UDC 007+001

P.P. TROKHIMCHUCK, O.M. VILIHURSKYI, O.M. ZAMURUJEVA
Lesya Ukrayinka Volyn' National University

SOME QUESTIONS OF SYNTHESIS IN CYBERNETICS AND COMPUTER SCIENCE

The problem of synthesis in computer sciences, including cybernetics, artificial intelligence and system analysis, is analyzed. Main methods of realization this problem are discussed. Ways of search universal method of creation universal synthetic science are represented. As example of such universal method polymetric analysis is given. A short classification method of synthesis is represented. Main methods of synthesis are next: deductive, duductive-inductive, inductive and pragmatic. Perspective of further development of this research, including application polymetric method for the resolution main problems of computer sciences, is analyzing too. Deductive methods are using for the creation generalizing theories or theories of everything. For creation these theories six criteria were formulating. Deductive-inductive method is Newtonian four rules of conclusion in physics. This method allows creating classical mechanics, B. Russel logical types, etc. Inductive methods use for the receiving inductive generalized laws as Shennon theorem. Pragmatic methods is using for the creation systems, which are necessary for the rersolution for solving particular problems, for example, creating some kind of unit for solving a specific practical problem. This method often is using in engineering or in an area of human activity where there are already many developments and they often need to be combined with developments from other related fields. In programming, an example of pragmatic synthesis is the Python programming language, which includes elements of earlier programming languages. The boundaries between these four types of synthesis are sometimes rather arbitrary. A modern example of deductive-inductive synthesis is the Vladislav Dorofeev concept of strong artificial intelligence. Cybernetics itself is also a synthesis of various sciences. However, its synthesis in the Georg sense is inductive, and in the sense of polymetric analysis, it is deductive.

Key words: synthesis, cybernetics, computer science, artificial intelligence, system analysis, polymetrical analysis, Moiseev principle, Python.

П.П. ТРОХИМЧУК, О.М. ВІЛІГУРСЬКИЙ, О.М. ЗАМУРУЄВА
Волинський національний університет імені Лесі Українки

ДЕЯКІ ПИТАННЯ СИНТЕЗУ В КІБЕРНЕТИЦІ ТА ІНФОРМАТИЦІ

Проаналізовано проблему синтезу в інформатиці, зокрема в кібернетиці, штучному інтелекті та системному аналізі. Обговорюються основні методи реалізації цієї проблеми. Представлено шляхи пошуку універсального методу створення універсальної синтетичної науки. Як приклад такого універсального методу наведено поліметричний аналіз. Представлено короткий класифікаційний метод синтезу. Основними методами синтезу є дедуктивний, дедуктивно-індуктивний, індуктивний і прагматичний. Аналізуються перспективи подальшого розвитку цього дослідження, в тому числі застосування поліметричного методу для вирішення основних проблем інформатики. Дедуктивні методи використовуються для створення узагальнюючих теорій або теорій всього. Для створення цих теорій було сформульовано шість критеріїв. Дедуктивно-індуктивний метод – чотири правила висновку Ньютона у фізиці. Цей метод дозволяє створювати класичну механіку, логічні типи Б. Рассела та ін. Індуктивні методи використовують для отримання індуктивних узагальнених законів як теорема Шеннона. Прагматичні методи використовують для створення систем, необхідних для перерозв'язання конкретних завдань, наприклад, створення якогось блоку для вирішення конкретної практичної задачі. Цей метод часто використовується в техніці або в сфері людської діяльності, де вже є багато розробок і їх часто потрібно поєднувати з розробками в інших суміжних галузях. У програмуванні прикладом прагматичного синтезу є мова програмування Python, яка включає елементи попередніх мов програмування. Межі між цими чотирма видами синтезу іноді досить умовні. Сучасним прикладом дедуктивно-індуктивного синтезу є концепція сильного штучного інтелекту Владислава Дорофєєва. Сама кібернетика також є синтезом різних наук. Але синтез у сенсі Джорджа індуктивний, а в сенсі поліметричного аналізу – дедуктивний.

Ключові слова: синтез, кібернетика, інформатика, штучний інтелект, системний аналіз, поліметричний аналіз, принцип Моісеєва, Пайтон.

Introduction

The problem of synthesis in modern computer sciences is connecting with the problem of creation the universal system of knowledge and has long history [1 – 16].

https://doi.org/10.32782/mathematical-modelling/2022-5-2-10

We use short classification method of synthesis. Main methods of synthesis are next: deductive, duductive-inductive, inductive and pragmatic. Perspective of further development of this research, including application polymetric method for the resolution main problems of computer sciences, is analysing too. Deductive methods are using for the creation generalizing theories or theories of everything. For creation these theories six criteria were formulating. Deductive-inductive method is Newtonian four rules of conclusion in physics. This method allows creating classical mechanics, B. Russel logical types [3], etc. Inductive methods use for the receiving inductive generalized laws as Shennon theorem. Pragmatic methods is using for the creation systems, which are necessary for the rersolution for solving particular problems, for example, creating some kind of unit for solving a specific practical problem. This method often is using in engineering or in an area of human activity where there are already many developments and they often need to be combined with developments from other related fields. In programming, an example of pragmatic synthesis is the Python programming language, which includes elements of earlier programming languages. The boundaries between these four types of synthesis are sometimes rather arbitrary. Therefore, the Newtonian four rules of conclusions in physics, in principle, represent a deductive system. However, the fourth rule, where induction is mentioned, allows us to present it as a deductive-inductive system, although most researchers consider him the founder of the inductive method. Since this is a theoretical method, it is natural that it includes elements of deduction. A modern example of deductive-inductive synthesis is the concept of strong artificial intelligence by Vladislav Dorofeev, which is basing on three principles: Moiseev, Legasov and Efremov [9, 10, 14]. Roughly speaking, this is the application of Newton's method to artificial intelligence problems. Cybernetics itself is also a synthesis of various sciences [4, 5]. However, synthesis in the sense of George is inductive, and in the sense of polymetric analysis, it is deductive.

For the tasks of artificial intelligence, this direction was developing by N. Nillson [6, 7, 13].

Cybernetics as a science appeared in connection with the development of computer technology and with the need to process and operate with large amounts of information. According to N. Wiener cybernetics is science about control and communication in the animal and the machine [3].

However, according to [3 – 5] cybernetics is synthesis of many sciences (mathematics, physics, biology, psychology and other).

