Method for Determining the Level of Criticality Elements when Ensuring the Functional Stability of the System based on Role Analysis of Elements

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Abstract

The introduction of artificial intelligence technologies in the education process has become an urgent need at the current pace of development of society. The integration of various intelligent technologies is a key factor in this era. The article deals with the issues of adapting the educational process to new technologies. The technology of testing respondents using closed questions focused on multiple-choice answer options is proposed. The paper proposes a new approach to calculating the grade during testing using closed questions oriented to multiple choices. The approaches used earlier in practice were proposed primarily because of their simplicity. However, in connection with the development of soft computing, approaches that were previously used in practice can be supplemented and one should distinguish, for example, a completely incorrect answer from a partially incorrect one.

Keywords

Artificial intelligence, big data, cloud computing, Internet of Things, intellectual systems, knowledge testing tasks, closed questions.

1. Introduction

The first industrial revolution is associated with the development of light industry, the second (Industrial Society) with the advent of heavy and chemical industries, and the third (Information Society) with the introduction of computers and the Internet. The fourth industrial revolution implements various technologies such as artificial intelligence, big data, cloud computing, and the Internet of Things (IoT) [1].

The integration of various intelligent technologies is a key factor in this era. The data is really important. Information and data make decisions during this period, and a person or society must prepare to meet him [2]. In Japan, this is known as the concept of Society 5.0. Society 5.0 is "a human-centered society that balances economic development with the solution of social problems through a highly integrated system of cyberspace and physical space."

2. Directions of Research in the Field of IT

The IoT provides cyber connectivity. Without the Internet and an intelligent server system, the IoT is limited to just sensors and actuators [3, 4]. Support for artificial intelligence with machine learning, the use of big data allows you to process data better and faster, extract it, and make decisions. Intelligent decision support systems are used in a variety of

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applications ranging from tourism, finance, and education. Cloud Computing provides a dynamic infrastructure (Cloud Computing) that provides Artificial Intelligence (AI) solutions without large upfront costs [5].

Digital transformation is changing the way organizations operate and deliver services. The use of multiple technologies such as artificial intelligence, machine learning, big data, IoT, and cloud computing will provide improvements. Using these technologies, an organization can better describe situations, and be more flexible in turbulence because it can better predict and apply the recommended strategies for the organization [6]. Business process innovation driven by digitally driven business process reengineering is a key driver of digital transformation. AI is one of the main tools for innovation [7].

People—Process—Technology (P—P—T) are important when introducing a new technology. In many cases the People aspect is ignored, most organizations focus only on the Technology aspects. Staff need more time to develop, as well as more financial support. Employees are critical and determine the success of technology adoption and adoption. Strategic workforce planning should be included in technology development as well as the implementation of artificial intelligence. Education is a key factor in employee training [8, 9].

The automation system mainly consists of data input (sensors), automatic processing, and output (actuators). Not all automation systems use AI, such as the Elevator, a simple line tracker used by a logistics system. Artificial intelligence can help make the automation process smarter, more efficient, and more accurate. AI-assisted automated processing can be performed using a machine learning algorithm. AI can learn from examples, such as situations in the environment.

3. Basic Approaches in the Field of Artificial Intelligence

Approaches in artificial intelligence:

1. Symbolic approaches:
   - Facts are expressed in symbols.
   - Characters are transformed into other characters by a set of rules.
   - Reasoning is carried out depending on the logical type.
   - High-order logical heuristic search, state-space search, knowledge representation.
   - Expert system, automatic theorem proving, and design optimization using these approaches [10, 11].
2. Numerical approaches:
   - Facts are represented by numbers [12, 13].
   - Numbers are processed using various algorithms, mainly artificial neural networks now also known as deep learning [14].
   - The number of results is expressed in the target form [15, 16].
   - Other methods such as genetic algorithms, and fuzzy logic [17, 18].
3. Cognitive approaches (thinking like a human):
   - This method imitates the process of human thinking and memorization.
   - Examples: SOAR, CLARION, ACT-R.

A non-intelligent system can only find the answer based on the facts (data) available in the database. The answer must be stored in the system. It only produces information from data. An intelligent system can perform a thought process to get answers based on learned facts. The inference can be based on a rule or a data pattern.

