GIS education. According to this program, educational institutions that conduct training classes on their base and introduce GIS courses into the curriculum have the opportunity to purchase the necessary software products of the ArcGIS family on a competitive basis ArcGISvirtually free of charge (they will only pay a fee for delivery, customs clearance, and a reduced cost of training in working with the provided products in certified training bases) [6]. The purpose of Esri remains, as before — to improve and promote GIS technologies and provide comprehensive assistance to users in their work for the benefit of society [1]. Today, GIS education at the university level prevails in Kazakhstan. Therefore, it is necessary to carry out a number of measures to introduce innovations in teaching spatial thinking in the study of the environment in primary and secondary schools. In many countries of the world (USA, Great Britain, Austria, etc.), digital educational resources and GIS are actively used in school geography education [6]. In Kazakhstan, in the next 3 years, with the supportНұpof the Nur Otanparty,about 1000 free IT classes will be opened to thoroughly study programming and robotics, where up to 150,000 schoolchildren will study annually [9]. In 2017, the National Chamber"Atameken" decided to make a rating of Kazakhstani universities and start working with the training of IT specialists. Independent experts evaluated the use of IT technologies in the educational process. 66 universities and institutes took part in the competition. The 1st place was taken by the Kazakh-British Technical University (Almaty, South Kazakhstan region), the 2nd place — the International University of Information Technologies (Almaty, South Kazakhstan region), the 3rd place-the D. Serikbayev East Kazakhstan State Technical University Серикбаева(Ust-Kamenogorsk, East Kazakhstan region) [10]. D. Serikbayev East Kazakhstan State Technical UniversityСерикбаева he launched 8 absolutely modern innovative projects with digital content. These are "Precision Agriculture", "Medical equipment"," Robotic unmanned vehicles"," Additive Technologies"," Digital Methods of Earth exploration"," Human interaction Interfaces with computer systems"," Intelligent Life Support Management Systems","BIM technologies in Design". Even in the usual disciplines, the volume of IT content has increased significantly. The share of high technologies is now at least 45 %. In this higher education institution, computers and

software are updated [10]. The interest of students in computer images gives teachers a unique opportunity to reveal to students the unique world of maps, images, three-dimensional models, animation, develop a unique "cartographic worldview", expand their horizons in the field of Earth sciences and raise the level of cartographic literacy [3]. A number of universities in Kazakhstan have opened departments of geoinformatics, GIS, geoinformation mapping, etc. Along with higher technical education in the field of GIS, a special place in the educational process will be given to advanced training courses for specialists in related disciplines who seek to improve their technical skills in modern GIS. The process of training specialists should be based on combining a theoretical course and a practical course, which is as close as possible to имеющимсяthe methods and technologies of work available in production [5]. To unite industry and education in the educational process of higher education institutions in Kazakhstan, representatives of enterprises will be attracted at the expense of extra-budgetary funds due to the opening of competence centers on the basis of higher education institutions. Also, ICT departments of universities will be opened at enterprises, where courses for students will be provided within the framework of ICT projects of economic sectors [8]. 20 modern IT centers will be opened in Kazakhstan to train qualified specialists in this field in accordance with the new projectНұрof the Nur Otanparty— the Digital Kazakhstan program. In May 2018Акмолинской, a similar center was opened in the Akmola region of Kazakhstan, which is based at Кокшетаускомthe A. Myrzakhmetov Kokshetau University. In three years, 100,000 people, including unemployed and self-employed youth, are expected to learn the required digital skills and modern programming languages самозанятую[9]. Based on the analysis of the conducted empirical studies, it can be concluded that the competence-based approach is based on the following criteria: The approach and integrative basis of modern higher professional education served as a source of a new perspective for the development of GIS technologies. By simplifying GIS and distributing it on the Internet and in cloud environments, as well as integrating it with real-time information, GIS promises to become the basis for almost all forms of human activity. GIS contributes to the development of a new view of the world in society, which ensures its integrated perception and optimal understanding of the relationships between its components. Specialists in this field are necessary for society and have excellent prospects for obtaining interesting, prestigious and well-paid jobs. As a result, courses on GIS and related technologies are very popular in all developed countries [1].

The key problems of implementing GIS education in the training of specialists in various fields of activity in the Republic of Kazakhstan are the lack of adequate funding, lack of qualified personnel, insufficient awareness of stakeholders, difficulties with technical and software support, lack of theoretical and methodological developments.

Lack of cartographic literacy is one of the factors that adversely affect the economy and planning, the attitude to nature in national relations, and international politics and cooperation. Therefore, mastering cartographic literacy should be a must at all levels of education.

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MACHINE LEARNING AND BIG DATA TECHNOLOGY IN THE MODERN EDUCATIONAL SPACE

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Abstract - This article explores the impact of machine learning and big data technologies on the modern educational space. It considers the use of machine learning for analyzing large amounts of data in educational institutions, automating learning processes and assessing student performance. It also explores the use of machine learning techniques to personalize education and tailor curricula to the needs of each individual student. The paper also discusses how data analytics can be used to predict student success and prevent dropouts. It concludes that machine learning and big data technologies can significantly improve the efficiency and quality of education.

Keywords **-** machine learning, big data, personalized learning, educational analytics

I. INTRODUCTION

Education plays one of the most important roles in any state. The pace of its economic and political development, its moral state of affairs. The rapid development of information technologies allows to automate many spheres of human activity efficiency, and education is no exception.

Modern educational institutions are faced with huge amounts of data collected during the student learning process. These data contain valuable information about learning processes, students' performance, and their individual needs. However, processing and analyzing this data requires a large amount of time and resources. In this regard, machine learning and big data technologies are becoming indispensable tools to efficiently deal with such volumes of information.

II. PROCEDURE FOR PAPER SUBMISSION

This article explored the use of machine learning and big data technologies in the modern educational space. The results of the study showed that these tools can significantly improve the efficiency and quality of education. Data analytics, learning automation, personalizing education, and predicting student success all help teachers and administrators make informed decisions and create optimal learning environments. The use of machine learning and big data technologies is an important step in the development of modern education.

III. RESULTS AND THEIR ANALYSIS

Machine leaning and Big Data technology have significantly transformed the modern educational space in various ways, enhancing the learning experience, improving administrative processes, and enabling data -driven decision- making. Here are some key aspects of their impact:

Table 1. The impact of machine learning (Machine Learning) and big data technology (Big Data) on the modern educational space

Personalized Learning	*Adaptive Learning Systems*	Machine learning algorithms analyze student data to create personalized learning paths. This helps students learn at their own pace, receive tailored content, and get immediate feedback.
	Recommendation Engines	Educational platforms use recommendation algorithms, similar to those on streaming services, to suggest relevant courses, resources, or exercises to students based on their preferences and past performance.
Enhanced Teaching and Assessment	*Automated Grading*	Machine learning algorithms can grade assignments, quizzes, and even essays, reducing the administrative burden on educators and providing quicker feedback to students.
	Predictive Analytics	Big Data analysis can predict student performance, helping educators identify at-risk students and intervene with targeted support.
Administrative Efficiency	*Student Enrollment and Scheduling*:	Big Data technology helps in managing course enrollments, class schedules, and resource allocation efficiently, optimizing the use of educational facilities.
	Resource Allocation	Machine learning algorithms can optimize the allocation of resources, such as faculty time, classroom usage, and budget allocation, to improve the efficiency of educational institutions.
Research and Development	*Data-Driven Research*	Educational researchers use Big Data to conduct in-depth studies on learning patterns, curriculum effectiveness, and educational trends, leading to evidence-based improvements.
	Predictive Modeling	Machine learning models can predict future trends in education, assisting institutions in planning for changes in enrollment, technology adoption, or curriculum development.

Administrative Decision-Making	*Data Dashboards*	Educational administrators can access real-time data dashboards that provide insights into various aspects of the institution, facilitating data-driven decision-making.
	Financial Management	Big Data analytics assist in managing budgets, identifying cost-saving opportunities, and optimizing financial resources.
Accessibility and Inclusivity	*Customized Accessibility Tools*	Machine learning can be used to create customized accessibility tools for students with disabilities, making educational materials more inclusive.
	Language Translation	Language processing technology helps bridge language barriers, allowing students from diverse backgrounds to access educational content in their preferred language.
Security and Privacy	*Data Security*	Institutions must implement robust security measures to protect sensitive student and faculty data from cyber threats.
	Privacy Compliance	Compliance with data protection regulations is essential to ensure the ethical use of student data.
Quality Assurance	*Assessment of Learning Outcomes*	Machine learning can help assess whether students are meeting learning objectives and provide insights into areas that need improvement.
	Continuous Improvement	Data analytics can track the effectiveness of teaching methods, curricula, and educational technology, enabling institutions to continuously refine their offerings.

Research and development of machine learning and big data technologies have great potential for education. They enable the creation of intelligent systems that can personalize the educational process, adapt to individual student needs, and optimize learning.

Some sources use the clustering method, but in our opinion this is not entirely correct, since we already have class labels, namely the amount of debt, so in this case, the classification method should be used.

Clustering refers to methods of machine learning without a teacher, and classification and regression, in turn, to learning with a teacher, since they have markers for each class as the initial data.