Therefore the main problem of our research is ascertainment of question about possible application of PA for the resolution the problems of cybernetics, including general problems (S. Beer centurial problem, problem of complexity) and particular (matrix calculations, arrays sorting, pattern recognition).

Artificial intelligence (AI) is intelligence demonstrated by machines, as opposed to natural intelligence displayed by animals including humans. Leading AI textbooks define the field as the study of "intelligent agents": any system that perceives its environment and takes actions that maximize its chance of achieving its goals. Some popular accounts use the term "artificial intelligence" to describe machines that mimic "cognitive" functions that humans associate with the human mind, such as "learning" and "problem solving", however, this definition is rejected by major AI researchers. It may be represented as chapter of cybernetics, but F. George is selected it as independent science.

Main ways of synthesis in artificial intelligence (logic, engineering and Moiseev type) are analyzed too. First two represented by S. Russel and P. Norwig [15], N. Nillson [13] and N. Kasabov [16] concepts, and have more engineering nature. Vladislav Dorofeev concept of strong artificial intelligence has more deep anthropic nature [9, 10]. This concept is connected with influence human activity on environment. Therefore, in this concept we have three principles: two ecological (Legasov and Efremov) and one system cybernetic (Moiseev) [14]. This concept was used to the resolution system aspects of COVID-19 [9, 10, 14]. These methods have inductive nature.

However, cybernetics is synthetic science [4, 5]. Therefore, we must been create universal synthetic deductive theory. This theory is Polymetric Analysis.

https://doi.org/10.32782/mathematical-modelling/2022-5-2-10

More fully, realization of this idea is Polymetric Analysis (PA): theory of variable measure or theory of systems with variable hierarchy. We can say that this system was created for the formalization L. Hall phrase “All, which come from head, is intelligent” [1, 3].

PA includes the procedure of measurement in finish result of measurement [13, 14]. Basic and derivative measurements are connecting with quantitative and qualitative mathematical transformations. First is corresponded the procedure of measurement (arithmetic) the observed quantity, second – the analysis of dimensions (dimensional analysis).

Polymetric analysis is basing on the idea of triple minimum (particularly scientific, methodical and mathematical). Main principles of PA are criteria of reciprocity and simplicity. The first criterion is the principle of assembling the elements of the corresponding construct into a single system. Second criterion is principle optimality (simplicity-complexity) of this assembling.

One of main component of this method, hybrid theory of systems (theory systems with variable hierarchy) show that only ten minimal types system of formalization the knowledge are existed [3, 14].

Therefore, methods of PA as universal theory of optimal formalized synthesis may be using for the resolutions the main cybernetical problems. Structure of PA may be representing as more deep formalization the neuronets [1, 3].

Since, PA as universal system formalization of knowledge may be used for the resolution the basic problems of natural and artificial intelligence too [3, 10, 14].

The bonds of Polymetric Analysis and computer sciences are shown. The using of polymetric method for the resolution the problems of cybernetics and artificial intelligence is discussed. Perspective of using synthetic methods for the development of computer sciences is analyzed too.

II.Cybernetics as synthetic science

Cybernetics (from the Greek κυβερνητική “governance,” κυβερνώ “to steer, navigate or govern,” κυβερνη “an administrative unit; an object of governance containing people”) is the science of general regularities of control and information transmission processes in different systems, whether machines, animals or society [1 – 5].

Cybernetics studies the concepts of control and communication in living organisms, machines and organizations including self-organization. It focuses on how a (digital, mechanical or biological) system processes information, responds to it and changes or being changed for better functioning (including control and communication).

Cybernetics is an interdisciplinary science [1 – 5, 8]. It originated “at the junction” of mathematics, logic, semiotics, physiology, biology and sociology. Among its inherent features, we mention analysis and revelation of general principles and approaches in scientific cognition. Control theory, communication theory, operations research and others represent most weighty theories within cybernetics [8].

Short history of cybernetics is represented in [1 – 5, 8].

The latter case covers partial “intersection” of these results (see Fig. 1 – figuratively speaking, the central rode of the “umbrella”), i.e., usage of common results for all component sciences. Furthermore, we will adhere to this approach over and over again for discrimination between the corresponding umbrella brand and the common results of all component sciences in the context of different categories such as interdisciplinarity, systems analysis, organization theory, etc.

Cybernetics today (disciplines included in cybernetics in the descending order of their “grades” of membership, see Fig. 1, with year of birth if available) [8]:

– control theory (1868–the papers published by J. Maxwell and I. Vyshnegradsky);
– mathematical theory of communication and information (1948 – C. Shannon’s works);
– general systems theory, systems engineering and systems analysis;
– optimization (including linear and nonlinear programming; dynamic programming; optimal control; fuzzy optimization; discrete optimization, genetic algorithms, and so on);

https://doi.org/10.32782/mathematical-modelling/2022-5-2-10

– operations research (graph theory, game theory and statistical decisions, etc.);

– artificial intelligence (1956–The Dartmouth Summer Research Project on Artificial Intelligence);

– data analysis and decision-making;

– robotics

and others (purely mathematical and applied sciences and scientific directions, in an arbitrary order) including systems engineering, recognition, artificial neural networks and neural computers, ergatic systems, fuzzy systems (rough sets, grey systems, etc), mathematical logic, identification theory, algorithm theory, scheduling theory and queuing theory, mathematical linguistics, programming theory, synergetics and all similar sciences [8].

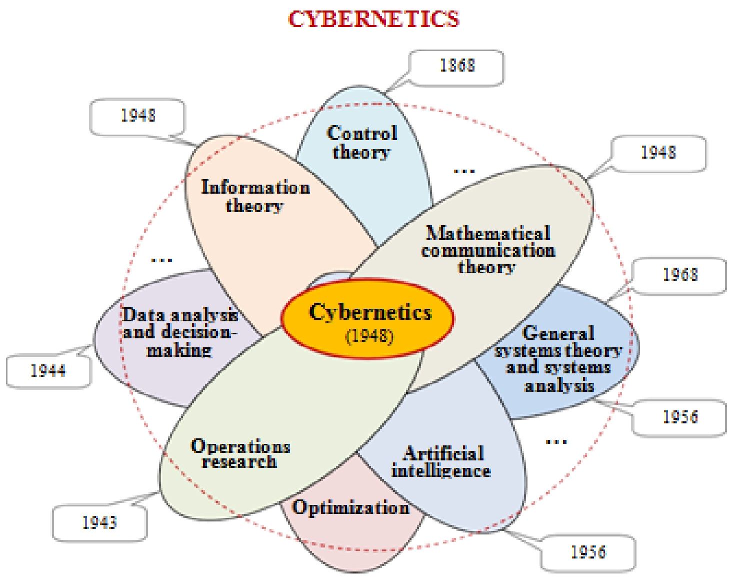

Fig. 1. The composition and structure of cybernetics [8].