4. Operational Stages of Machine Learning

The following main operational stages of machine learning are distinguished:

- Training Phase: In this phase, the AI outputs a sample training set. The result of this step is a “model”. A model is a set of values (neural network weights).
- Inference phase: In this phase, AI is used to evaluate, predict, control, and infer from the learning model based on the input test. The inference process is carried out using the “model” created during the training phase.
- Evaluation Phase: During the evaluation process, the algorithm is evaluated using various criteria.

The following types of learning strategies are suggested:

- In unsupervised training, the training set consists of input patterns only, data points are not labeled. Algorithms organize data and group it based on the similarity of input patterns. Usually used when you don't know what the result should be, for example, Adaptive Resonance Theorem, Self-Organizing Map, Hopfield Network.
- Supervised training: The training set consists of an input and an expected output pattern, i.e. a set of labeled examples. This strategy is used when the result is known. After training, the system can perform classification, prediction, and prescribing strategies, namely Perception, Forward, Backpropagation, Deep Learning, and GAN.
- Reinforcement learning: Algorithms that learn from results and decide the next actions. After each action, the algorithm receives feedback that helps it determine whether the choice made is right, neutral, or wrong. This is a good method for use in automated systems that need to make many small decisions without human intervention. The style should be switched to Normal.

5. AI is at the Service of Humans

AI can replace a human (replacement). Many media such as science fiction films see AI in this direction. People fear that AI will replace humans.

AI helps the person (support). This is the current situation. AI-powered systems help people in their work environment. Most AI programs are inspired by "natural intelligence" and are not yet designed to replace it.

The Turing test is a way to test artificial intelligence for human abilities. This test is administered in the form of questions and answers. Based on the Chinese room paradox, the ability to answer all possible questions that a person can answer does not always indicate intelligence, but can also indicate the ability to remember, think, and produce new knowledge—this is the ability of the mind.

Information technology and artificial intelligence enter many aspects of our lives. AI threatens jobs, but it also creates new opportunities. AI skills are required for all disciplines, not just technicians. It is necessary to prepare the younger generation for the future, otherwise, there are more risks than opportunities. A national AI strategy is needed, and national AI talent should be part of the national AI strategy.

Implementation of AI can be carried out in primary or secondary schools using appropriate tools and teaching materials. However, the most important part of educational preparation at the national level is the training of teachers. It is far more important to teach students how to think computationally than how to use a computer.

The data is important. However, many organizations ignore how they manage data. An AI solution can only be developed based on data. Therefore, organizations seeking to implement artificial intelligence must first properly manage their data. This is a positive effect of artificial intelligence. Learning paths are important for an AI engineer. AI requires basic knowledge, students must follow learning trajectories. New professions require "old" knowledge and skills.

It is necessary to develop a special laboratory that encourages cooperation between students. This laboratory should be dedicated to solving AI problems. Students from different disciplines sit together at a table to solve AI decisions. Group discussion collaboration and following directions are key learning strategies in this lab. The instructors move from one kiosk (group) to another group. The group works at a table, discusses, and displays the results on a large screen that the group members can see. Groups can work on different tasks or assignments and discuss them together in class.

6. Types of Collaboration That Can Be Used in the Laboratory

The main types of cooperation that can be used in the laboratory are:

- Parallel arrangement—students receive the same instructions. It looks like a traditional cool model.

- Clear order—in this model, each group works on a separate task. The desktop is a semi-private workspace.
- General arrangement—collaboration between groups is possible, and discussion takes place in a large class.

AI can automate key activities in education such as assessment. Educational programs can be adapted to the needs of students. AI can point out areas where courses need improvement. Students can get additional help from AI tutors. AI-based software can provide useful feedback for students and educators. AI is changing the way we find information and interact with it. AI can change the role of teachers. AI can make learning by trial and error intimidating. AI-driven data can change how schools find, teach, and support students. AI could change where students learn, who teaches them, and how they acquire key skills.

