AXIOMATIC METHODOLOGY OF FORMALIZATION AS A WAY TO INTELLECTUAL ANALYSIS IN COMPUTER SCIENCE

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ABSTRACT

The report discusses the possibility of creating a universal mathematical formalization tool for the formalized solution of intellectual problems of cognition of both real processes and phenomena of the surrounding world and man-made processes. A path based solely on the tools of classical mathematics is proposed – the methodology of axiomatic modelling. At the same time, the problems that prevent obtaining an effective true solution to these problems by the proposed means today are described in order to eliminate them. The report is devoted to this topic. The proposed methodology is capable of carrying out semantic data analysis and solving intellectual problems, complementing the existing most modern methods of computer science with semantic accuracy, practical or experimental verification and formal proof of statements.

KEYWORDS

Formalization, Axiomatic Modelling, Intellectual Analysis, Computer Science, Intellectual Task

1. INTRODUCTION

Computer science, as it develops, captures all new areas of knowledge and takes on new functions. «We contend that understanding how data are acquired and processed into functional information will be instrumental in developing a richer understanding of complex evolving systems, and to building a general theory of life. A full examination of the role that information plays in various biotic and abiotic systems requires a more granular level of exploration» [1].
The understanding of the term "information" is also being improved. «The act of transforming data into a state that increases a system's survivability generates functional or semantic information» [1].

And yet, the key question of the subject of computer science - information, remains the question of its truth.

2. RELEVANCE

Researchers use top-end methods and language models to analyse the veracity of a particular information, achieving fantastic skill in this [2], in the absence of uniform, understandable for everyone and competently formulated capacious criteria for scientific evaluation of truth. It's no secret that the truth of the statement "this apple is delicious", although it will be approved by the majority of respondents, but as a rule there is someone who will challenge this fact. At the

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household level, we could neglect the opinion of a small number of the most demanding respondents. But when it comes to complex tasks or large dimensions, accuracy requirements in particularly important scientific and practical tasks, such an error can cast doubt on the truth of the final result and the legitimacy of its further use [3]. This fact, as well as the rapid development of IT technologies, determined the relevance and the need to analyse our existing capabilities to create more advanced approaches to formalization. After all, formalization is exactly the proven tool that can reduce the cost of making intelligent decisions. The use of the results of modern studies of the human thinking process [4] for the correct formalization procedure determines the success of the proposed approach.

Unfortunately, with the exception of the scientific concept of "law" [5], today there are not only clearly defined and used scientific criteria for the truth of facts (evidence-based medicine is a pleasant exception), especially in formal sciences, although intuitive and social, directly or allegorically expressed assessments certainly exist. There are also no objective estimates of optimality for data handling methods. For example, mathematical science has more than 1,500 mathematical structures [6], before the appearance of modern structural structures adapted to the needs of AI and IT, and instructions or "passports" describing these structures and their capabilities: optimally solved problems, types of optimally processed data, restrictions, and so on, are traditionally absent. They are sometimes present in specific tasks, but when it comes to choosing a solution method and mathematical structure for a practical purpose, this choice is made more intuitively and often by specialists in various fields of knowledge, but not by mathematicians.

3. MATERIAL AND METHOD

In order to advance computer science towards the goal of creating universal artificial intelligence tools and their safety for humans, it is necessary to define each of the scientific concepts and tools used to operate with these concepts with precision.

The creation of a universal formalization methodology that is optimal in terms of resource costs, capable of carrying out data mining and solving intellectual tasks, is quite a feasible task [7], if at each step of its implementation one adheres to the principle of reliability of facts and scientifically justified legality of using tools for formal operation in this way. The solution to this strategic task can be found only in proven historical practice and well-studied scientific achievements, the legacy of centuries-old scientific observations concentrated in scientific laws and philosophical truths.

The physiological fact that a person can effectively reason only on the foreseeable amount of initial data [8] should have been a guide to the creation of this methodology, offering a convenient and simple formal language.

The purpose of the report is to identify the possibilities of creating a universal formalization methodology.