According to [4, 5] cybernetics is synthesis of many sciences (mathematics, physics, biology, psychology and other Fig. 2.

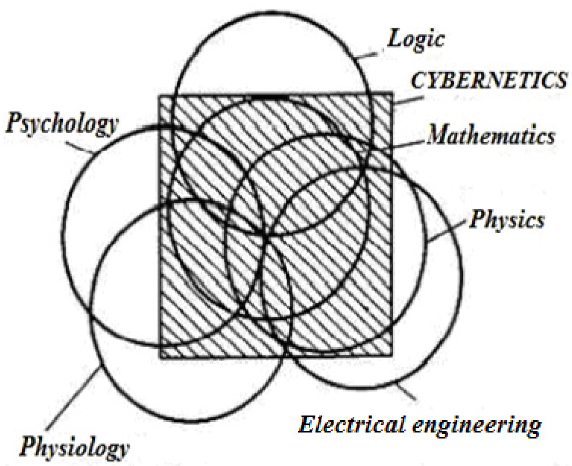

Fig. 2. A diagram that roughly illustrates the areas of intersection of the main disciplines that feed cybernetics [4, 5]

Really, this synthesis is more widely. For specific systems, this synthesis is quite general and therefore, as a rule, it is detailed. Therefore, in our times the new particular synthetic science,

https://doi.org/10.32782/mathematical-modelling/2022-5-2-10

which are basing on cybernetics are created. These particular synthetic sciences were called as biological cybernetics, economical cybernetics, physical cybernetics etc. [3, 4, 8].

There is one further argument which we will consider and that is that a computer, or any other artificially constructed system, only does what it is made to do by its programmer. This is a view that was held by Lady Lovelace [4]. It is a popular fallacy that computers can only do what the programmers make the computers do. The fallacy arises from various considerations. One is the failure to remember that human beings only do what they are programmed to do, although they are programmed by various different features of the environment, including parents, teachers, etc. and are adaptable and change according to changing circumstances. Now in this sense it is perfectly true to say that computers can only do what they are programmed to do, but they can certainly be given exactly the same flexibility as humans. In other words, various people can program them and they can be made adaptive so that they change and function in changing circumstances [4, 5].

The problem of not being able to do anything really new also relates in some measure to Lady Lovelace's objection which was really dependent upon the idea that the computer, or any other "machine" which was manufactured by human beings, could do no more than the programmer programmed it to do [4].

Schema of Fig. 1 shows the composition and structure cybernetics in historical way of its development. We see that artificial intelligence is the son and daughter of cybernetics, but it development in last years allow to select and represent the synthesis in this engineering science as separate paragraph.

Artificial intelligence as synthetic science

Less than a decade after breaking the Nazi encryption machine Enigma and helping the Allied Forces win World War II, mathematician Alan Turing changed history a second time with a simple question: "Can machines think?"[4].

Turing's paper "Computing Machinery and Intelligence" (1950), and its subsequent Turing Test, established the fundamental goal and vision of artificial intelligence [4, 7].

At its core, artificial intelligence (AI) is the branch of computer science that aims to answer Turing's question in the affirmative. It is the endeavor to replicate or simulate human intelligence in machines.

The expansive goal of artificial intelligence has given rise to many questions and debates. So much so, that no singular definition of the field is universally accepted.

The major limitation in defining AI as simply "building machines that are intelligent" is that it doesn't actually explain what artificial intelligence is? What makes a machine intelligent? AI is an interdisciplinary science with multiple approaches, but advancements in machine learning and deep learning are creating a paradigm shift in virtually every sector of the tech industry [4, 7].

According to N. Moiseev "Anyway, the term "artificial intelligence" established in the scientific literature, and with this it follows to be considered. However, it is important to clearly stipulate pragmatic, applied meaning of this term. So we agree to associate its use only with modern processing technology and use information" [3, 10].

In their groundbreaking textbook Artificial Intelligence: A Modern Approach, authors Stuart Russell and Peter Norvig approach the question by unifying their work around the theme of intelligent agents in machines. With this in mind, AI is "the study of agents that receive percepts from the environment and perform actions" [15]

Norvig and Russell go on to explore four different approaches that have historically defined the field of AI [15]:

1. Thinking humanly
2. Thinking rationally
3. Acting humanly
4. Acting rationally

https://doi.org/10.32782/mathematical-modelling/2022-5-2-10

The first two ideas concern thought processes and reasoning, while the others deal with behavior. Norvig and Russell focus particularly on rational agents that act to achieve the best outcome, noting "all the skills needed for the Turing Test also allow an agent to act rationally" [15].

Winston, the Ford professor of artificial intelligence and computer science at MIT, defines AI as "algorithms enabled by constraints, exposed by representations that support models targeted at loops that tie thinking, perception and action together" [15].

While these definitions may seem abstract to the average person, they help focus the field as an area of computer science and provide a blueprint for infusing machines and programs with machine learning and other subsets of artificial intelligence.

The Four Types of Artificial Intelligence are existed [15]:

1. *Reactive Machines.*

A reactive machine follows the most basic of AI principles and, as its name implies, is capable of only using its intelligence to perceive and react to the world in front of it. A reactive machine cannot store a memory and as a result cannot rely on experiences to inform decision making in real-time.

Perceiving the world directly means that reactive machines are designed to complete only a limited number of specialized duties. Intentionally narrowing a reactive machine's worldview is not any sort of cost-cutting measure, however, and instead means that this type of AI will be more trustworthy and reliable – it will react the same way to the same stimuli every time.

A famous example of a reactive machine is Deep Blue, which was designed by IBM in the 1990's as a chess-playing supercomputer and defeated international grandmaster Gary Kasparov in a game. Deep Blue was only capable of identifying the pieces on a chessboard and knowing how each moves based on the rules of chess, acknowledging each piece's present position, and determining what the most logical move would be at that moment. The computer was not pursuing future potential moves by its opponent or trying to put its own pieces in better position. Every turn was viewed as its own reality, separate from any other movement that was made beforehand.