The use of artificial intelligence in the education system:

- Help the person learn at their own pace.
- Accurate determination of human needs.
- Practical solutions to chronic problems.
- Eliminate red tape in schools.
- Do not waste time in vain.
- Improving the quality of education.
- Ensuring comfort for work.
- For the right decision thanks to fast data analysis.
- Planning learning according to the abilities and pace of the students.
- Use or select effective teaching methods through educational analysis.
- Opportunity to practice in small groups with effective planning.
- Increasing the efficiency of the individual learning process.

Problems in education and their solutions with the help of AI are presented in

Table 1.

Table 1

Problems in education and their solutions with the help of AI

Number of order	Problem	AI Solution
1	Standardized curricula are not suitable for individual needs.	Personalized education.
2	Limited time available for a tutor.	Personal virtual teachers.
3	Big several students in class, many questions cannot be answered.	Virtual Classroom assistants.
4	Personalized communication is very difficult for a large number of students.	Chatbot quickly answers administrative questions.
5	Selecting the best students from applications.	AI can select based on criteria using multiple data.
6	Increasing dropout rates.	AI Sentiment Analysis.
7	Difficult to analyze the success of learning experiences.	Complements existing learning analytics by providing timely insights into student success, challenges, and needs that can be used to shape the learning experience.
8	Difficult to track the other skills.	AI develops reliable and accurate metrics to track student progress, including hard-to-measure traits such as creativity and curiosity.
9	Teachers have to deal the clerical administrative work.	The AI acts as an intelligent server to perform clerical tasks. However, the final decision remains with the teacher, as human intelligence is still required.
10	Stop and test approach in assessment.	AI can perform qualitative analysis, sentiment analysis, and provide personalized and tailored assessments, and provide role play and collaborative projects within the assessment method.
11	Provide new insights that are difficult or impossible to ascertain from traditional assessments	AI can analyze various data sources to correlate and visualize them so that the teacher can better understand the students.

AI can be used in education in the following cases:

- Academic analytical assessment of students and schools using an adaptive learning method and a personalized learning approach.
- Grading papers and exams using image recognition, computer vision, and predictive methods and learning analytics using datasets.
- Real-time virtual personal assistant for analytical training.

- Intelligent automation of educational materials and processes.
- Creation of automatic learning programs using augmented intelligence, focused on the specific needs of students.
- Interaction with students and teachers based on artificial intelligence.
- Support for students with disabilities and health problems through robotics and virtual reality.
- Identifying students at risk of dropout, helping them reduce dropout and dropout rates.
- Learning a foreign language by speech recognition and analysis, pronunciation correction, and error correction, reducing the percentage of errors by an average of 83%.
- Strengthening the decision-making process with the help of AI.
- Adaptation and personalization of training programs based on the knowledge, interests, and strengths of users.
- Create customized textbooks for a particular school, course, or even group of students.

Functions of AI in education:

1. In control:
   - Faster administrative tasks that require study time, such as grading exams and providing feedback.
   - Helping teachers with decision support and data-driven work.
   - Timely and direct work with the student.
2. Writing instructions:
   - Predict how a student will exceed expectations in projects and exercises, as well as the dropout rate.
   - Help teachers create an individual learning plan for each student.
   - Allow learning outside the classroom, and support for collaboration.
   - Customize learning styles for each student based on their personal information.
   - Analysis of the proposed program and course material.
3. In the process of studying:
   - Identification of shortcomings in the student's learning and their elimination at the initial stage of learning.
   - Customize the learning path for each student by collecting learning data.
   - Identify learning situations and apply intelligent adaptive intervention to students.

7. Testing Tasks

A fixed test is the same number of questions for all students. Most tests are currently used in this model [19, 20]. In an adaptive test, each student is asked a separate question, the questions are determined by preference and recommended by the AI, and the question must be adapted to the abilities of the students. As a result of the test, qualitative and quantitative data can be processed. With the help of artificial intelligence, you can analyze by connecting it with other data sources. It is guaranteed that the estimates will be of higher quality and more extensive [21, 22].

The training catalog should be available on the knowledge-sharing platform. The student database also stores the learning path, benefits, class schedule, student qualifications, and expected educational career [23, 24]. Students are enrolled in the system based on their wishes, tests, and educational goals. The AI-based system offers a curriculum that matches their learning goals. The AI also checks the available time, training schedule, workload, etc. After completing the training process and passing the exam, the system can provide a certificate of completion of the training as an assessment [25, 26]. This approach tailors the learning path to individual needs and goals [27, 28].