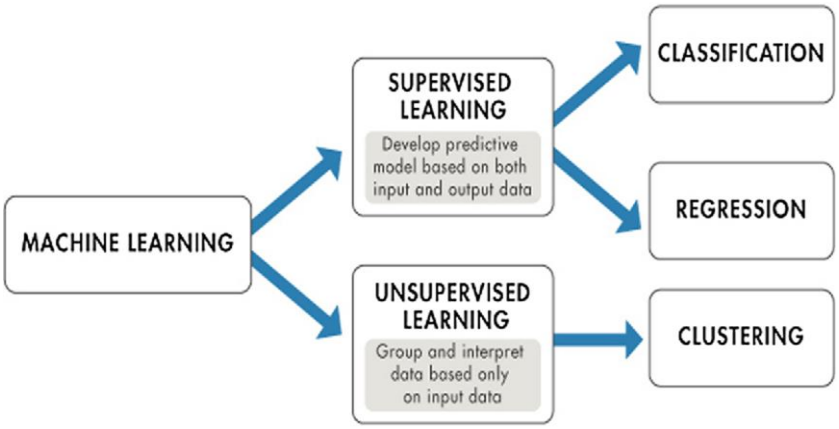

Figure 1 – machine learning methods

One of the key areas of research is the development of machine learning models to predict student success. By analyzing learning data such as grades, in-system activity, and other factors, the likelihood of student success can be predicted and appropriate interventions can be taken to support it.

Also, research on machine learning and big data technologies helps in creating intelligent educational platforms. These platforms can offer personalized educational content and assignments based on a student's individual knowledge and skill level. They can also automatically adapt to a learner's changing needs and provide feedback to facilitate more effective learning.

There are several approaches to using machine learning to predict student performance:

1. Using Data Analytics: Data such as test scores, homework assignments, class participation can be used to create a machine learning model that will predict a student's points in future tests or exams. This model can be trained on historical data using various machine learning techniques such as logistic regression, artificial neural networks, etc.
2. Using behavioral data: Student behavioral data, such as time spent on tasks, their dynamics while completing tasks, can help create a model to predict which students will have problems with a course in the future. This model can use supervised learning techniques such as decision trees or random forests to predict student performance.
3. Using a Recommendation System: A recommendation system can be used to suggest materials and tasks to students that are best suited to their level. This can be achieved by using collaborative filtering and content analysis techniques.

In each of these approaches, the key is collecting student data and creating an algorithm that can be used to analyze that data and predict student performance.

There is an increasing amount of research and development focused on the application of machine learning and big data technologies in the modern educational space. The integration of these technologies has the potential to transform traditional educational practices and enhance learning outcomes. Numerous studies have explored various aspects of this topic and highlighted its potential benefits and challenges.

One common area of research is the use of machine learning algorithms to personalize and enhance learning experiences. By analyzing large datasets of student information, these algorithms can identify individual learning needs, provide personalized recommendations, and adapt instructional materials to suit each learner's unique preferences and abilities. Researchers have examined the efficacy of these algorithms in improving student engagement, motivation, and academic performance.

Furthermore, the application of big data analytics in the educational space has enabled researchers and educators to gain valuable insights into various aspects of teaching and learning. By leveraging data from multiple educational platforms, systems, and sources, educators can identify patterns, trends, and correlations that help inform instructional strategies and decision-making processes. For example, researchers have used data analytics to identify factors that influence student attrition, predict academic success, and even detect early signs of learning difficulties.

Overall, the literature on the research and development of machine learning and big data technologies in the modern educational space highlights the potential benefits and challenges of these technologies. It provides insights into the various ways they can be applied to enhance teaching and learning practices, improve educational outcomes, and inform educational decision-making. Additionally, it raises important considerations regarding privacy, ethics, and equity that need to be addressed when implementing these technologies in educational settings.

IV. CONCLUSION

In conclusion, machine learning and big data technology have transformed the modern educational space by personalizing learning experiences, improving teaching methods, and optimizing administrative processes. These technologies have tremendous potential to enhance education and ultimately improve student success.

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APPLICATION OF PROCESS MINING TECHNOLOGY FOR THE FORMATION OF DATA-DRIVEN SOLUTIONS IN THE BANKING SECTOR

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Data-driven decision-making has become a fundamental aspect of modern business operations, particularly in the banking industry. Banks must collect, analyze, and interpret vast amounts of data to make informed decisions that can impact the success of their business. The use of data analytics in bank business process management (BPM) has proven to be a powerful tool for improving operational efficiency, customer satisfaction, and profitability.

In recent years the banking industry has undergone significant transformation due to advancements in technology, the rise of fintech, and changing customer expectations. To stay competitive, banks are embracing digital transformation and leveraging technology to optimize their business processes. One of the most significant challenges banks face is managing their complex, interconnected processes efficiently. Data-driven BPM offers a solution by providing insights into these processes, allowing banks to identify areas of improvement and optimize their operations.

In this article we explore the role of data-driven BPM in the banking industry. We examine the benefits of data-driven decision-making and explore how banks can leverage data analytics to optimize their business processes. Additionally we discuss the challenges that banks face in implementing data-driven BPM and offer insights into best practices for successful implementation. Overall, this article aims to provide a comprehensive overview of data-driven BPM in the banking industry and its potential to transform banking operations.

One crucial aspect of BPM is business process analysis, which is the process of analyzing and understanding a business's current processes to identify areas of improvement and streamline operations.

Business process analysis involves breaking down a business's processes into individual steps and examining each step to understand how it contributes to the overall process. This process can involve gathering data on process performance, mapping out process flows, and conducting stakeholder interviews to gain insights into process issues.

The goal of business process analysis is to identify opportunities for improvement that can enhance the efficiency and effectiveness of a business's processes. For example, it may identify bottlenecks in a process that slow down operations or redundancies in a process that increase costs. By identifying these issues, businesses can develop solutions to optimize their processes and increase their overall performance.

In addition to identifying opportunities for improvement, business process analysis can also help businesses meet compliance requirements, reduce risks, and improve customer satisfaction. By gaining a better understanding of their processes, businesses can identify areas where they are not meeting compliance standards or putting themselves at risk. They can then take steps to address these issues and ensure they are operating in a compliant and

safe manner. Similarly, by understanding how their processes impact customers, businesses can make changes that improve customer satisfaction and loyalty.

One of the most effective tools for analyzing business processes in the transition to digital space is Process Mining or process analytics. Process Mining is a powerful tool for business process analysis, which involves using data mining techniques to analyze and understand complex business processes. Data mining is the process of discovering patterns, relationships, and insights within large datasets, which can be used to improve business operations.

In the context of business process analysis, data mining can be used to identify patterns and trends within a business's processes that can help identify areas for improvement. For example, it can be used to identify bottlenecks, redundancies, or other inefficiencies within a process that may be causing delays or increasing costs.

The Process Mining for business process analysis typically involves several stages. The first stage is data collection, where data is gathered from various sources, such as databases, logs, or other data sources. This data is then cleaned and prepared for analysis, which involves removing duplicates, correcting errors, and transforming data into a format suitable for analysis [1, p. 117].

The next stage is data mining, where data is analyzed using various techniques such as association rule mining, clustering, or classification. This stage involves identifying patterns or relationships within the data that can provide insights into the underlying processes.

The final stage is interpretation and reporting, where the results of the analysis are interpreted and presented in a meaningful way. This stage involves creating visualizations or reports that clearly communicate the insights gained from the analysis and provide actionable recommendations for process improvement. The main feature of process mining technology is the ability to create a digital twin of a process that fully reflects the actual execution of the process and provides insight into where, when, and why inconsistencies and deviations from the process regulations occur. In addition, the digital process map enables answering questions such as «Why does the process behave in this particular way?».

Banks, being among the most innovative and technologically advanced organizations, are actively implementing process analytics technologies in their operations. Thanks to the successful combination of resources, personnel, technologies, and data, banks can fully utilize Process Mining both for operational management of key processes and for developing a long-term management strategy.

For example, a bank has a process for opening a new account, which involves several steps such as filling out an application form, verifying the customer's identity, and performing a credit check. By analyzing the process using Process Mining technology, the bank can identify bottlenecks and inefficiencies in the process, such as long wait times or frequent errors in data entry. Based on these insights, the bank can then make data-driven improvements to the process, such as simplifying the application form, automating certain steps, or adding additional staff during peak periods. These changes can result in a faster, more efficient account opening process that leads to increased customer satisfaction and reduced costs for the bank. Moreover, by continuously monitoring the process using Process Mining, the bank can ensure that the improvements are effective and make further adjustments as needed. This ongoing optimization can lead to significant long-term benefits for the bank's business process, such as improved productivity, reduced risk of errors, and increased profitability.

Misunderstood processes are causing delays in digital transformation initiatives, with manual routing and process gaps further complicating the picture. According to Forrester, 37% of business and technology decision-makers report experiencing these problems [2]. However, process mining has emerged as a key factor in enabling automation efforts. In fact,

the 2020 Process Mining Sector Scan found that 78% of people who automate see process mining as crucial to their efforts.

Sponsored by IBM, case studies indicate that process mining can increase process automation rates by 75% and process conformance by 67% [2]. Similarly, businesses can increase their business value by 40%, reduce RPA implementation time by 50%, and decrease RPA project risk by 60% by using process mining during RPA implementation, as reported by QPR.

In terms of benefits, Jan Claes found that 61% of respondents consider the provision of factual process data for further diagnosis to be the most significant advantage of process mining. Additionally, executives see the most opportunities for process mining in procurement process optimization (22 %) and audit and control-related activities (19 %), according to QPR [2].

Although case studies have proven to be effective in demonstrating the benefits of process mining, PwC reports that challenges remain in the adoption of this technology. The unavailability of process mining tooling or expertise (52 %), limited focus due to a missing process function (33 %), and complex IT landscape (30 %) are cited as the top challenges preventing adoption [3].