Another example of a game-playing reactive machine is Google's AlphaGo. AlphaGo is also incapable of evaluating future moves but relies on its own neural network to evaluate developments of the present game, giving it an edge over Deep Blue in a more complex game. AlphaGo also bested excellent competitors of the game, defeating champion Go player Lee Sedol in 2016.

Though limited in scope and not easily altered, reactive machine artificial intelligence can attain a level of complexity, and offers reliability when created to fulfill repeatable tasks.

2. *Limited Memory.*

Limited memory artificial intelligence has the ability to store previous data and predictions when gathering information and weighing potential decisions — essentially looking into the past for clues on what may come next. Limited memory artificial intelligence is more complex and presents greater possibilities than reactive machines.

Limited memory AI is created when a team continuously trains a model in how to analyze and utilize new data or an AI environment is built so models can be automatically trained and renewed. When utilizing limited memory AI in machine learning, six steps must be followed: Training data must be created, the machine-learning model must be created, the model must be able to make predictions, the model must be able to receive human or environmental feedback, which feedback must be stored as data, and these steps must be reiterated as a cycle.

Three major machine-learning models utilize limited memory artificial intelligence:

- Reinforcement learning, which learns to make better predictions through repeated trial-and-error.
- Long Short Term Memory (LSTM), which utilizes past data to help predict the next item in a sequence. LTSMs view more recent information as most important when making predictions and discounts data from further in the past, though still utilizing it to form conclusions
- Evolutionary Generative Adversarial Networks (E-GAN), which evolves over time, growing to explore slightly modified paths based off previous experiences with every new decision. This

https://doi.org/10.32782/mathematical-modelling/2022-5-2-10

model is constantly in pursuit of a better path and utilizes simulations and statistics, or chance, to predict outcomes throughout its evolutionary mutation cycle.

3. *Theory of Mind.*

Theory of Mind is just that – theoretical. We have not yet achieved the technological and scientific capabilities necessary to reach this next level of artificial intelligence.

The concept is based on the psychological premise of understanding that other living things have thoughts and emotions that affect the behavior of one's self. In terms of AI machines, this would mean that AI could comprehend how humans, animals and other machines feel and make decisions through self-reflection and determination, and then will utilize that information to make decisions of their own. Essentially, machines would have to be able to grasp and process the concept of "mind," the fluctuations of emotions in decision-making and a litany of other psychological concepts in real time, creating a two-way relationship between people and artificial intelligence.

4. *Self-awareness.*

Once Theory of Mind can be established in artificial intelligence, sometime well into the future, the final step will be for AI to become self-aware. This kind of artificial intelligence possesses human-level consciousness and understands its own existence in the world, as well as the presence and emotional state of others. It would be able to understand what others may need based on not just what they communicate to them but how they communicate it.

Self-awareness in artificial intelligence relies both on human researchers understanding the premise of consciousness and then learning how to replicate that so it can be built into machines.

According N. Nillson [6, 7, 13] artificial intelligence, broadly (and somewhat circularly) defined, is concerned with intelligent behavior in artifacts. Intelligent behavior, in turn, involves perception, reasoning, learning, communicating, and acting in complex environments. Al has as one of its long-term goals the development of machines that can do these things as well as humans can, or possibly even better. Another goal of artificial intelligence is to understand whether it occurs in machines or in humans or other animals. Thus, artificial intelligence has both engineering and scientific goals. N. Nillson is focused main attention on the important concepts and ideas underlying the design of intelligent machines.

Main elements of N. Nillson synthesis are [6, 7, 13]:

1. Reactive machines, which are included: stimulus-response agents (perception and action, representing and implementing action functions); neural networks, machine evolution (evolutionary computation, genetic programming); state machines (representing the environment by feature vectors, Elman networks, iconic representations, blackboard systems); robot vision.

2. Search in state spaces: agents that plan (memory versus computation, state-space graphs, searching explicit state spaces, feature-based state spaces, graph notation); uniformed search; heuristic search; planning, acting and learning; alternative search formulations and applications; adversarial search.

3. Knowledge representation and reasoning: the propositional calculus; resolution in the propositional calculus; the predicate calculus; resolution in the predicate calculus; knowledge-based systems; representing commonsense knowledge; reasoning with uncertain information; learning and acting with Bayes nets.

4. Planning methods based on Logic: the situation calculus; planning.

5. Communication and integration; multiple agents; communications among agents; agent architectures.

N. Kasabov engineering synthesis of artificial intelligence including four areas [16]:

1. Foundations: evolving processes and their representation as data, information and knowledge; brain information processing, evolutionary computation; quantum-inspired computation; molecular information processing; information theory; computational architecture.

2. ECOS and SNN methods: artificial neural networks (ANN) and evolving connectionist system (ECOS); spiking neural networks (SNN) methods; ANN and ECOS computational methods; SNN

https://doi.org/10.32782/mathematical-modelling/2022-5-2-10

methods; evolving SNN (eSNN); brain inspired SNN (BI-SNN) and the design brain inspired – artificial intelligence; SNN, eSNN, BI-SNN parameter optimization with evolutionary computation (EC).

3. Applications: deep learning and deep knowledge from brain data; audio- and visual information processing; bioinformatics data modeling; SNN for neuroinformatics and personalized modeling; predictive modeling in ecology; predictive modeling in transport; predictive in environment.

4. Future directions: brain-computer interfaces with BI-SNN; affective computation; neuromorphic systems; new spike-time information theory for data compression; integrated quantum-neurogenetic-brain-inspired models; towards integrated human intelligence and artificial intelligence.

Now we represent the model of strong hybrid intelligence proposed in [9, 10, 14], which is based on N. Moiseev's idea of complex modeling of the noosphere [10] in order to predict the consequences of any external influences on it, including anthropogenic ones [10].

The proposed strong hybrid intelligence architecture is shown in Fig.3 [14]. The explanation of schema of Fig. 3 is next [14]:

1. The real world is information about the problem area, collected using the sensors available to the system. The real world includes both real world objects and automated transactional information processing systems. For example, in the case of a pandemic, contact tracing systems, medical information systems with patient data, etc.

2. People – a team of specialists involved in solving a problem. The team may include subject matter experts, developers, information system operators, etc.

3. Artificial intelligence is an adaptable and developed system for the automated collection and processing of real-world information with an interface for communication with a group of experts, including in natural language.

4. Modeling system – a set of systems for modeling and forecasting the real world with the capabilities of scenario analysis of the consequences of impact on the real world.