7.1. Application of Knowledge Testing Procedure

The knowledge testing procedure is used in various fields of human activity: programming, technology, medicine, psychiatry, education, etc. [29, 30]. In particular, control is an important element and one of the most important components in educational activities [31, 32]. Moreover, pedagogical control simultaneously performs several functions: educational, diagnostic, evaluation, stimulating, developing, educational, etc. [32, 33].

Testing is a convenient, but ambiguous way of assessing knowledge [34, 35]. This procedure contains many "pitfalls," elements of ambiguity, and lack of justification [36, 37]. There are many opinions regarding the expediency of using tests: on the one hand, tests are considered a means of positively transforming the educational process in the direction of its technology, reducing labor intensity and objectivity; on the other hand, the tests are seen as a means of degrading the role of the teacher, and the test results are considered insufficiently reliable [38, 39].

7.2. Types of Test Tasks

Test tasks are traditionally divided into two large groups:

- Closed-type test tasks.
- Open type test tasks.

In this paper, we will study a closed-type task—when each question is accompanied by options for answers, from which several correct ones should be selected. In turn, closed tasks with several options for correct answers provide different options for choosing:

- Task with multiple options—choosing one answer option from the given list.
- A choice: the subject must answer "yes"/"no".
- Determination of correspondence: the subject is asked to establish the correspondence of the elements of two lists.
- Establishing the correct sequence—to arrange the elements of the list in a certain sequence, that is, to solve the ranking problem.

multiple choice: selection of several answer options from the given test option from the list of answers.

7.3. Setting the Testing Task

Let's consider the formal description of multiple choice in closed questions when testing using models and methods of multiple choice based on the axiom of unbiasedness.

Let there be a set of answer options $a_i \in A$ and $i \in I = \{1, \dots, n\}$, the number of which is equal to n, $n = |A|$. Part of the answers n_1, $n_1 < n$, are correct and they make up a subset A^1, $A^1 \subset A$, and the other part n_0, $n_0 < n$, of the answers, are wrong and they make up a subset A^0, $A^0 \subset A$, and $A^1 \cup A^0 = A$.

In addition, we will assume that all the answers offered by the test task $a_i \in A$, $i \in I$, are of equal value.

For many test tasks, this setting is natural and logical. For example, to choose among the given options of numbers those that are divisors of the given number. There are many variants of this kind of task. That is, this approach takes place in everyday life and the task of its formalization during testing is urgent. The peculiarity of such problems lies in the fact that they reflect the well-known truth: "How many people have so many opinions". Therefore, the solution must be justified to the extent suggested by the logic of its construction, the evaluation policy determined by the test organizers, common sense, etc.

7.4. Knowledge Assessment Algorithm

It is proposed to apply an algebraic approach to determining the evaluation results, which is successfully used in decision-making theory and the application of expert evaluation technologies. With the algebraic approach, formalization involves the calculation and justification of all possible answer options. The maximum number of points for a reliably selected subset of options is equal to B. The number of points for the correctly selected element of the subset of correct answers $b = \frac{B}{n_1}$.

Problems that a priori depend on a subjective component cannot be solved without using heuristics. A heuristic formula for determining the score for the choice of answer options in the form of a set generated by the respondent's answers is proposed: $V \subset A$.

Moreover, the number of elements $\nu = |V|$ in the set V can be different: from 0 to n, $0 \leq |\nu| \leq n$. We will denote the number of correct answers chosen by the respondent and the number of incorrect answers that he identified as correct by ν_0, $\nu_1 + \nu_0 = \nu \leq n$. Accordingly, the number of answer options that are not involved in the respondent's response to the question is equal to $n - \nu$.

Heuristics E1. The value of the penalty for each non-matching answer is entered, which is equal to k:

- E1.1—to some reasonable coefficient k, that reflects the subjective perception of

the test organizers about the "price of an error", for example, $k = 2$.