The genetic feature of the human thinking function is that the power of the creative component of this function is maximal when all the components of the studied law are in the field of view of this person [9]. Otherwise, this power decreases exponentially. James Clerk Maxwell [10], guided by this feature, worked on only one hundred symbols of the law, unlike Michael Faraday [11], who worked with a thousand pages of typewritten text of the same law. The modern statistical man remains in the Faraday situation. and he will never be able to repeat Maxwell's success in the same way that Faraday failed to do it. And this is because a person always reflects on the context of the law located in his psyche, on a large number of pages of his own memory. Maxwell, on the other hand, previously created a formal language that allows describing a problem task with a number of symbols-identifiers of scientific categories smaller than a hundred, and then on the same categories created an ingenious law reflecting vital activity in all its subtleties for an infinite set of electromagnetic fields [12].

In principle, there can be no alternative to formal languages because of their property of automatically increasing by several orders of magnitude the semantic load per symbol of a language compared to natural language, which corresponds to an increase in the power of the creative component in the function of human thinking. Classical mathematics, as an arsenal of formal languages for describing stereotyped logical and numerical relations between variable physical quantities that functionally fully characterize the permissible states of material processes and phenomena, can provide such a universal formal language – the logic of predicates of the first order [13]. Provided that we have learned how to use it, in the most fundamental sense, covering the knowledge of all related fields of science [14].

A formal language is a mathematical model of operating functions with the meanings of one of the natural languages, for example, English [15].

The semantic elements in English are words. The symbolic codes of each of the words and their semantic load are recorded in explanatory and encyclopaedic dictionaries. The rules for the formation of correct meanings made up of words are defined in grammar.

There are no grammars similar to English grammar in formal (formulaic) languages. Moreover, there are no words fixed in dictionaries that carry elementary meanings. The statement of a specific task clearly and unambiguously formulates each of the meanings and its identifier, which are assigned to them as operands of this task.

The grammar of formal languages consists of two components [16]:

- the syntax of the language, i.e. the rules for the correct spelling of language formulas;
- language semantics, i.e. rules of correct interpretation:
- for the language of mathematical logic – the aspect of truth, or falsity, conveyed by the formula of compound meaning;
- for one of more than 1500 formal languages of classical mathematics – the aspect of matching the meanings of each of the operations in this formal language.

Classical mathematics is a product of the spiritual production of the highest mental function of human thinking [17] and contains more than 1,500 formal languages of description and methods for solving problematic functional problems for the processes and phenomena of the universe.
One of the most important features of the higher mental function of human thinking is the formulaic interpretation of **the functions of operating with meanings** when solving problematic functional tasks of analysing material dynamic systems. Here we will give another characteristic of each formal language, which significantly affects the effectiveness of operating with meanings.

Each of these formal languages has another name "mathematical structure" [18], since it is provided with stereotypical methods for solving problematic functional problems, the formulation of which is feasible exclusively in this language.

The data types of this language, as well as its types of operations and types of relationships between data, are properties of physical variables that functionally fully characterize all permissible states of the process under study, or phenomena in the universe. Of all mathematical structures, the mathematical structure called first-order predicate logic [19] is fantastically universal and, like no other, is designed to solve so-called intellectual problems, i.e. logical problems that do not have pre-known solution algorithms.

A mandatory requirement for the formulation of intellectual tasks in the language of first-order predicate logic is their presentation in the format of theorems formulated on the basis of material axioms, which are facts of full-scale experimentation with the processes and phenomena of the universe under study.

Science is a system of knowledge about the laws of life and the development of matter, society and thinking [20]. It is both a system of knowledge, and their spiritual production, and practical activity based on them.

This is a historically formed form of human activity aimed at cognition and transformation of objective reality. This is a spiritual production that results in purposefully selected and systematized facts, logically verified hypotheses, generalizing theories, fundamental and particular laws, as well as research methods [21]. Like any form of activity, science is improving, responding to new challenges and tasks.

The subject of science is the media of inanimate and living matter, their various forms and types of movement, their reflection in human consciousness. According to their subject, sciences are divided into natural-technical, studying the laws of nature and ways of its development and transformation, and social, studying various social phenomena and the laws of their development, as well as man himself as a social being [22]. Among the social sciences, a special place is occupied by a complex of philosophical disciplines that study the most general laws of the development of nature, society, and thinking [23].

In the natural sciences, one of the main methods of research is experiment, and in the social sciences – statistics. It is these concepts that can serve as a criterion for **the truth of a fact**, and should be explicitly taken into account in the structure of formal sciences.