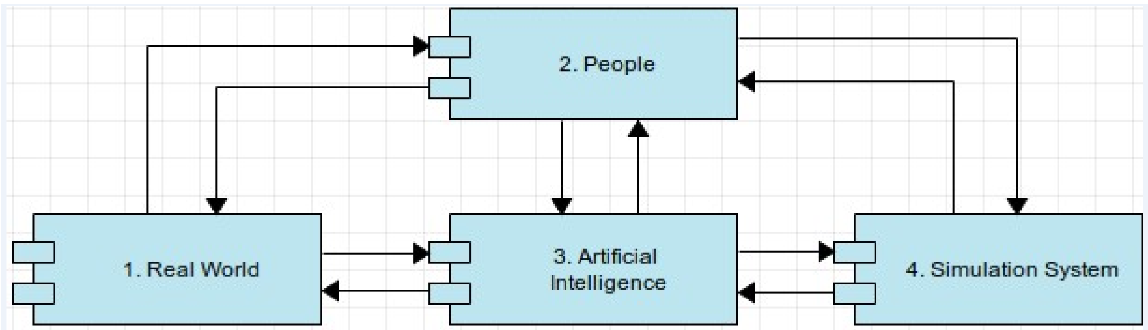

Fig. 3. Architecture the strong hybrid intelligence of N. Moiseev type [14]

The goal of the system of strong hybrid intelligence is the most accurate forecasting of the development of the real world with the possibility of scenario analysis of the consequences of external influences on it.

In a sense, the proposed architecture can be considered an extension of the concept of "digital twins", developed in the world since 2002, to include the human factor. In addition, at present, the main successes in the field of solving complex problems are associated with precisely such systems [9, 10, 14].

The architecture of the proposed system itself assumes its transparency and controllability, since the consequences of the supposed impacts on the real world are checked on the modeling system. However, taking into account the complexity of the real world and the limited possibilities of methods for its modeling, there are no complete guarantees of the safety of such a system. The following principles can be used to improve security.

1. Legasov's principle: a technostructure uncontrolled by society threatens the global security of humankind.

https://doi.org/10.32782/mathematical-modelling/2022-5-2-10

2. Efremov's principle [10]: anthropogenic changes in the environment, the rate of which exceeds the physical, biological and social mechanisms of adaptation to them, carry the risks of destroying life.

3. Moiseev's principle [10]: the complexity of the models of the world should be comparable to the complexity of the problems they are designed to solve.

As we see, a tendency of differentiation is characterized AI too. Represented concepts are show this picture.

As we see, main synthetic concepts of artificial intelligence (Nillson, Russel and Norwig, Kasabov and Moiseev) have more inductive and inductive with elements deduction nature and haven't general value for all computer sciences. It may be used for the concrete problems ov computer sciences and depending from level of development of modern electronics and information technologies. Therefore, we must search method, which may be represented as universal system formalization of knowledge, including computer sciences [1, 3, 10]. This method should be deductive in nature and include not only the rules of logical formalization, like the Leubniz-Russell-Klini-Nillson approach [3, 10], but also based on the nature of mathematics: analysis, synthesis and formalization of any field of knowledge.

As example of pragmatic synthesis may be programming language Python [17, 18].

Python is a multi-paradigm programming language. Object-oriented programming and structured programming are fully supported, and many of their features support functional programming and aspect-oriented programming (including metaprogramming and metaobjects). Many other paradigms are supported via extensions, including design by contract and logic programming.

Python uses dynamic typing and a combination of reference counting and a cycle-detecting garbage collector for memory management. It uses dynamic name resolution (late binding), which binds method and variable names during program execution.

Its design offers some support for functional programming in the Lisp tradition. It has filter, mapandreduce functions; list comprehensions, dictionaries, sets, and generator expressions. The standard library has two modules (itertools and functools) that implement functional tools borrowed from Haskell and Standard ML [17, 18].

Its core philosophy is summarized in the document The Zen of Python (PEP 20), which includes aphorisms such as: Beautiful is better than ugly; Explicit is better than implicit; Simple is better than complex; Complex is better than complicated; Readability counts.

Rather than building all of its functionality into its core, Python was designed to be highly extensible via modules. This compact modularity has made it particularly popular as a means of adding programmable interfaces to existing applications. Van Rossum's vision of a small core language with a large standard library and easily extensible interpreter stemmed from his frustrations with ABC, which espoused the opposite approach [17, 18].

Python strives for a simpler, less-cluttered syntax and grammar while giving developers a choice in their coding methodology. In contrast to Perl's "there is more than one way to do it" motto, Python embraces a "there should be one – and preferably only one—obvious way to do it" philosophy.

Alex Martelli, a Fellow at the Python Software Foundation and Python book author, wrote: "To describe something as 'clever' is not considered a compliment in the Python culture."

Python's developers strive to avoid premature optimization and reject patches to non-critical parts of the CPython reference implementation that would offer marginal increases in speed at the cost of clarity. When speed is important, a Python programmer can move time-critical functions to extension modules written in languages such as C; or use PyPy, a just-in-time compiler. CPython is also available, which translates a Python script into C and makes direct C-level API calls into the Python interpreter [17, 18].

Python's developers aim for it to be fun to use. This is reflected in its name – attribute to the British comedy group Monty Python – and in occasionally playful approaches to tutorials and reference materials, such as examples that refer to spam and eggs (a reference to a Monty Python sketch) instead of the standard foo, and bar.

https://doi.org/10.32782/mathematical-modelling/2022-5-2-10

A common neologismm in the Python community is pythonic, which has a wide range of meanings related to program style. "Pythonic" code may use Python idioms well, be natural or show fluency in the language, or conform to Python's minimalist philosophy and emphasis on readability. Code that is difficult to understand or reads like a rough transcription from another programming language is called unpythonic. Python users and admirers, especially those considered knowledgeable or experienced, are often referred to as Pythonistas. Roughly speaking, this method was developed in more general sense in polymetric analysis.

Polymetric analysis as operational concept of computing science

Polymetric analysis (PA) was created as alternative optimal concept to logical, formal and constructive conceptions of modern mathematics and theory of information [13, 14]. This concept is based on the idea of triple minimum: mathematical, methodological and concrete scientific.

However, one of the main tasks of polymetric analysis is the problem of simplicity-complexity that arises when creating or solving a particular problem or science. It must be open system [1, 3].