Gartner reports that locating, selecting, extracting, and transforming process data is the most time-consuming aspect of process mining, with 80% of efforts and time being spent on these activities [2]. However, when data is readily available, the time required to apply process mining is significantly reduced.

According to global studies on digital transformation, the market for process analytics technologies was valued at over 160 billion US dollars in 2022, and this figure is expected to grow significantly. Germany, the Netherlands, and Finland stand out among the leading countries that are actively adopting technologies based on big data for business process management, while Japan, the USA, and Canada represent the Asian and North American regions. In the CIS countries, Russia is following the path of developing its own technological products in the field of process analytics as part of a policy of active import substitution. Banks were the first to introduce Process Mining technology, being the most innovative and flexible structures. For instance, VTB24 Bank was the first to implement Process Mining for digitization, choosing the «Credit Cards» and «Cash Loan» processes, with data from the CRM system as the basis. The innovation resulted in a reduction of labor costs by 8.5 % and an increase in process productivity by 6-8 %. By introducing modern tools in the bank's process management system (such as artificial intelligence, Process Mining, robotic automation, and CJM), Sberbank OJSC in the Republic of Belarus was able to generate additional operating income amounting to USD 1.2 million [4]. With the trend towards digitalization of the economy and the socio-technical sphere, it is expected that the process analytics market will continue to grow, and that more and more companies will adopt process analytics technology.

In conclusion, we formulate the main conclusions and proposals:

1. Process Mining technologies are becoming increasingly important in the context of the growing role of data as the basis for decision making.

2. The accumulated volumes of big data are often not used, not analyzed, which does not allow banks to use fully all potentially available information about the real state of business processes.

3. Process Mining Technology expands the boundaries of process analysis, allowing you to create digital process maps and identify bottlenecks, process imperfections and defects that cannot be identified using this tool.

4. Thanks to Process Mining banks can improve process efficiency, reduce costs and minimize lost profits.

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PROGRESS IN BIOTECHNOLOGIES ALLOWS MONITORING AT MOLECULAR LEVEL THE NERVE INJURY REGENERATION IN THE CENTRAL AND PERIPHERAL NERVOUS SYSTEM VIA CHAPERONES PROTEINS

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Abstract- Axon damage in both the peripheral and central nervous systems (PNS) is associated with the up- and down-regulation of a wide range of molecules that either mediate nerve repair or exacerbate the initial damage. Whether regeneration and functional recovery occur depends on enhancing the activities of beneficial components while lowering the characteristics of damaging agents. Chaperones have an essential function in improving behavioral outcomes, facilitating axon regeneration and remyelination, and mediating the survival of injured neurons. Here, we go into the many chaperone proteins that are implicated following axonal damage to the nervous system using CRISPR-Cas9 technology with evolved prime editing and base editing, allows for unprecedented precision in genome manipulation. Single-cell RNA sequencing enables the exploration of cellular heterogeneity, providing insights at the individual cell level. Cryo-electron microscopy has become a powerful tool for high-resolution structural biology without the need for crystallization, thus facilitating the study of chaperones proteins and their effects on both the central and peripheral nervous systems, and potential modes of action.

Keywords-- chaperone proteins, neuronal cell death, peripheral nerve injury, spinal cord injury.

I. INTRODUCTION

Numerous cellular and molecular processes are triggered in response to injury to the axons of neurons in the central nervous system (CNS) and peripheral nervous system (PNS) in order to facilitate the regeneration of injured nerve fibers, remyelination, and target reinnervation [1]. For instance, in the injured PNS, axon outgrowth is mediated by the re-expression of regeneration associated genes (RAGs) such as c-jun and growth associated protein-43 [2], while Schwann cells and infiltrating hematogenously-derived macrophages phagocytose inhibitory axonal and myelin debris [3]. Additionally, Schwann cells release adhesion molecules and neutrophic factors. These substances enable the survival and regulated growth of regenerated axons. Axotomized PNS neurons typically regenerate robustly due to these favorable conditions; however, this is not always the case in humans. However, damaged CNS neurons regenerate less well than PNS neurons, and this has been linked to decreased and/or early truncation of favorable processes. For instance, the injured CNS shows reduced RAG expression, subpar immunological responses, and oligodendrocyte death [4].

II. CHAPERONE PROTEINS

Proteins must be in a precise conformation to carry out their functions. When cells are subjected to stresses such as high and low temperatures, pH changes, oxygen deprivation, or disease conditions, proteins struggle to create and keep their appropriate structures. Misfolded proteins can also cause perfectly structured proteins to unfold. Misfolded proteins can form aggregates that can cause cell death if not repaired [5]. Chaperones aid in the

correct non-covalent polypeptide assembly. They can identify unfolded or partially denatured proteins and prevent improper polypeptide chain connections and aggregation.

III. EXPRESSION OF CHAPERONES AFTER PNS AND CNS NERVE INJURY

One of the first chaperones that was shown to be altered following axonal injury in the PNS and CNS was Hsps. Cauley *et al*. 1986 [6] discovered that goldfish optic nerve compression increased the production of a 30 kDa HSP. It was further found that *HSP70* could be retrogradely transported in damaged frog sciatic nerves and that it could be induced after facial nerve axotomy in hamsters and crush damage to rat spinal cords. Other chaperone proteins besides hsps have been associated with axonal damage in the PNS and CNS. Bcl-2-associated athanogene-1 (BAG1), a co-chaperone for *HSP70/HSC70* expression, is elevated in Schwann cells following sciatic nerve crush in rats. *GRP94* is another chaperone whose expression rises after contusion injury in the rat spinal cord [7].

IV. FUNCTION OF CHAPERONE PROTEINS AFTER PNS AND CNS AXONAL DAMAGE

Neuronal Survival - The possibility that the chaperone plays a role in the demise of injured neurons was raised by Törnqvist *et al*.[8] based on the higher expression of clusterin in axotomized motorneurons. Conversely, other research suggests that a few chaperone proteins help injured neurons keep functioning. For example, Benn *et al*.[9] discovered that following sciatic nerve transection, sensory and motor neurones needed to be preserved by the overexpression and phosphorylation of *HSP27*. The researchers next expanded on this study in vivo and in vitro to demonstrate that the expression of *HSP27* by DRG cells was correlated with the survival of PNS neurons from wounded neonatal or adult rats after nerve growth factor (NGF) ablation.

Axon Regeneration - Chaperones have been linked to the regeneration of injured PNS and CNS axons in addition to cell survival. For instance, because this mechanism was compromised in clusterin null mice, it was shown that clusterin was critical for the regeneration of sensory neurons following sciatic nerve transection and crush injury. Furthermore, neurite outgrowth of rat retinal cells was increased by exogenous administration of the tiny heat shock protein, αBC [10]. Rat optic nerve fibers that had been crushed were regenerated in vivo by crystallin via decreased RhoA activation and phosphorylation of cofilin and myosin light chain. Chaperones may also mediate regeneration through other ways, such as cytoskeleton regulation of Schwann cells and axons. In particular, it was discovered that *HSP27* stimulates axonal outgrowth in Schwann cells by potentially encouraging the formation of intermediate filament proteins [11].

Myelination - D'Antonio *et al.* [12] previously shown that crystallin may have a role in myelination by establishing a link between the expression of the HSP and the growth of myelinating Schwann cells. Another chaperone that has been discovered to be involved in Schwann cell activity following PNS damage is αBC. Since the number of protein zero positive Schwann cells in culture was decreased upon BAG1 siRNA knockdown, it was demonstrated that BAG1, which is upregulated in Schwann cells following sciatic nerve crush, is crucial for the differentiation of myelinating Schwann cells.

Neuropathic Pain - While all of the aforementioned roles are advantageous, chaperones might also have a role in the promotion of neuropathic pain following damage. Following sciatic nerve ligation, the chaperone σ1R was shown to be linked to neuropathic pain since spinal sensitization and pain hypersensitivity were decreased by the use of an antagonist named *4-[2-[[5-methyl-1-(2-naphthalenyl)-1H-pyrazol-3-yl]oxy]ethyl]morpholine [13]*.

V. THERAPEUTIC STRATEGIES

Efforts have been made to harness the protective qualities of chaperone proteins to promote repair following CNS and PNS nerve injury, due to the numerous positive functions that have been reported. When a rat spinal contusion injury occurs, the agonist pioglotazone improves functional recovery and decreases motor neuron loss, astrogliosis, and microglial activation. *PPARγ* is a ligand-activated transcription factor belonging to the nuclear hormone receptor superfamily. The increased expression of *HSP27*, *HSP32*, and *HSP70* in the cord was one factor contributing to this improvement [14].

BRX-220 (bimoclomal analog) is another chaperone-inducing drug that has been employed as a post-nerve transection therapy. According to Vígh *et al*. [15], BMX-220 is a derivative of hydroxylamine that enhances cell viability by upregulating the production of HSP70 and HSP90. BRX-220 enhanced HSP70 and HSP90 in the injured spinal cord while improving motor neuron survival in the central nervous system (CNS).

VI. CONCLUSION

Over the past three decades, a plethora of studies has demonstrated that not only are chaperone proteins' expressions altered after nerve damage to CNS and PNS neurons, but these proteins also actively participate in the repair processes and mediate some of the pathogenic events. Future and ongoing research using tools such *as surface plasmon resonance*, *thermal shift assay*, and even *circular dichroism spectroscopy* must take into account ways to maximize the positive attributes while minimizing the harmful ones in order to improve CNS and PNS recovery.

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UNVIELING THE TECHNOLOGICAL WONDERS: DECODE THE INNOVATION IN THE ENCODE PROJECT.