General scientific logical methods of empirical data processing are: deterministic or probabilistic approach, induction, deduction, analysis, synthesis.

In each science, the empirical level differs, that is, the accumulated factual material - the results of observations and experiments, and the theoretical level, that is, the generalization of empirical material expressed in relevant theories, laws and principles; scientific assumptions based on facts, hypotheses that need further verification by experience [24]. The theoretical levels of individual sciences converge in the general theoretical, philosophical explanation of open principles and laws, in the formation of ideological and methodological aspects of scientific knowledge as a whole [21].

The spiritual products of science are true **informational reflections -** objective knowledge about the laws of vital activity and development of inanimate and living matter in the universe, about the studied matter of the universe. Therefore, the actions of science can be figuratively represented as the transmission of a light beam of the material medium under study, in the reflection of which (the light beam) the target information about this material medium is manifested. And this should also be implemented in intelligent modelling and formalization.
The objectivity of solutions to intellectual problems will be ensured if only **formal proofs** of theorems by the method of resolute inference act as proofs. The complexity of such a solution,

subject to the principles outlined above and the proposed solution algorithms, will be the minimum possible.

First of all, thinking is the highest cognitive process. It represents the generation of new knowledge, an active form of creative reflection and transformation of reality by a person [25]. Thinking generates a result that does not exist either in reality itself or in the subject at this moment in time. It is this observation that requires special attention of physiologists, biologists, psychologists, representatives of all sciences about the functioning of human thinking for the most in-depth understanding of the algorithms of thinking and the functions of permissible operation with information received from the outside.

The essential **qualities** of human **thinking** are:

logical thinking is the ability to follow a strict sequence of reasoning, taking into account all the essential aspects in the object under study, all its possible relationships;

evidence-based thinking is the ability to use facts and patterns at the right moment, confirming the correctness of judgments and conclusions;

critical thinking is the ability to strictly evaluate the results of mental activity in order to discard incorrect judgments, conclusions and decisions (the ability to abandon the actions started if they contradict the requirements of the task) [26]. Today, this component is the least provided for in formal languages offered for use in AI sciences today.

4. CONCLUSION

The movement towards intellectualization in the sciences of AI creation, along with the invention of new ways of processing various data using existing AI and LM methods, combines the study of the physiology of human thinking and a formal description of this process in order to increase its productivity.

The key issue in the problem of cognition of thinking is the generation of new knowledge by the brain on the basis of knowledge stored in its memory, requires further study and experimental confirmation of research results. The answer to this question about the possibilities and properties of thinking is the key to the creation of formalisms capable of intellectual analysis of information. Creation of a methodology for formal assessment of the truth of the information received – a universal algorithm of intellectual analysis and a methodology for solving intellectual problems.
We have already developed proposals for creating such a methodology [27] in the form of the author's axiomatic modelling methodology, but a lot of interdisciplinary work is required to effectively implement these proposals in the practice of artificial intelligence and in the theory of AI, LM and IT.

This work, despite numerous approbations of our proposals [7,14,27], will not be able to achieve maximum efficiency if it is not applied systematically. The simple procedure of using knowledge from various fields of science and practical life in each specific task, in the methodology of axiomatic modelling, generates a desire to use the entire complex of knowledge obtained today for the most accurate solution of each of the tasks. In turn, all the new knowledge used should not destroy the accuracy and reliability of the final result, i.e. must meet the accepted criteria of truth. This requirement also applies to the use of mathematical structures, as well as to each of the permissible means of operation. Therefore, their critical assessment will certainly become a priority in the roadmap for creating universal artificial intelligence tools.

Mathematics, as the most important tool for cognition of reality, has repeatedly been criticized for its objectivity [28-30]. This article does not pursue this goal. It is the high role of mathematics in objective science that makes it the first to respond to the growing challenges and requirements for the accuracy of its tools, its compliance with our new, powerfully accumulating knowledge. Moreover, we would like to emphasize that the centuries-improving, precise apparatus of classical mathematics is capable of solving the most modern problems and responding to the most pressing challenges, confirming its perfection. We hope that the implementation of the axiomatic modelling methodology will demonstrate this.

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