In methodological sense, PA is the synthesis of Archimedes thesis: "Give me a fulcrum and I will move the world", and S. Beer idea about what complexity is a problem in cybernetics century, in one system. In addition, as cybernetics is a synthetic science, the problem should be transferred and for all of modern science. Basic elements of this theory and their bonds with other science are represented in Fig. 4 [3].

The polymetric analysis may be represented as universal theory of synthesis in Descartian sense. For resolution of this problem, we must select basic notions and concepts, which are corresponded to optimal basic three directions of Fig. 4. The universal simple value is unit symbol, but this symbol must be connected with calculation. Therefore, it must be number. For the compositions of these symbols (numbers) in one system, we must use system control and operations (mathematical operations or transformations). After this procedure, we received the proper measure, which is corresponding system of knowledge and science.

Main elements of PA are functional numbers (generalizing functional quadratic forms); generalizing mathematical transformations (quantitative and qualitative), which are acted on functional numbers. Only 15 minimal types of generalizing mathematical transformations are existed [3]. Qualitative transformations are corresponded to basic (first-order) measurements, quantitative – to derivative (second-order) measurements [3]. Element of functional numbers with acting mathematical transformations was called generalizing mathematical element. Set of generalizing mathematical elements is created informative lattice. Theory of informative calculations was created for this lattice analogously to analytic mechanics [3]. Basic principle of this theory is principle of optimal informative calculations (analogous to action principle in mechanics) [3]. For classification main possible systems of formalization for informative lattice hybrid theory of systems was created. The main principles of this theory are: the principle of reciprocity (the principle of arranging elements into a system), which is based on the idea of completeness; and the principle of simplicity (the principle of optimality or pragmatism), one of the elements of which is the principle of optimal information calcuulations. Only 10 minimal types of formalization systems may be existed, taking into account the number of mathematical transformations – 150 types [3].

Only first six types of hybrid systems may be considered as mathematical, last four types are not mathematically. Therefore, HTS may be describing all possible system of knowledge. Problem of verbal and nonverbal systems of knowledge is controlled with help of types the mathematical transformations and parameter connectedness [3].

This theory has finite number of types the knowledge formalization systems. In general, this theory is the theory of open systems with a changeable hierarchy.

Therefore, HTS with its operational nature may be used for all knowledge and culture, including cybernetics and artificial intelligence.

We can analyze PA and computer sciences with point of conditions, which are formulated for the general theories (theories of everything) [1, 3]:

https://doi.org/10.32782/mathematical-modelling/2022-5-2-10

1. It must be open theory or theory with variable hierarchy.
2. This theory must be having minimal number of principles.
3. It must based on nature of mathematics (analysis, synthesis and formalization all possible knowledge).
4. We must create sign structure, which unite verbal and nonverbal knowledge (mathematical and other) in one system.
5. We must have system, which is expert system of existing system of knowledge and may be use for the creation new systems of knowledge.
6. Principle of continuity must be true for all science.

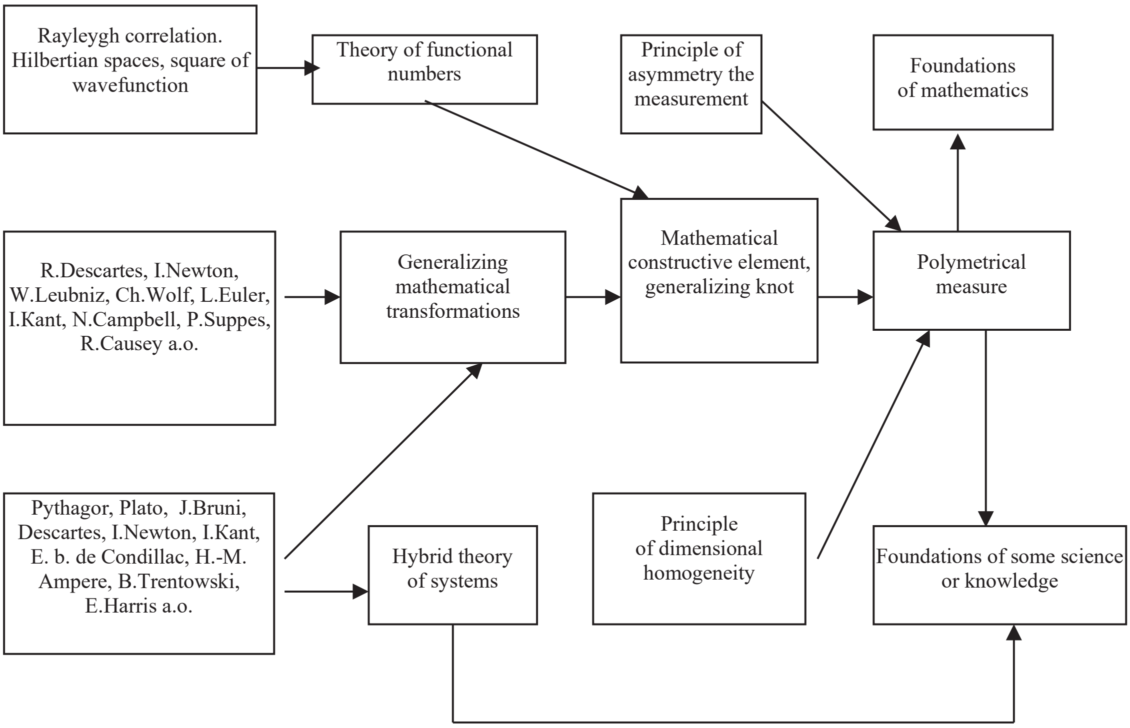

Fig. 4. Schema of polymetric method and its place in modern science [13, 14]

These conditions must be used for the creation any dynamic science, which can be presented as open system.

These conditions were formulated on the basis of polymetric analysis. But other theories of everything may be creating according to these six conditions.

But main conditions for the computer systems must be: completeness, unambiguity, simplicity and possibilities to create corresponding system and measure and estimate proper set of information in this system [1, 3, 10]. But in real computer system we must include corresponding technologies, which which impose limitations on computing capabilities, especially performance. Further, we must transform all possible information in the form convenient for its processing by a computer processor, and then its adequate presentation for the user. But modern processors worked with various matrixes, therefore informative lattice of generalized constructive elements may be represented as mathematical generalization of computer processor.