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Abstract— Using a variety of state-of-the-art technologies, the ENCODE Project—an amazing project at the forefront of genomic exploration has managed to piece together the complex human genome. This paper explores the technological wonders that made the project possible, ranging from the three-dimensional insights obtained from Hi-C and 3C techniques to ChIP-seq's ability to clarify protein-DNA interactions. It draws attention to the significant contributions made by the project, revealing regulatory components and providing a window into the direction that genomics, predictive modelling, and personalized medicine will take. A monument to human ingenuity, the ENCODE Project opens the door to new understandings of genetic make-up and the secrets contained within the DNA.

Keywords—ENCODE project, technologies, mapping, sequencing, DNA, epigenetics, genes.

I. INTRODUCTION

The Encode (Encyclopaedia of DNA Elements) Project, launched over a decade ago, has been an importance source in scientific world, helping to unravel the complexities of human genome and its fundamental elements. By decoding the DNA, the Encode Project gives an open access to the blue print of human life. Encode has shed light on the regulatory roles and functional significance of previously unknown regions of the genome by utilizing a wide range of cutting-edge technologies, including sophisticated computational analyses and advanced sequencing methods.

The multidisciplinary approach of the project halters various technological wonders. With unprecedent resolution and accuracy, researchers have been able to track the dynamics of chromatin accessibility, transcription factor binding, and gene expression through the use of high-throughput sequencing techniques like ChIP-seq, RNA-seq, and ATAC-seq. By the use of innovative CRISPR-based techniques, it was able to facilitate the exact manipulation of genomic elements thus achieving a deeper understanding on its functional importance.

Together with these breakthroughs the application of computational frameworks and machine learning algorithm made scientists unveil the complexities of functional elements of human genome so that, new discoveries can be implied for the development of human health through their association with diseases.

As the Encode Project continues to expand, the use of these technologies will play a pivotal role in uncovering the hidden secrets of human genome.

II. NEW TECHNOLOGIES USED IN THE PROJECT

Chromatin immunoprecipitation, followed by sequencing, or ChIP-seq:The goal of ChIP-seq is to map the genome's regions bound by particular proteins (such transcription factors or histone modifications) and to identify protein-DNA interactions. To ascertain the genomic regions bound by the target protein, DNA-protein complexes are crosslinked, immunoprecipitated with particular antibodies, and subsequently sequenced.[1]

RNA sequencing, or RNA-seq: The goal of RNA-seq to detect distinct RNA molecule types (such as mRNA and non-coding RNA) and assess the levels of gene expression. To obtain quantitative data regarding gene expression, complementary DNA (cDNA) is created by converting RNA molecules.[1][2]

ATAC-seq and DNase-seq: The goal of these assays is to locate open chromatin regions, which are representative of accessible transcription factor regions and regulatory elements. DNase-seq and ATAC-seq include digesting DNA in areas that aren't protected by proteins, then sequencing the resulting fragments to determine which ones are accessible.[1]

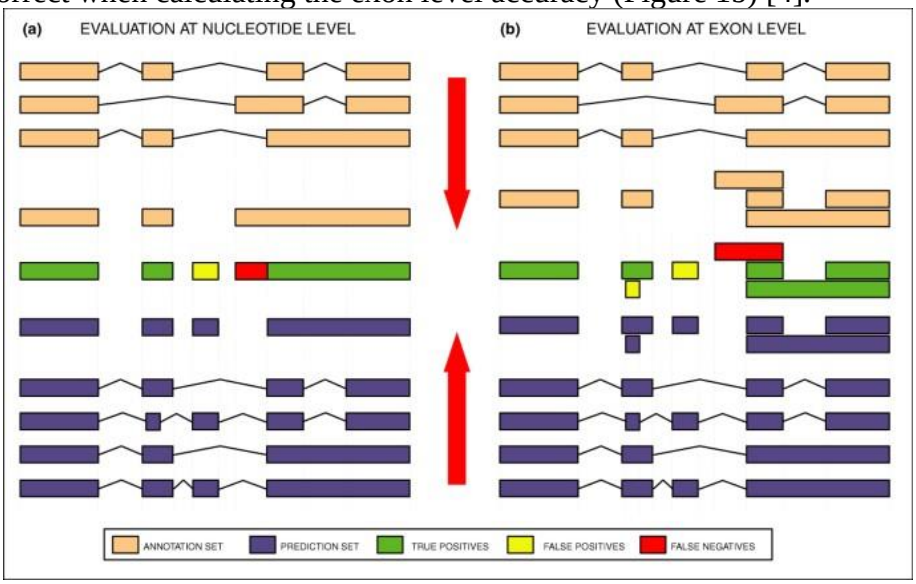
Chromosome Conformation Capture, or 3C and Hi-C): These methods shed light on the three-dimensional organization of the genome and the spatial interactions between distant genomic regions.To record the physical interactions between various genomic regions, DNA is crosslinked, broken up, and ligated. The resulting fragments are then sequenced.[1]

Methylation sequencing, or methyl-seq: By identifying DNA methylation patterns, this technique contributes to the field of epigenetics and gene regulation.Unmethylated cytosines are converted to uracil by bisulfite treatment, and then each cytosine's methylation status is ascertained through sequencing.[1][2]

Proteomics and Mass Spectrometry: Useful for identifying and measuring proteins—such as transcription factors and chromatin-modifying enzymes—present in particular cellular contexts.To identify and measure the proteins, they are separated, broken down into peptides, and then subjected to mass spectrometry analysis. [1]

III. RESULTS OBTAINED USING INNOVATIVE TECHNOLOGIES

The ENCODE Project annotated functional elements that were previously thought to be non-functional or "junk DNA," greatly advancing our understanding of the human genome. It was discovered that almost 80% of the genome contains elements that are biochemically active and involved in regulatory processes through integrative analyses of various genomic datasets. These included areas controlling RNA transcription, chromatin structure, and gene expression.[1][3] Nucleotide and exon level evaluation are used as measures to evaluate the accuracy of findings. A comparison between the predicted and annotated nucleotides determines the accuracy of the nucleotide level. For the nucleotide level statistics, individual nucleotides that appear in multiple transcripts in the annotation or the predictions are only taken into account once (Figure 1a). An exon in the prediction must have the same start and end coordinates as an exon in the annotation in order for it to be counted correct when calculating the exon level accuracy (Figure 1b) [4].



The mapping of protein-DNA interactions across different cell types was made possible by techniques such as ChIP-seq, which revealed complex regulatory networks. These analyses characterized histone modifications linked to gene regulation and located transcription factor binding sites. Furthermore, it was discovered that a large number of regulatory elements show cell-type specificity (Fig 2), affecting the patterns of gene expression in a context-dependent way [1].

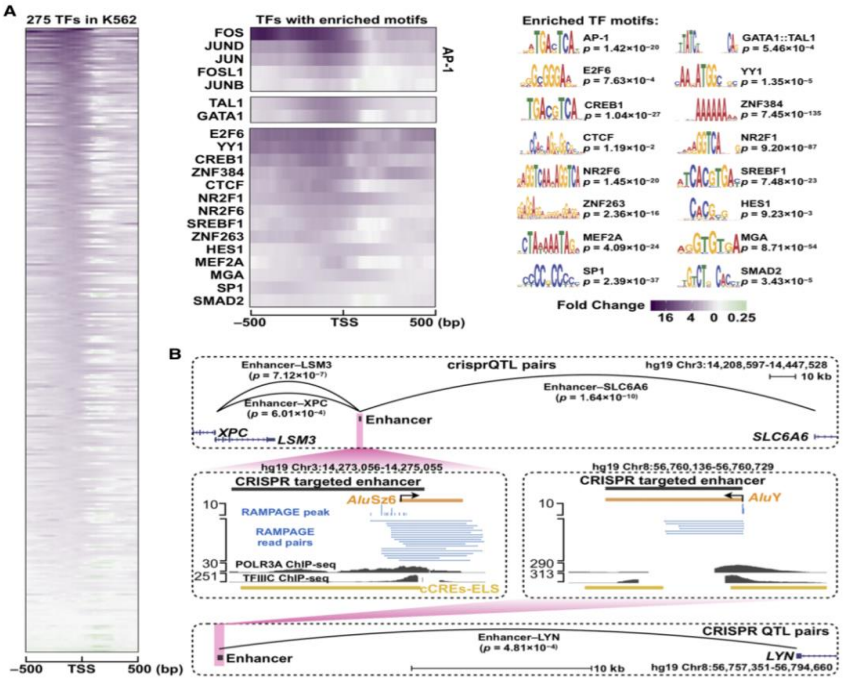


Figure 2 shows cell type specific enhancer function of polymerase III transcribed Alu elements. While the human-specific Alu elements are transcriptionally repressed, the older, expressed Alu elements may be expressed by the human host to function as cell-type-specific enhancers for their nearby protein-coding genes. This was discovered through an integrative analysis of the ChIP-seq data of 10 histone marks and hundreds of transcription factors, whole-genome bisulfite sequencing data, ChIA-PET data, and functional data in several biosamples [5].

Understanding chromatin accessibility was facilitated by DNase-seq and ATAC-seq analyses, which revealed open chromatin regions linked to regulatory elements. The role of chromatin structure in regulating gene expression was underscored by this comprehension of accessible chromatin regions, which also helped explain how transcription factors access DNA to control gene expression [1]. The three-dimensional structure of the genome was revealed through the use of Hi-C and 3C techniques, which also revealed spatial interactions between distant genomic regions. These discoveries shed light on chromosomal conformations and the ways in which the genome's spatial organization affects regulatory mechanisms and gene expression [2].