- E1.2—the value of the expression $k = 1 + p_0$, $k = 1 + p_0$, where p_0—the probability of an incorrect answer.
- E1.3—the value of some function established by experts $k = f_{E1}(n_0, p_0)$, which depends on the number of incorrect answers and their probability.

Heuristics E2. For an incomplete answer, that is, when $v < n_1$, a partial proportional assignment of points is assumed:

- E2.1—according to the ratio of received correct answers $v_1 \le v$, to the total number of correct answers n_1.
- E2.2—the value of some function established by the experts $f_{E2}(n_1, p_1)$, where p_1—the probability of receiving the correct answer.

Of course, a partially correct answer can be guessed by the respondent with a higher probability, but the points for it are also proportionally lower.

Heuristics E3. For situations when the respondent did not choose any answer ($v = 0$) or all answers were marked as correct, that is $v = n$, the penalty is a zero evaluation of the result—for lack of selectivity: $B = 0$.

An important and ambiguous situation is when the respondent does not identify a single correct answer. In this case, respondents may be given a different number of incorrect answers. Depending on the policy of planning test tasks and the position of the decision-maker, the specified situation can be described and regulated by additional heuristics.

Heuristics E4.1. In the absence of correct answers, the score is always zero, regardless of the number of wrong answers.

Heuristics E4.2. With zero correct answers, fewer incorrect answers are preferred over more incorrect answers.

To formalize this heuristic, we will use the lower limit value of the described situation. To do this, consider the situation $c(v_1 = 1, v_0 = n_0)$ when the respondent identified one correct answer and all incorrect ones n_0.

According to the described technology, the value of the estimate is determined by the following heuristics.

Heuristics E5. We will assume that the situation $c(v_1 = 0, v_0 = 1)$ follows the situation $c(v_1 = 1, v_0 = n_0)$ and worsens the resulting estimate by one step, i.e.

$$c(v_1 = 0, v_0 = 1) = c(v_1 = 1, v_0 = n_0) - c(v_1 = 1, v_0 = n_0 - 1) \quad (1)$$

The following situations of determining the resulting assessment are calculated in one of the ways:

- E5.1—descending function: for $i = 2, \dots, n_0$

$$c(v_1 = 0, v_0 = i) = \frac{c(v_1 = 0, v_0 = i - 1)}{k} \quad (2)$$

- E5.2—the situation $c(v_1 = 0, v_0 = n_0)$ is equivalent to the situation $v_1 + v_0 = n$: $c(v_1 = n_1, v_0 = n_0)$ that is, its consequence is a zero rating of the respondent.

In this case, the scores for different numbers of incorrect answers ($v_0 = 1, \dots, n_0$) with zero number of correct answers ($v_1 = 0$) are determined as follows:

$$c(v_1 = 0, v_0 = i) = c(v_1 = 1, v_0 = n_0) - i * \frac{c(v_1 = 1, v_0 = n_0)}{n_0} \quad (3)$$

where $i = 1, \dots, n_0$.

8. Prospects for Further Research on Knowledge Testing Problems

In the future, modifications of the described approach and the development of the idea of multiple closed-type testing should be investigated:

- Enter estimates or calculate the numerical value of the accuracy of each answer or cluster the variants of the correct answers according to significance.
- Into account indicators of the complexity of questions and answers, for example, depending on the number of combinations of correct and incorrect answer options or other factors.
- Consider choosing any number of closed questions from a set of answers—when the respondent does not know how many answers are correct, thus complicating the task.
- Enter answers of different weights or different proximity to the ideal, although this contradicts some principles of testing.

Take into account the similarity coefficients of the answers and the standard—according to the algebraic approach.

9. Other Areas of Application of AI

AI can be applied to businesses and organizations to make organizational practices more efficient. Owning artificial intelligence is an important tool for the future. This need is necessary not only for workers associated with the computer but also for other areas. Many technologies implement artificial intelligence. The decision to implement AI is a critical one for executives or decision-makers. AI talents are huge opportunities for the development of countries. The role of universities and research centers should be enhanced.

Students can more freely choose the path of their competence. They may be general to the entire curriculum but may focus on specific approaches. Students are encouraged to participate in extracurricular activities that are assessed as credit points. Collaboration between industry and universities supports, among other things, the development of artificial intelligence education. Competence standards in data science and artificial intelligence are required.