The one of central problem of modern computing sciences is problem of information complexity [1, 2]. This problem was formulated in cybernetics by S. Beer (S. Beer centurial problem in cybernetics). This formulation is next [2]: “Apparently, the complexity becomes the problem of the century, just as the ability to process natural materials has been a problem of life and death for our forefathers. Our tool must be computers, and their efficiency should be provided by science,

https://doi.org/10.32782/mathematical-modelling/2022-5-2-10

able to handle large and complex systems of probabilistic nature. This science may be cybernetics – the science of management processes and communication. The basic thesis of cybernetics can be set forth as follows: there are natural laws behavior of the large multibonds systems of any character submits that – biological, technical, special and economic."

In whole problem of complexity, have two sides. First is pure computational. This problem is represented by two Smale's problems [3], which are not only problems of modern computing science but it are problems of modern mathematics. The complexity of networks is represented as problem of complexity in modern physics [1]. However, neuronets were introduced in cybernetics: M. Minsky as perceptrons [1] and A. Ivakhnenko [1]. Therefore, this problem is cybernetic too. In this case, we have third Kolmogorov algorithmic concept [1] in theory of information. However, according F. H. George [5] cybernetics is the synthesis of many sciences: physics, mathematics, biology, psychology, linguistics and other. Therefore, we must add three Kolmogorov concepts in information theory by fourth system concept. This concept is second side of problem complexity in modern science. It has more cybernetic and computing science nature as physical [1]. Problem of complexity is the basic of other computing sciences, including artificial intelligence, and as "sons" and "daughters" of cybernetics too [1]. Therefore, system concept of complexity is more necessary for cybernetics and computing science as for physics because its sciences have more synthetic nature as physics [1, 10].

Therefore, methods of PA as universal theory of optimal formalized synthesis may be used for the resolutions the main cybernetic problems. Therefore the main problem of our paper is ascertainment of question about possible application of PA for the resolution the problems of cybernetics, including general problems (S. Beer centurial problem, problem of complexity) and particular (matrix calculations, arrays sorting, pattern recognition).

Structure of PA may be represented as more deep formalization the neuronets too [1, 3].

According to F. George, "The brain is universal computer" [4, 5]. Therefore PA as universal system formalization of knowledge may be used for the resolution the basic problems of natural and artificial intelligence too [1, 3].

Polymetric analysis fully satisfies these conditions, the represented cybernetics and artificial intelligence concepts and systems – partially.

Polymetrical Analysis is more general system as cybernetics, including artificial intelligence. It is operational system, which is included the procedure of measurement with help generalizing mathematical transformations. Generalized constructive element (8) is term of polyfunctional matrix. However, computer processors are using matrix calculation [1]. Therefore PA may be represented as functional expansion of computer processor, which are include the procedures of collection and processing of information using generalized mathematical transformations and criteria of reciprocity and simplicity.

Therefore Legasov and Efremov principles have ecological nature. Legasov principle is characterized the irreversible change in nature, Efremov principle is corresponded to the establishing the boundaries of this irreversibility.

From mathematical point of view, the Legasov principle may be represented as boundary conditions on corresponding qualitative transformations, Efremov principle imposes an additional cyclic condition, which must be imposed on the corresponding mathematical construct. For the Efremov principle, a reversible reproducible feedback is important, which can be set both through inverse mathematical transformations and through their combinations [10, 14].

Other chapters of computer sciences, including cybernetics, artificial intelligence, computer arithmetic may be expand, represent and explain with help Polymetric Analysis.

Therefore, theory of informative calculations and principle of optimal informative calculations allow resolving many computer problems of modern cybernetics in area of the obtained algorithms, matrix algebra and the problem of forming arrays. From a fundamental point of view, the principle

https://doi.org/10.32782/mathematical-modelling/2022-5-2-10

of optimal informational calculations makes it possible to bring physical processes and information theory closer together. This is shown in the theory of information-physical structures [3].

From a systemic point of view, polymetric analysis is a synthetic optimal extension of those concepts and methods that played a decisive role in the formation and development of both modern science and other areas of knowledge and culture. It can be used both to determine the complexity of computations (theory of information calculations) and to determine the complexity of systems and in the choice of both an expert system and a new promising system for the corresponding synthesis (theory of hybrid systems) [3, 10, 14].

The way of the resolution the problem of complexity in computer sciences must be connected with problem of calculations [3, 10, 14].

In whole, the creation of effective computer science must be include general system principles, which are corresponded its universality and particular principles, models and theories, which are corresponded to modern level of information and optoelectronics and may be in nearest future biological technologies. In last case the idea of rapprochement of the living and inanimate worlds, including intelligence, can be more fully realized than at the same stage in the development of science and technology. To solve this problem, we must look for both new ways of both formalizing knowledge and their hardware representation and processing.

Thus in this work we represented the main peculiarities of modern state computer sciences on the examples of cybernetics, artificial intelligence, programming language Python and shown the perspectives of creation universal theory of synthesis, which are based on modern computer sciences.

Conclusions

1. The problems of synthesis in computer sciences are analyzed.
2. A classification of synthesis is included for types.
3. Short analysis cybernetics as synthetic science is represented.
4. Main types of artificial intelligence and synthetic aspects of its development are observed.
5. Questions of using Polymetric Analysis methods for the resolution some problems of synthesis in computer sciences are discussed.
6. The six rules of creation universal theories, which are basing on polymetric analysis, are represented.
7. Perspective of development the synthetic system methods in computer sciences is analyzed too.
8. The expediency of using the pragmatic concept of synthesis in computer science is analyzed on the example of the Python programming language.

List of used literature

1. Trokhimchuck P. P. S. Beer centurial problem in cybernetics and methods of its resolution. In: *Advanced in computer science*, vol. 7, ch. 5. Ed. Mukesh Singla. New Delhi: AkiNik Publications, 2020. P. 87-118.
2. Бир С. Мы и сложность современного мира. В: Кибернетика сегодня: проблемы и предложения. М.: Знание, 1976. С. 7 – 32.
3. Trokhimchuck P. P. Theories of Everythings: Past, Present, Future. Saarbrukken: Lambert Academic Publishing, 2021. 260 p.
4. George F. H. Philosophical Foundations of Cybernetics. Abacus Press, London, 1976, 157.
5. George F. H. Foundations of cybernetics. Gordon and Breach Science Publishing, London, Paris, New York, 1977, 260
6. Genesereth M. R., Nillson N. I. Logical foundations of artificial intelligence. Palo Alto: Morgan Kauffman Publishers, Inc., 1988. 406 p.
7. Nillson N. I. The Quest for Artificial Intelligence: A History of Ideas and Achievements. Cambridge University Press, New York, 2010, 562.