DNA methylation patterns that are essential for gene regulation and cellular differentiation were discovered through methyl-seq analyses. These epigenetic changes affect how genes are expressed and imprinted, which is important for both disease mechanisms and developmental processes [2]. Several combinatorial patterns that identify active promoters/TSSs, transcribed gene bodies, inactive regions, and enhancers are formed by epigenetic information, histone modifications, and variants. The ENCODE project has employed unbiased computational techniques, such as a multivariate hidden Markov model with combinatorial patterns of chromatin marks and spatial relationships to identify

chromatin states across nine distinct cell types. The genome could be split into 15 chromatin states using these nine chromatin marks, which also included eight histone modifications, CCCTC-binding factor (CTCF), and input controls. Strong promoters identified by H3K4me2/3 and H3K9/27ac and weaker promoters with decreased H3 acetylation at K9/27 are among these states (some of which are displayed in Table 1). H3K9/27ac is decreased and H3K27me3 is elevated in repressed promoters [6].

Chromatin state	H3K4me1	H3K4me3	H3K27ac	H3K36me3	H3K27me3	CTCF	RNA
Active promoter	+	+++	+++	–	–	+	+
Weak promoter	++	+++	+	–	–	–	+
Repressed/poised promoter	++	++	–	–	+++	–	+
Strong enhancer	+++	+	+++	+	–	+	++
Weak enhancer	++	–	+	–	–	–	++
Insulator	–	–	–	–	–	+++	++
Transcriptional elongation	–	–	–	++	–	–	+++

Utilizing mass spectrometry and proteomic analyses, ENCODE identified and quantified proteins involved in genomic regulation. This comprehensive catalog of proteins provides insights into the molecular mechanisms underlying cellular processes and gene regulation [1].

IV. FUTURE PERSPECTIVES

As single-cell technologies develop, combining them with ENCODE data may provide previously unheard-of insights into the dynamic changes in gene regulation and cellular heterogeneity. Through this integration, it will be possible to investigate regulatory landscapes at a more granular level and identify regulatory mechanisms unique to individual cells.

By combining information from various cell types, developmental stages, and disease states, it will be possible to continuously improve functional annotation and expand our knowledge of genomic regulation. An enhanced annotation will offer a more thorough understanding of regulatory components and their roles in relation to specific contexts.

Gene regulatory elements and their functions can be predicted more easily by utilizing machine learning algorithms and predictive modelling on the large datasets produced by the ENCODE Project. This method could hasten the discovery of regulatory elements in non-coding regions and the medical consequences they may have.

A comprehensive understanding of cellular processes and regulatory networks will be possible through the integration of data from multiple 'omics' levels, including transcriptomics, proteomics, genomics, and epigenomics. This integration will make complex relationships between various molecular regulatory layers clear.

It will be essential to keep functionally validating predicted regulatory elements with CRISPR-based methods. The functional significance of regulatory elements and their influence on cellular phenotypes will be confirmed by additional research using CRISPR screens and perturbation assays.

Ingenuity and discovery will be promoted by ongoing efforts to preserve open access to ENCODE datasets and to promote collaborative research. Expanding the availability of high-quality data will spur new findings and progress in the field of genomics.
The potential for converting ENCODE findings into clinical applications is enormous. Comprehending the regulatory environment in diverse illnesses may result in the discovery of innovative therapeutic targets and customized approaches to treatment.

V. CONCLUSION

When it comes to figuring out the mysterious complexities woven throughout the human genome, the ENCODE Project is a testament to human inventiveness and technological prowess. By means of a symphony of innovative techniques and unrelenting scientific investigation, this enormous endeavour has cleared the previously darkened passageways within our genetic terrain.

The ENCODE Project has led the way in genomic exploration, from the ground-breaking use of ChIP-seq to map protein-DNA interactions to the discovery of complex three-dimensional genome structures using Hi-C and 3C techniques. It provided insight into the coordination of gene expression and cellular function by showcasing the complex choreography of regulatory elements.

Additionally, the project's exploration of epigenetics using Methyl-seq and the significant discoveries made from proteomic analyses have expanded our comprehension of the complex regulatory mechanisms controlling our genetic heritage.

With the project developing and the scientific community utilizing these technological wonders, single-cell resolutions, predictive modelling, and multi-omics integrations appear to be bright future prospects. Our understanding of disease mechanisms and the development of personalized medicine will deepen as a result of ongoing collaborations and open access to data.

Beyond its astounding findings, the ENCODE Project leaves a lasting legacy that serves as a constant source of inspiration, reminding us of the limitless possibilities presented by human curiosity, ingenuity, and teamwork in the pursuit of understanding the fundamental qualities of life as encoded in our DNA.

The ENCODE Project is a living example of human tenacity, curiosity, and the unwavering quest of knowledge as it works to unravel the secrets of the human genome.

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INVESTIGATING THE EFFECTIVENESS OF ROBOTICS IN COMPUTER SCIENCE EDUCATION

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Abstract **-** Educational robots have proven to be valuable tools in practical learning approaches, particularly in STEM (science, technology, engineering, and mathematics) education at the kindergarten, primary, secondary, and high school levels. However, their utilization in higher education, specifically in computer science education, remains limited. Despite their potential to provide a more engaging and comprehensive learning experience, their presence is primarily observed in robotics courses, with minimal integration into other computer science-related subjects. This research aims to investigate the effectiveness of educational robots in computer science education. Different activities supported by educational robots are indicated.

Keywords **-** educational robots, computer science, collaborative learning, computational thinking

I. INTRODUCTION

Educational robots have emerged as valuable tools in practical learning approaches, particularly in the field of STEM (science, technology, engineering, and mathematics) education. Their interactive and hands-on nature has proven effective in engaging students and fostering a deeper understanding of complex concepts. From kindergarten to high school, educational robots have found their place in various educational settings, enabling students to explore and apply their knowledge in a tangible and immersive manner. However, their utilization in higher education, specifically in computer science education, remains limited.

Computer science education plays a vital role in equipping students with the necessary skills and knowledge to thrive in the digital age. As the demand for computer science professionals continues to rise, it becomes crucial to explore innovative and effective teaching methodologies that can meet the evolving needs of learners. Educational robots offer a promising avenue for enhancing computer science education by providing a more engaging and comprehensive learning experience.

While the integration of educational robots in robotics courses is well-established, their presence in other computer science-related subjects remains minimal. The potential of educational robots to facilitate active learning, problem-solving, and collaboration is yet to be fully explored in computer science education. By incorporating educational robots into various computer science topics, educators can create dynamic learning environments that simulate real-world scenarios and foster critical thinking skills.

This research aims to investigate the effectiveness of educational robots in computer science education. By conducting a comprehensive review of various educational robots available in the market, their features, and applications, this study seeks to shed light on their potential in enhancing the teaching and learning process in computer science. Furthermore, the research will explore the integration of educational robots in different computer science-related subjects and assess their impact on learning outcomes and student engagement.

Understanding the effectiveness of educational robots in computer science education is crucial for educators, curriculum developers, and policymakers. By harnessing the power of educational robots, educators can inspire and empower students to develop a deeper understanding of computer science concepts and foster a passion for the field. Moreover, this research can contribute to bridging the gap between theoretical knowledge and practical

application in computer science education, preparing students for the challenges and opportunities in the digital era.

II. LITERATURE REVIEW

Several studies have examined the integration of educational robots in computer science curricula, aiming to enhance student learning outcomes and engagement. For example, Özüorçun & Bicen [1] conducted a study where educational robots were integrated into a programming course. The results showed that students who used the robots demonstrated improved understanding of programming concepts and increased motivation compared to traditional instruction methods.

Programming is a fundamental aspect of computer science education, and educational robots have been employed to enhance programming instruction. Research by [2] investigated the impact of educational robots on students' programming skills and problem-solving abilities. The findings revealed that students who engaged with educational robots showed higher levels of programming competence and better problem-solving skills compared to those who did not.

Educational robots can also support the development of computational thinking skills, which are crucial in computer science education. A study by [3] examined the use of educational robots in fostering computational thinking among middle school students. The results demonstrated that students who interacted with the robots exhibited improved computational thinking abilities, including algorithmic thinking, pattern recognition, and logical reasoning.

Computer science education often requires collaborative problem-solving and teamwork. Educational robots can facilitate collaboration and enhance teamwork skills. A study by Kamga et al. [4] investigated the use of educational robots in promoting collaboration in a computer science course. The findings indicated that students who worked with robots experienced increased collaboration, effective communication, and improved team dynamics.

While educational robots offer significant potential in computer science education, several challenges and barriers have been identified. For instance, some studies have highlighted technical difficulties in robot programming and maintenance, limited availability of suitable educational robot platforms, and constraints in instructor training and support. Addressing these challenges is crucial for successful integration and effective utilization of educational robots in computer science education.

The existing literature suggests that educational robots have the potential to enhance computer science education by improving learning outcomes, fostering computational thinking skills, promoting collaboration, and enhancing student engagement. However, more research is needed to explore the broader impact of educational robots across various computer science-related subjects and to address the challenges associated with their integration. By addressing these gaps, educators and researchers can unlock the full potential of educational robots in computer science education, preparing students for the demands of the digital age and nurturing the next generation of computer science professionals.