A learning process that can be easily replicated should be created to create a large amount of AI talent. It is necessary to develop complete teaching materials that will be free for teachers. Teachers should be trained in training courses before using the material. A national competency standard should be established before the development of training materials.

Python and R can be used as programming languages for AI. Python starts with minimal libraries and can be extended with additional libraries. There are several libraries for data science and artificial intelligence. Integrated Development Environment—Tools such as Jupyter are available notebook. Python runs on various operating systems as well as the Anaconda package manager. R is an open-source statistical program. Designed based on the language S. Various ready-to-use packages (CRAN) are available. R can be used for statistical calculations. Integrated Development Environments—RStudio and RCmdr are available.

Implementation of AI can be carried out in primary or secondary schools using appropriate tools and teaching materials. However, the most important part of educational preparation at the national level is the training of teachers. It is far more important to teach students how to think computationally than how to use a computer.

Most programmers or students are not interested in learning mathematics, logic, or statistics. They just want to learn how to program. Developing AI solutions requires an understanding of mathematics, statistics, and logic. The excitement around artificial intelligence is now pushing programmers to study mathematics and statistics. However, how AI-enabled theoretical learning materials are provided needs to change.

10. Conclusions

Artificial intelligence, as a set of new advanced technologies, has emerged relatively recently and is currently developing rapidly. Some researchers consider this area to be the technology of the future. Like any other new technology, AI has undoubtedly positive characteristics, but at the same time, it carries obvious and hidden risks, and perhaps even dangers.

AI is designed to create new content based on input data or rules. Today, it is used in various areas of our lives: e-commerce, energy and utilities, telecommunications, automotive and transportation, airport chatbots, etc. The range of AI applications is constantly growing, and the elements of its presence in people's lives are steadily increasing.

It is clear that in such conditions, there is a need for a systematic analysis of the impact of AI on society and the identification of potential problems associated with its development and further intellectualization. One of the main industries already significantly affected by AI is education and research. It is important to foresee the peculiarities of AI's impact on the existence and development of this industry, to identify its advantages and disadvantages, as well as threats from its use.

The negative impact of AI is largely due to its use in generating various kinds of content that will contribute to the spread of violations of the principles of academic integrity. But this

threat should not be exaggerated. It will certainly lead to the emergence of new trends in education that will be aimed at minimizing such violations. In addition, technologies will soon be available to determine whether AI has been used to generate content with the corresponding consequences.

The positive effect of the development, use, and implementation of AI technologies is much greater, and the tasks they can be used to solve can be divided into the following groups:

1. Generating express reviews of scientific papers at the initial stages of research in new scientific areas. This can help young researchers when writing articles and dissertations.
2. Advisory assistance to teachers in creating teaching materials and in generating questions for testing, tasks for independent work, etc. during control measures.
3. Assisting teachers in analyzing answers to open-ended questions when checking control measures and using AI to automatically evaluate students' work.
4. Creating adaptive learning platforms for mass online courses with the ability to form individual trajectories and implement personalized learning, which analyzes student data, including their academic progress, learning style, and other factors to create personalized learning materials and recommendations.
5. Creating virtual assistants that can support students in their learning process.
6. Creation of anti-generative programs for identifying text written by artificial intelligence. This problem is caused by the fact that the use of ChatGPT and other tools for writing text using artificial intelligence, especially in dissertations, theses, research articles, scientific reports, and other documents whose authors have relevant copyrights, may violate the principles of academic integrity.

An analysis of technology trends shows that new results periodically emerge that change our understanding of promising and rational directions for the development of society and socio-economic systems. AI technologies are bringing us closer to creating full-fledged artificial intelligence systems. The development and coexistence of such systems and human civilization, as well as the problems of expediency and security, require interdisciplinary research at the intersection of philosophy, psychology, linguistics, ethics, and other sciences.

Artificial intelligence has been developed using various disciplines such as philosophy, mathematics, economics, neuroscience, psychology, computing, control theory, as well as linguistics. Fundamentals of mathematics, statistics, logic, and programming play an important role in the development of AI solutions. Natural language processing such as chatbots and sentiment analysis requires an understanding of linguistics and psychology. The neural network starts with control theory, and now that deep learning has become popular, most AI solutions are based on this approach. Therefore, it is necessary to move to a more interdisciplinary approach to education.