https://doi.org/10.32782/mathematical-modelling/2022-5-2-10

8. Novikov D.A. Cybernetics 2.0. *Advances in Systems Science and Application*. Vol. 16(1), 2016. P. 1 – 18.
9. Dorofeev V., Trokhimchuck P. Hybrid Super Intelligence and Polymetrical Analysis. *AIP Conference Proceedings*, 2022, vol. 2656 (1), 020024, 9 p,.
10. Dorofeev V. P., Trokhimchuck P. P. Computer Sciences and Synthesis: Retrospective and Perspective. In: *Advanced in computer science*, vol. 13. Ed. Mukesh Singla. New Delhi, AkiNik Publications, 2022. P. 1-32.
11. Computer science/ Wilkipedia – the free encyclopedia. // http:/en.wikipedia.org/wiki/ Computer_ science
12. Computing/ Wilkipedia – the free encyclopedia. // http:/en.wikipedia. org / wiki/ Computing
13. Nillson N. I. Artificial Intelligence. A new synthesis. San Francisco: Morgan Kauffman Publishers, Inc., 1998. 514 p.
14. Дорофеев В.П. Система сильного гибридного искусственного интеллекта и принципы Моисеева, Ефремова и Легасова. В кн.: *Актуальные проблемы фундаментальной науки-2021*, Материалы IV международной конференции, под ред. П.П. Трохимчука и др. Луцк: Вежа-Принт, 2021. С. 47 – 50.
15. Russel S. J., Norwig P. Artificial Intelligence. A modern Approach. Harlow: Pearson Education Limited, 2021. 1166 p.
16. Kasabov N. K. Time-Space, Spiking Neural Networks and Brain-Inspired Artificial Intelligence. Berlin: Springer-Verlag GmbH, 2019. 738 p.
17. Замуруєва О. В., Кримусь А. С., Ольхова Н. В. Об’єктно-орієнтоване програмування в Python. Курс лекцій. Частина 1. Луцьк: Вежа-Друк, 2018. 64 с.
18. Замуруєва О. В., Вілігурський О. М. Об’єктно-орієнтоване програмування в Python. Курс лекцій. Частина 2. Луцьк: Вежа-Друк, 2020. 72 с.

References

1. Trokhimchuck, P. P. S. (2020). Beer centurial problem in cybernetics and methods of its resolution. In: *Advanced in computer science*, 7, ch. 5. Ed. Mukesh Singla. New Delhi: AkiNik Publications, 87-118.
2. Beer, S. (1976). We and complexity of modern world. In: Cybernetics today: problems and propositions. M.: Znaniye, 7 – 32. (In Russian)
3. Trokhimchuck, P. P. (2021). Theories of Everythings: Past, Present, Future. Saarbrukken: Lambert Academic Publishing.
4. George, F. H. (1976). Philosophical Foundations of Cybernetics. Abacus Press, London.
5. George, F. H. (1977). Foundations of cybernetics. Gordon and Breach Science Publishing, London, Paris, New York.
6. Genesereth, M. R., & Nillson, N. I. (1988). Logical foundations of artificial intelligence. Palo Alto: Morgan Kauffman Publishers, Inc..
7. Nillson, N. I. (2010). The Quest for Artificial Intelligence: A History of Ideas and Achievements. Cambridge University Press, New York.
8. Novikov, D.A. (2016). Cybernetics 2.0. *Advances in Systems Science and Application*. **16**(1), 1 – 18.
9. Dorofeev, V. P. (2021). System of Strong Hybrid Artificial Intelligence and Moiseev, Efremov and Legasov Principles. In: *Actual Problems of Fundamental science-2021,* Conference Proceedings IV, edited by P. P. Trokhimchuck et al., Vezha-Print, Lutsk, 47 – 50 (In Russian).
10. Dorofeev, V., & Trokhimchuck, P. (2022). Hybrid Super Intelligence and Polymetrical Analysis. *AIP Conference Proceedings*. **2656** (1), 020024, 9 p.
11. Computer science/ Wilkipedia – the free encyclopedia. // http:/en.wikipedia.org/wiki/ Computer_ science

https://doi.org/10.32782/mathematical-modelling/2022-5-2-10

12. Computing/ Wilkipedia – the free encyclopedia. // http:/en.wikipedia. org / wiki/ Computing
13. Nillson, N. I. (1998). Artificial Intelligence. A new synthesis. San Francisco: Morgan Kauffman Publishers, Inc.
14. Dorofeev, V. P., & Trokhimchuck, P. P. (2022). Computer Sciences and Synthesis: Retrospective and Perspective. In: *Advanced in computer science*, **13**. Ed. Mukesh Singla. New Delhi, AkiNik Publications, 1-32.
15. Russel, S. J., & Norwig, P. (2021). Artificial Intelligence. A modern Approach. Harlow: Pearson Education Limited.
16. Kasabov, N. K. (2019). Time-Space, Spiking Neural Networks and Brain-Inspired Artificial Intelligence. Berlin: Springer-Verlag GmbH.
17. Zamuruyeva, O. V., Krymus, A. S., & Olkhova, N. V. (2018). Object-oriented programming in Python. Course of lectures. Part 1. Lutsk: Vezha-Druk. (In Ukrainian)
18. Zamurueva, O.V., & Viligurskyi, O.M. (2020). Object-oriented programming in Python. Course of lectures. Part 2. Lutsk: Vezha-Druk. (In Ukrainian)

Трохимчук Петро Павлович – к.ф.-м.н., доцент, доцент кафедри теоретичної та комп’ютерної фізики імені А. В. Свідзинського Волинського національного університету імені Лесі Українки, e-mail: trope1650@gmail.com, ORCID: 0000-0003-2737-0506.

Вілігурський Олег Миколайович – старший викладач кафедри теоретичної та комп’ютерної фізики імені А. В. Свідзинського Волинського національного університету імені Лесі Українки, e-mail: viligurskyi@gmail.com.

Замуруєва Оксана Миколаївна – к.ф.-м.н., доцент, доцент кафедри теоретичної та комп’ютерної фізики імені А. В. Свідзинського Волинського національного університету імені Лесі Українки, e-mail: zamurueva@gmail.com, ORCID: 0000-0003-0032-0613.

https://doi.org/10.32782/mathematical-modelling/2022-5-2-10