III. ACTIVITIES SUPPORTED BY EDUCATIONAL ROBOTS

Educational robots offer a wide range of activities that can enhance computer science education by providing hands-on and interactive learning experiences. These activities leverage the capabilities of educational robots to engage students, promote problem-solving skills, and deepen their understanding of computer science concepts. This section discusses various activities supported by educational robots in computer science education.

a) Programming Practice and Algorithm Design

Educational robots provide a tangible platform for students to practice programming and design algorithms. Students can write code to control the movements and actions of the robot, allowing them to experiment with different programming constructs, such as loops, conditionals, and functions. Through this activity, students can gain practical programming experience and develop a deeper understanding of how algorithms work.

b) Simulating Real-World Scenarios

Educational robots can be used to simulate real-world scenarios and enable students to apply computer science concepts in practical contexts. For example, students can program a robot to navigate through a maze, mimicking pathfinding algorithms used in robotics and autonomous systems. By engaging in such activities, students can understand the relevance and applicability of computer science principles in real-life situations.

c) Human-Robot Interaction

Exploring human-robot interaction is another valuable activity supported by educational robots. Students can program robots to respond to specific human gestures, voice commands, or sensor inputs. This activity allows students to delve into the field of artificial intelligence and learn about concepts such as natural language processing, computer vision, and machine learning. By experimenting with human-robot interaction, students gain insights into the complexities and challenges of designing intelligent systems.

d) Collaborative Problem-Solving

Educational robots can foster collaboration and teamwork skills through group-based problem-solving activities. Students can work in teams to program robots to accomplish specific tasks or challenges. This collaborative approach encourages communication, cooperation, and division of labor among team members. Moreover, it provides students with an opportunity to understand the significance of effective teamwork in solving complex problems, a skill highly valued in computer science and related fields.

e) Sensor Data Collection and Analysis

Many educational robots come equipped with sensors such as distance sensors, color sensors, or gyroscopes. Students can design experiments or projects that involve collecting sensor data using the robot and analyzing that data using computer science techniques. For example, students can program a robot to collect environmental data and use data analysis algorithms to identify patterns or make predictions. This activity allows students to integrate computer science skills with data collection and analysis, emphasizing the interdisciplinary nature of the field.

f) Robotics Competitions and Challenges

Educational robots are often used in robotics competitions and challenges, which provide an exciting and motivating environment for students to apply their computer science knowledge and skills. These competitions can range from line-following races to complex robotic soccer matches. By participating in such events, students gain hands-on experience, improve their problem-solving abilities, and develop resilience and perseverance in the face of challenges.

g) Project-Based Learning

Educational robots can serve as a platform for project-based learning in computer science education. Students can undertake open-ended projects where they conceptualize, design, and implement robotic systems to solve real-world problems or address specific

challenges. This activity promotes creativity, innovation, and independent thinking while integrating computer science concepts into practical applications.

Incorporating these activities into computer science education through the use of educational robots not only enhances students' technical skills but also promotes critical thinking, creativity, collaboration, and problem-solving abilities. By engaging in hands-on activities, students can experience the direct application of computer science concepts and develop a deeper understanding of the subject matter. These activities contribute to a more comprehensive and engaging computer science education that prepares students for the dynamic and evolving field of technology.

IV. DISCUSSION

The integration of educational robots in computer science education holds great potential for enhancing learning outcomes, student engagement, and the development of essential skills. The discussion section explores the implications of the findings related to the effectiveness of educational robots in computer science education, as well as the challenges and considerations associated with their integration.

The findings from various studies indicate that educational robots can have a positive impact on learning outcomes in computer science education. Students who interact with educational robots demonstrate improved understanding of programming concepts, problem-solving skills, and computational thinking abilities. The hands-on and interactive nature of educational robots allows students to apply theoretical knowledge in practical contexts, leading to a deeper and more meaningful understanding of computer science concepts.

One of the key advantages of educational robots is their ability to engage students in computer science education. By providing a tangible and interactive platform, educational robots capture students' attention and motivate them to actively participate in learning activities. The incorporation of educational robots in computer science classrooms promotes active learning, collaboration, and experimentation, which can contribute to increased student interest, curiosity, and enjoyment of the subject matter.

Educational robots offer opportunities for interdisciplinary connections within computer science education. Through activities involving human-robot interaction, students can explore concepts from artificial intelligence, machine learning, and computer vision. Moreover, integrating sensor data collection and analysis with computer science techniques allows students to bridge computer science with data science and analytics. These interdisciplinary connections broaden students' perspectives and prepare them for the multidimensional nature of the evolving technological landscape.

While educational robots hold immense potential, several challenges and considerations must be addressed for their effective integration in computer science education. Technical challenges, such as robot programming and maintenance, can pose barriers for both students and educators. Providing adequate training and support for instructors is crucial to ensure their comfort and competence in utilizing educational robots effectively.

Furthermore, the cost and availability of educational robots can be a limiting factor for widespread implementation. Access to resources and funding should be considered to ensure equitable opportunities for all students. Additionally, the design and functionality of educational robots should align with the learning objectives and pedagogical approaches of computer science education. Thoughtful selection and evaluation of educational robots are necessary to ensure they meet the specific needs of the curriculum and learning outcomes.

V. CONCLUSION AND FUTURE DIRECTIONS

The findings and implications of the research on educational robots in computer science education open avenues for future exploration and development. Further research can investigate the long-term impact of educational robots on students' career choices, particularly in computer science and related fields. Additionally, the integration of educational robots into advanced computer science topics, such as cybersecurity, data science, and artificial intelligence, can be explored to expand the scope of their applications.

Moreover, the development of comprehensive guidelines, frameworks, and best practices for integrating educational robots in computer science education would benefit educators and curriculum developers. These resources can provide guidance on selecting appropriate educational robots, designing relevant activities, and assessing learning outcomes effectively.

The integration of educational robots in computer science education has the potential to transform the learning experience and outcomes for students. The findings indicate that educational robots enhance learning outcomes, foster engagement, and facilitate interdisciplinary connections. However, careful consideration of challenges and considerations is necessary for successful implementation. By addressing these challenges and advancing research and support for educational robots, computer science education can become more dynamic, engaging, and effective in preparing students for the digital age.

ACKNOWLEDGMENT

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INTERNATIONAL WORKSHOP ON EARTH OBSERVATION FOR EARLY WARNING OF LAND DEGRADATION AT EUROPEAN FRONTIER (EWALD)

Land degradation is the world's greatest environmental challenge affecting the environment, agriculture, and human well-being. Intensified by natural disasters and desertification, land degradation may present potential risks and socioeconomic tension. The workshop proposes a platform for the discussion of relevant trends in the Early Warning System, responses to land degradation, and innovative geo-informational frameworks and solutions.

- Earth Observation for Early Warning of Land Degradation at European Frontier (EWALD), European Union's Framework Programme for Research and Innovation Horizon Europe - the Framework Programme for Research and Innovation (2021-2027), grant no. ID 101086250;

EWS PROTOTYPE DESIGN: CONCEPTUAL FRAMEWORK, SUBTASKS AND INTERACTION WITH THE PARTNERS

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A conceptual framework of the future early warning system (EWS) prototype for land degradation hazard mapping and prediction, which is currently being developed under the European EWALD project, is presented. The primary data source in the conceptual framework are the Earth observation data products, associated with the natural and anthropogenic drivers influence on land degradation processes.

An approach is proposed, which consists in translating heterogeneous (bio)physical indicators into an unified probabilistic form, followed by fusing ones into a joint hazard map. Forecasting is based on the hazard's time series analysis. Concomitantly with hazard mapping, a risk assessment of land degradation is carried out by socioeconomic geospatial modelling.

A preliminary decomposition of the whole worktask into subtasks with the assignment of responsible teams participating in the project for each subtask is proposed. A total of 12 subtasks are planned, in the execution of which all project's teams will be involved to different extents. Also, a detailed schedule of the subtasks' progress, including the final deliverable preparation, is drawn up.

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MULTIVARIATE RISK ASSESSMENT OF LAND DEGRADATION BY REMOTELY SENSED DATA

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In this paper, a novel method for the evaluation of land degradation in mountain-protected reserve areas based on remotely-sensed data. A risk map is developed based on this method for the investigated area. The risk is computed based on quantifying drivers of land degradation that can be estimated remotely. Terrain slope, vegetation cover, and surface soil moisture (SSM) are considered as these drivers in this paper. The risk value for developing a risk map is computed, which should be from one of the indicated classes (typically, the number of classes is from three to five). Therefore, the threshold for risk should be

introduced to indicate the risk class on the map. The Slovakian National Park of Pieniny is chosen as the study area. The data for the investigation has been obtained from the European remote sensing satellite system Copernicus Sentinel. The terrain slopes have been extracted from a digital surface model (DSM), which in turn was obtained from an interferometric pair of radar images of the Sentinel-1. The vegetation cover has been indicated by the leaf area index (LAI). LAI maps can be derived from both optical Sentinel-2 satellite imagery and radar Sentinel-1. The specifics of this study and the presented result are the use of a short time series of Sentinel-2 multispectral images formed, acquired annually under the same phenological conditions – during the late June to early July period. Analysis of the risk map allows determining the terrain slope as the most significant driver of land degradation, which, moreover, has not changed much for decades. Vegetation cover acts as an additional land-strengthening agent. The SSM impact could not be disclosed, possibly due to small statistics and insufficient spatial resolution.

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SCHEME FOR PROVIDING EARLY WARNING PROCESS WITH ARCGIS PLATFORM

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Methodological scheme for providing Early Warning Process (Ewp). EWP consists of the following processes: Monitoring, Prognostication, Warning, and Appropriate actions.

1. To support the processes, it is proposed to deploy a geodatabase (GDB) and a data storage, where:

   - GDB is intended for accumulation and storage of meteorological and hydro geo-statistical data; field monitoring data; Earth observation data, pre-processed into a state for use in the analytical process.

   - The data repository is designed to store indicators and models of land degradation.