A positive feature of the proposed knowledge testing approach is the transparency of the rules set a priori by the test organizers, the absence of uncertainty situations during the evaluation procedure, and the monotony of the behavior of the function, which reflects the integral evaluation of the answers. According to the proposed technology, the determination of the resulting assessment is a well-founded and formalized procedure. In addition, the technology allows for further improvement of the described approach.

References

[1] V. Sokolov, et al., Method for Increasing the Various Sources Data Consistency for IoT Sensors, in: IEEE 9th International Conference on Problems of Infocommunications, Science and Technology (PICST) (2023) 522–526. doi: 10.1109/PICST57299.2022.10238518.

[2] G. Luger, Artificial Intelligence: Structures and Strategies for Complex Problem Solving, Fourth Edition Addison-Wesley (2002).

[3] Z. Hu, et al., Development and Operation Analysis of Spectrum Monitoring Subsystem 2.4–2.5 GHz Range, Data-Centric Business and Applications 48 (2020) 675–709. doi: 10.1007/978-3-030-43070-2_29

[4] I. Bogachuk, V. Sokolov, V Buriachok, Monitoring Subsystem for Wireless

Systems based on Miniature Spectrum Analyzers, in: V International Scientific and Practical Conference Problems of Infocommunications. Science and Technology (2018) 581–585. doi: 10.1109/INFOCOMMST.2018.8632151.
[5] N. Nilsson, Artificial Intelligence: A New Synthesis, Morgan Kaufmann Publishers (1998).
[6] V. Zhebka, et al., Optimization of Machine Learning Method to Improve the Management Efficiency of Heterogeneous Telecommunication Network, in: Workshop on Cybersecurity Providing in Information and Telecommunication Systems, vol. 3288 (2022) 149–155.
[7] S. Russell, P. Norvig, Artificial Intelligence: A Modern Approach, Second Edition, Prentice-Hall (2003).
[8] V. Buriachok, et al., Implementation of Active Cybersecurity Education in Ukrainian Higher School, Information Technology for Education, Science, and Technics, vol. 178 (2023) 533–551. doi:10.1007/978-3-031-35467-0_32.
[9] V. Buriachok, V. Sokolov, Implementation of Active Learning in the Master's Program on Cybersecurity, Advances in Computer Science for Engineering and Education II, vol. 938 (2020) 610-624. doi:10.1007/978-3-030-16621-2_57.
[10] J. Giarratano, G. Riley, Expert Systems: Principles and Programming, Third Edition Brooks/Cole Publishers (1998).
[11] P. Jackson, Introduction to Expert Systems, Third Edition, Addison-Wesley (1998).
[12] A. Voloshin, G. Gnatienko, E. Drobot, A Method of Indirect Determination of Intervals of Weight Coefficients of Parameters for Metricized Relations Between Objects, J. Automat. Inf. Sci. 35(3) (2003) 25–30. doi: 10.1615/JAutomatInfScien. v35.i3.30.
[13] T. Babenko, et al., Modeling of Critical Nodes in Complex Poorly Structured Organizational Systems, 26th International Conference on Information Society and University Studies Vol. 2915 (2021) 92–101.
[14] S. Bilan, et al., Technology of Selection and Recognition of Information Objects on Images of the Earth's Surface Based on Multi-Projection Analysis, in: International Scientific Symposium "Intelligent Solutions" (IntSol-2023) Vol. 3538 (2023) 23–32.
[15] H. Hnatiienko, N. Tmienova, A. Kruglov, Methods for Determining the Group Ranking of Alternatives for Incomplete Expert Rankings, Mathematical Modeling and Simulation of Systems (MODS'2020), AISC 1265 (2020) 217–226. doi: 10.1007/978-3-030-58124-4_21.
[16] H. Hnatiienko, et al., Determining the Effectiveness of Scientific Research of Universities Staff, in: Information Technology and Interactions Vol. 2833 (2020) 164–176.
[17] H. Hnatiienko, V. Snytyuk, O. Suprun, Application of Decision-Making Methods for Evaluation of Complex Information System Functioning Quality, in: Information Technologies and Security Vol. 2318 (2018) 56–65.
[18] H. Hnatiienko, V. Snytyuk, A Posteriori Determination of Expert Competence Under Uncertainty, in: Information Technologies and Security Vol. 2577 (2019) 82–99.
[19] A. Housen, F. Kuiken, I. Vedder, Dimensions of L2 Performance and Proficiency, Complexity, Accuracy, and Fluency in SLA (2012).
[20] P. Black, et al., Working Inside the Black Box: Assessment for Learning in the Classroom. Phi Delta Kappan 86(1) (2004) 9–21. doi: 10.1177/003172170408600105.
[21] D. Wiliam, More About Formative Assessment (2008). URL: www.kcl.ac.uk/ssp/education/research/iccamsfa.html
[22] N. Ziegler, Taking Technology to Task: Technology-Media (2016).
[23] M. García Mayo, Investigating Tasks in Formal Language Learning, Multilingual Matters (2007).
[24] R. Brooks, S. Tough, Assessment and Testing: Making Space for Teaching and Learning, Institute for Public Policy Research (2006).
[25] L. Bachman, Fundamental Considerations in Language Testing, Oxford University Press (1990).