2. Creation of a tool for assessing land hazards and vulnerabilities.

3. Creation of a cloud environment and a geoportal with the functions of administrative control of rights and access, functional applications and information services. For providing user needed information in the form of WEB applications, this geoportal should combine models, data and a cartographic sub-base.

We choose Arc GIS as the base platform to support the analysis of the Early Warning Land Degradation Process.

Our choice was based on the following properties of these GIS products: reliability, technical support, ready-to-use solutions and full compliance with the requirements of the prototype Early Warning System (EWS).

Let's have a quick look on ESRI ArcGIS software solutions and applications we offer to build the system.

1. Filling of storage facilities and storage. A set of mobile applications ArcGIS Field Maps will provide us with the collection and verification of all necessary data in the field when organizing monitoring on site.

2. Geoprocessing tools will help us create the necessary analytical process with the help of existing algorithms and models.

3. ArcGIS OnLine server and Portal for ArcGIS provide the cloud environment for storage and visualization of various types of services and applications. Distributed access to services and applications with defined rights to use them will be organized through the Portal administrator interface.

Due to **ready-to-use portal application templates**, the Portal could be quickly deployed and the applications necessary for the organization of the workflow could quickly configured as well. The use of ESRI Base Map data set for the whole world is suggested as cartographic support.

With existing algorithms, data and models are quickly transformed into the necessary portal services and applications with the help of basic software ArcGIS OnLine and ArcGIS Desktop Pro. All of them are accessible through the Portal as shown in Fig.1.

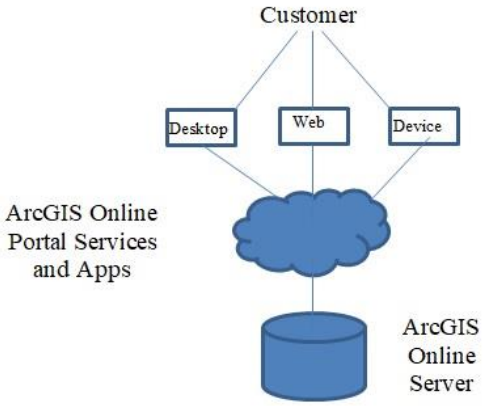

Fig.1. Structure of the portal

A set of **ready-to-use** or those configured according to application templates, in accordance with their purpose, are divided into field, office and public.

A set of applications for field monitoring Field Maps includes many useful applications that can be used both individually and in any necessary combination of Navigator, Tracker QuickCapture, Collector, Survey123, etc.

Special attention is paid to Operation Dashboard among office applications, which in a very convenient and visual form provides spatial and attribute information with the possibility of presenting data changes not only on surface but also in time.

ArcGIS Hub. A site prototype was created using the Hub application on the ArcGIS OnLine platform.

The site is called Earth Observation for Early Warning of Land Degradation at the European Frontier. It consists of seven thematic pages with text, media materials, as well as services created on the ArcGIS platform.

"Home" page of the site introduces the history of the project idea to users.

"About project" page has four subtopics.

"Partners" page is also divided into additional pages that introduce all project participants.

The following pages have a template look and are created to be filled with necessary information that will appear during the project.

The first published service of this project was created on the ArcGIS OnLine platform using the "ArcGIS StoryMaps" application.

This is a web multimedia presentation that introduce participants of the project and their experience in the performed works.

Conclusion. The ArcGIS OnLine platform chosen by us is fully meets the requirements for supporting information resources and scientific research works of the EWALD project.

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ADDRESSING LAND DEGRADATION IN AN OASIS DOMAIN: A REMOTE SENSING AND MODELING APPROACH FOR PREDICTION AND MONITORING OF SALINITY AND SILTATION

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Land degradation is a major problem worldwide, especially in semi-arid areas where the impact of climate change is aggravating the situation. The Tafilalet plain in southeastern Morocco suffers from land degradation through salinity and siltation, which poses significant challenges to sustainable development efforts, affecting ecological integrity, agricultural productivity, and socio-economic stability. In this work, we explore a method that integrates remote sensing data obtained by different sensors (Sentinel 2, Landsat 4-5, Landsat 7, and Landsat 8), field observation and laboratory work to develop a model for the detection and prediction of soil salinity and the evolution of silting in the largest oasis in Africa. We conducted an analysis on 16 commonly used indices in the literature and correlated them with data obtained from 25 soil samples taken at a consistent depth of 0.20 m during the 2018 campaign. The application of a linear, logarithmic, polynomial (degree two and four) models on indices shows that the second-degree polynomial model of the salinity index (SI-KHAN) is the most efficient one for detecting and mapping soil salinity

in the Tafilalet oasis, with a coefficient of determination (R2) and the Nash–Sutcliffe efficiency (NSE) equal to 0.93 and 0.86, respectively. Percent bias (PBIAS) calculated for this model equal was 1.868% < 10%, and the low value of the root mean square error (RMSE) confirms its very good performance. The standardized precipitation anomaly index (SPAI) is strongly correlated to the soil salinization process and silting. An increase in salinized surfaces is observed during the periods of 1984–1996 and 2000–2005, which cover a surface of 11.50 and 24.20 km2, respectively, while a decrease of about 50% is observed during the periods of 1996– 2000 and 2005–2018. Silting coupled with salinity, have completely degraded 24% of the oasis in the last 30 years especially the southern part. Our study will allow decision makers to act properly and develop effective policies for the sustainable management of this fragile ecosystem.

Keywords: Land degradation; Tafilalet oasis; Remote sensing; Soil salinity; Silting; SPAI.

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USING OF REMOTE SENSING DATA FOR DROUGHT ASSESSMENT

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The increasing droughts and their intensity are one of the global climate change consequences. This process is related to a significant decrease in moisture availability in the territory. Therefore, up-to-day information regarding the moistening conditions and manifestations of degradation processes is crucial. Combining data from the Landsat and Terra satellites with drought indices calculated based on, a map of the development of degradation processes in landscapes of Ukraine was obtained. Among the damage to the landscape is the biota, water, and soil cover. Nevertheless, stable trends towards gradual changes in the boundaries of Ukraine's natural zones can be seen.

The study's results will make it possible to substantiate measures and proposals regarding the adaptation of Ukraine's environment and society to climate changes effect. In particular, based on the obtained results, we developed a set of approaches and methods for studying the condition of irrigated and non-irrigated lands. Such a technique is universal and can be tested on the territory of any arid region of the world, in particular for North Africa.

Keywords: desertification, remote sensing, climate change, index of drought, moisture

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LAND COVER CLASSIFICATION ENHANCEMENT BY TRAINING SAMPLES SEPARATION: A CASE STUDY FOR LAND DEGRADATION INDICATION

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Land cover is a fundamental land surface parameter considered a key indicator of land degradation processes. Changes in land cover indicate a reduction or increase in vegetation, habitat fragmentation and land conversion as triggers of land degradation. The rate of land cover changes also indicates the intensity of the degradation processes.

Land cover mapping is generally derived from Earth observation and requires reliable and comparable classification techniques. However, despite the wide range of land cover classification techniques and information products, enhanced land cover mapping is still challenging, especially for highly heterogeneous natural areas and areas with different agricultural or functional land use types.

In this study, we propose two approaches to enhance land cover classification for land degradation indication, namely:

- training samples clustering;
- input dataset optimization.

The first approach aims to lessen the subjectiveness of expert-selected classes and training samples mixing. This point is reached by the application of unsupervised methods to perform clustering of classes training samples.

The second approach implies the selection of the input dataset layers. Thus, it not only increases training samples separability but also decreases the initial number of dataset layers, reducing dataset volume.

Since each approach is presented as an optimization procedure and aims to increase the separability of the training samples, its objective function should quantify the separability. To assign the objective function, the Separability Index of Training Samples is developed.

The developed approaches were applied to enhance the land cover mapping of the heterogeneous natural landscapes in the case of the Shatsk National Natural Park. The experiment revealed that the land cover classification of the study area was enhanced by applying both of the developed approaches. This is evidenced by a 4% increase in overall accuracy from 77% to 81% with the training samples clustering. After input dataset optimization, overall accuracy was increased by 1% from 90 % to 91 %. Also, the dataset was reduced by 2.93 times from 167 to 57 layers.

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EARTH OBSERVATION BASED EARLY WARNING OF LAND DEGRADATION ARCHITECTURE

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Early detection and prevention of natural and anthropogenic degradation processes are especially relevant. This paper proposes a suitable architecture of a cloud-based early warning system for assessing land degradation based on satellite Earth observation and other necessary geospatial data. The early warning system is based on efficient methods for the time series of land degradation indicators fusion and algorithms for land degradation risk assessment. Earth observation data includes multispectral and radar satellite imagery and derived data products. Ground-truth data construct auxiliary data in concert with topographic, geoclimatic, cadastral, socioeconomic, and other statistical data. The use of the ArcGIS Online Portal is suggested for the processing of heterogeneous geospatial data. As a result, the authors intend to build a general knowledge-based model for assessing and predicting land degradation.

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EVALUATING THE USE OF VERY HIGH-RESOLUTION RGB IMAGERY FROM UAV FOR VEGETATION CLASSIFICATION

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The article explores using very high-resolution RGB data from unmanned aerial vehicles (UAVs) to explore the possibilities of utilizing data to monitor vegetation. The Baroch nature reserve, located in the Pardubice region of the Czech Republic, is used as an area of interest. Data is collected using the UAV DJI Mavic 2 DUAL Enterprise. The reserve is overgrown mainly with reed and cattail and is used as a pasture. The paper aims to determine the effectiveness of utilizing UAV technology and very high-resolution RGB data to identify, monitor, and classify vegetation types in this grassy habitat and to provide insights into the practicality of using such data for ecological research and landscape management purposes.