[26] R. Batstone, Planning as discourse activity: a sociocognitive view, In Planning and Task Performance in a Second Language 10 (2005) 277–295.
[27] H. Hnatiienko, et al., Application of Expert Decision-Making Technologies for Fair Evaluation in Testing Problems, in: Information Technologies and Security Vol. 2859 (2021) 46–60.
[28] C. Boston, The Concept of Formative Assessment, Pract. Assess. Res. Eval. 8(9) (2002) 1–6. doi: 10.7275/kmcq-dj31.
[29] D. Duran, J. Builes, A. Gamboa, A Knowledge Management Model for Improving the Software Test Process, European Conference on Knowledge Management 18 (2017) 922–929.
[30] V. Reka, Educational Ontology and Knowledge Testing, Electron. J. Knowl. Manag. 5(1) (2007) 123–130.
[31] D. Thissen, R. Mislevy, Testing Algorithms, Computerised Adaptive Testing (1990) 103–135.
[32] F. Zaromb, H. Roediger, The Testing Effect in Free Recall is Associated with Enhanced Organization Processes, Mem. Cognit. 38 (2010) 995–1008. doi: 10.3758/MC.38.8.995.
[33] R. Schmidmaier, et al., Using Electronic Flashcards to Promote Learning in Medical Students: Retesting Versus Restudying, Med. Educ. 45 (2011) 1101–1110. doi: 10.1111/j.1365-2923.2011.04043.x.
[34] R. Baker, Educational Data Mining and Learning Analytics, The Cambridge Handbook of the Learning Sciences (2019).
[35] D. Nurakhmetov, Reinforcement Learning Applied to Adaptive Classification Testing, Theoretical and Practical Advances in Computer-based Educational Measurement, MEMA (2019) 325–336. doi: 10.1007/978-3-030-18480-3_17.
[36] L. Xue-Mei, et al., Research and Implementation of Knowledge Management Methods in Software Testing Process, WRI World Congress on Computer Science and Information Engineering 7 (2009) 739–743. doi: 10.1109/CSIE.2009.360.
[37] H. Roediger, A. Putnam, M. Smith, Ten Benefits of Testing and Their Applications to Educational Practice, Psychol. Learn. Motivation-Adv. Res. Theor. 55 (2011) 1–36. doi: 10.1016/B978-0-12-387691-1.00001-6.
[38] Z. Schrank, An Assessment of Student Perceptions and Responses to Frequent Low-Stakes Testing in Introductory Sociology Classes, Teach. Sociol. 44(2) (2016) 118–127. doi: 10.1177/0092055X1562474.
[39] R. Thomas, M. McDaniel, Testing and Feedback Effects on Front-End Control Over Later Retrieval, J. Exp. Psychol. Learn. Mem. Cognit. 39 (2013) 437–450. doi: 10.1037/a0028886.