SATELLITE NAVIGATION RECEIVERS. ACCURACY MEASUREMENTS AND PRINCIPLES OF OPERATION

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This article represents the main distance-measuring principles of modern global navigational systems and describes several distortion factors in distance and position calculations. A description of user equipment necessary for using GPS is provided. NMEA communicating protocol is observed. The method of assessment of the accuracy of coordinates determining is provided.

INFORMATION ECOLOGY, PROBLEMS AND NEGATIVE IMPACTS IN THE CONTEXT OF INFORMATION TECHNOLOGIES

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Information ecology is the presentation of a middle way between theories of the influence of new technologies on human life and culture. We know from practice that technology is either taken as the salvation of humanity or as a tool to exterminate life on planet Earth.

The article primarily presents the relatively unknown concept of information ecology, aiming to define the idea of information ecology in modern information science. It also describes other closely related concepts of digital well-being and digital ecology.

Information ecology wants to teach us to use, but not abuse, technical inventions. Although we are partly dependent on technology, we must not let this dependence grow unhealthy. Theoretically, the article analyzes the main problems of the information environment and discusses the consequences of informationally "unhealthy" behavior.

LST QUALITY EVALUATION SERVICE FOR HETEROGENEOUS EARTH OBSERVATION DATA

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Radiometer Suite (VIIRS) LST environmental data record against ground observations in Armenia and Belarus. The data from the Landsat-8 satellite is used due to its high spatial resolution. In contrast, the VIIRS information is obtained due to its high temporal resolution, accessible with a minimal delay after the flyby of satellites. Algorithms to calculate LST were analyzed to find the best performance for both daytime and nighttime data. The evaluation shows that the current VIIRS LST products demonstrate a reasonable accuracy, with a root mean squared error average of 2.77 K and an average coefficient of determination of 0.92 K.

A MULTICRITERIA DECISION ANALYSIS FRAMEWORK FOR MONITORING AND FORECASTING LAND DEGRADATION RISK IN ECOSYSTEMS WITH MULTIPLE ASSETS

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Land degradation (LD) represents the foremost global environmental challenge, impacting ecosystems sustainability and human well-being. This study proposes a conceptual methodological framework to monitor, forecast, and issue early warnings for LD risks in areas with diverse ecosystem assets. The framework integrates multicriteria decision analysis and predictive artificial intelligence methods. We apply the methodology to an abstract map including diverse ecosystem assets (tree, vegetables, soil, water), representing an agriculture land with diverse fruit trees and vegetable crops, as a test bed for a future case study in a date palm oasis in Morocco which has been affected by productivity losses and desertification leading to the contraction of its agricultural land. Spatial and temporal satellite data at 300-meter pixels obtained from Copernicus Sentinel satellite data will be used to infer crop types, extent, and condition. The framework generates spatial risk maps that facilitate the identification of areas currently and potentially at risk of LD, enabling the prioritization of protective response measures.

Keywords: Land Degradation, Methodology, Risk, Multicriteria Decision Analysis, Forecasting

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PROJECT MANAGEMENT PERSPECTIVE ON UAV DATA COLLECTION: WATER MANAGEMENT CASE STUDY BAROCH

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Currently, environmental protection is one of the main priorities. Vegetation cover as a complex system and water bodies are examples of land cover types that are observed and understood as important parts of our environment and need to be cared for. It is very important to collect up-to-date data on such systems. The use of unmanned aerial vehicles for data collection has become very used in recent years due to its scalability, efficiency, and instrumentality in various fields. Managing data collection projects using UAVs can be quite complex and challenging. This text examines the use of the Agile Scrum methodology in realization such a project.

LAND DEGRADATION ASSESSMENT IN SKOURA OASIS: TOWARDS A BLENDED SPATIALLY EXPLICIT WARNING SYSTEM

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Land degradation, very common in arid, semi-arid, and dry sub-humid areas, refers to loss of the biological or economic productivity of any land (soil proprieties and vegetation loss). It is a consequence of human activities and climate variation, and often lead to desert-like conditions.

Southern Morocco is characterized by the presence of oases, which are a complex and fragile socio-ecosystem. Farming system is carried out under increasingly restrictive climatic conditions. Yet these traditional systems have proved sustainable and productive for centuries, thanks to efficient management of plants, soil and water. However, they are now

experiencing ecological disruptions (aridification, soil degradation and salinization, and climatic disruption) which compromise their viability.

The Skoura oasis (2700 ha in the upstream of the Draa oases) is experiencing a profound agrarian crisis, leading to a breakdown in the farming system, reflected in the desertion of the majority of parcels, left fallow for several years, and the increasing of the rural exodus. The early 1980s marked the first farming crisis linked to water scarcity and climate change (warming of low temperatures), which caused a high mortality rate among fruit trees (apricot, almond and apple). For two decades now, olive orchards have been replacing date palms (Bayoud disease prevalent) and other fruit trees. Furthermore, in the recent years, we are witnessing to a second crisis marked by a clear decline in cultivated areas and in water-consuming crops (maize) and a dieback of olive trees due to a lack of sufficient water resources and of land degradation.

This work aims to develop a land degradation monitoring system for the oasis area, which is the most effective way to assess desertification processes as it helps to understand the mechanisms and changes of this ecosystem.

Land cover/Land use change, soil attributes shifting and surface properties are the most used variables to study desertification using remote sensing techniques. However, how these variables could be aggregated to be more explicit for depicting changes in land proprieties? What changes determine the risks of desertification and when it can be considered irreversible? And how we can set up thresholds for such variables that determine the presence or absence of desertification?

For this purpose, three approaches were tested to built-up an aggregative desertification monitoring index (DMI): (1) Spatial distance Approach, (2) Supervised machine learning (Max. likelihood, Random forest algorithms) and (3) hierarchic clustering based on Factor Component Analysis (PCA).

All these approaches use spectral information (VNIR and SWIR) at pixel level (pansharpened Landsat images, 15 m) to calculate the relevant indices (pixel-oriented approach) and contextual information obtained by segmenting a very high-resolution Pléaides image (0.5 m pixels) to take into account neighborhoods and adjacency effects (object-oriented approach). After that, the dynamic of land degradation (between 2000 and 2023) is carried out based on the best-performing aggregation approach.

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AN OVERVIEW OF THE WATER RESOURCE MANAGEMENT CHALLENGES IN THE ZIZ BASIN, SOUTHEAST OF MOROCCO

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The Ziz Basin is within an arid climate, with limited water availability, and growing demand for water resources. As a result, sustainable management of water resources becomes imperative to ensure the well-being of both the environment and the local communities. Surface and groundwater are under increasing pressure due to low annual rainfall (45 to 275 mm), decreasing stream flow and increasing pumping due to agricultural activities. In this work, we highlight the impact of increasing irrigation water demand on the water balance of the Ziz basin, based on multivariate statistical analysis combined with GIS techniques of a dataset from (2009 to 2021). Results show that crop water demand exceeds supply in the entire study area. Crop water requirements in the middle Ziz valley are better covered than in the Tafilalet plain. The needs satisfaction rates are 50 and 40%, respectively in the perimeters of the middle Ziz valley and the Tafilalet plain with high interannual variability. In 2018-2019, considered a dry year, the coverage rates are very low (between 22 and 15%). Water consumption for irrigation purposes in the Ziz Basin has increased, especially in recent years with the installation of large palm and watermelon farms in the region. On the other hand, an observation of the stream flows on 6 gauging stations shows low values, oscillating between 0.75 and 3.30 m^3/s in medians on a series between 1954 and 2014. Faced with these realities, the situation is becoming increasingly critical and threatens the availability of water resources in the Ziz basin. Therefore, water management measures such as the use of modern irrigation methods, the adaptation of crops, and the use of unconventional water are encouraged for resource sustainability in this fragile ecosystem.

Keywords: Water availability; irrigation water; crops adaptation; resource sustainability; Tafilalet plain; middle Ziz valley.

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ROLE OF REMOTE SENSING DATA IN ENVIRONMENTAL RESEARCH. DESERTIFICATION AND ITS EXPLORATION USING REMOTE SENSING METHODS

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Over the past 30 years, satellite remote sensing (SRS) has demonstrated high efficiency in informing about biodiversity and ecosystems and determining anthropogenic pressure on landscape, regional, ecosystem, continental and global spatial scales.

Regional and global land surface products derived from data from long-duration satellite missions such as Landsat, the Terra and Aqua Earth Observing System satellites, and the Polar-orbiting Operational Environmental Satellite (POES) series are widely available and offer relatively inexpensive and proven means of obtaining data on various types of geospatial information for large areas that are constantly updated. Commercial systems with very high spatial resolution above 5 m have provided new opportunities for ecosystem mapping.

One of the most significant environmental threats to humanity today is desertification. Desertification is a complex concept that includes a set of degradation processes within the upper soil layer. Desertification is land degradation in semi-arid and arid regions of the globe caused by human activity (anthropogenic causes) and natural factors and processes.

The presence of arid landscapes is the norm for many regions of the Earth, where certain climatic, landscape and geological conditions have formed: high average daily and average annual temperature, low rainfall and, accordingly, low density of vegetation or its complete absence, lack of fertile soils, etc.

Desertification as a process of dynamic change of the Earth's surface over large areas is the subject of many studies using remote sensing data. Complex studies of processes using remote sensing data require the combination of many types of data and the involvement of several processing methods.

Keywords: Desertification, Remote Sensing Data, Ecological modelling

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