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Logical Operations in Scientific Search System

Abstract

At present, in the context of scientific and technological progress, the issues of developing and disclosing the foundations associated with the awareness of the development of scientific knowledge, its internal mechanisms are acquiring enormous methodological significance. A huge experience of scientific research has been accumulated (scientific methods, regulatory and heuristic principles of *scientific creativity). We mean not only the nature and features of ready-made established knowledge, but also the analysis of the process of scientific search. It should also be noted that, at present, the problems of scientific search and scientific creativity in this regard are acquiring particular relevance. This is due to the fact that in modern conditions, human computer activity is carried out most intensively and quite widely. Human-machine systems are being developed, and research related to the field of artificial intelligence is also being intensively conducted. The research strategy requires putting forward extraordinary ideas, using the production of scientific search - "production" of new knowledge. This article attempts to show the methodological significance of the role of logical reasoning, evidence in the process of scientific search.*

Keywords: *Logic, Scientific Research, Axiomatic Method, Sequential Method, Natural Inference System, Scientific Theory, Reasoning*

Bilimsel Arama Sisteminde Mantıksal İşlemler

Öz

Günümüzde, bilimsel ve teknolojik ilerleme bağlamında, bilimsel bilginin gelişiminin farkındalığı ile ilgili temellerin geliştirilmesi ve açıklanması konuları, iç mekanizmaları muazzam bir metodolojik önem kazanmaktadır. Büyük bir bilimsel araştırma deneyimi birikmiştir (bilimsel yöntemler, bilimsel yaratıcılığın düzenleyici ve sezgisel ilkeleri). Burada sadece hazır yerleşik bilginin doğasını ve özelliklerini değil, aynı zamanda bilimsel araştırma sürecinin analizini de kastediyoruz. Günümüzde, bilimsel araştırma ve bu bağlamda bilimsel yaratıcılık sorunlarının özel bir önem kazandığını da belirtmek gerekir. Bunun nedeni, modern koşullarda insan bilgisayar faaliyetinin en yoğun ve oldukça yaygın şekilde gerçekleştirilmesidir. İnsan-makine sistemleri geliştirilmekte ve yapay zeka alanıyla ilgili araştırmalar da yoğun bir şekilde yürütülmektedir. Araştırma stratejisi, bilimsel araştırmanın üretimini - yeni bilginin "üretimini" - kullanarak olağanüstü fikirler ortaya koymayı gerektirir. Bu makale, bilimsel araştırma sürecinde mantıksal akıl yürütmenin, kanıtların rolünün metodolojik önemini göstermeye çalışmaktadır.

Anahtar kelimeler: *Mantık, Bilimsel Araştırma, Aksiyomatik Yöntem, Sıralı Yöntem, Doğal Çıkarım Sistemi, Bilimsel Teori, Akıl Yürütme*

Introduction

With the improvement of the methodology of scientific research, the issue of developing auxiliary, conceptual, mathematical, and logical apparatus at both the general scientific and regional levels arises. This apparatus should ensure the transition from universal epistemological principles, positions, and requirements to the level of solving specific scientific problems (Tykhtin, 1983, p. 326). An example of this conceptual apparatus is the tools developed by modern logic, which are used for scientific reasoning and proofs. In this context, the construction of logical proofs leads to new propositions, which in turn are part of various forms of creative activity, and throughout this process, natural-scientific thinking is modeled.

It is known that scientific inquiry, as well as the formulation and justification of new data, hypotheses, and various scientific ideas, is carried out using specialized scientific languages. Scientific languages have specific semantics and syntactic structures. According to the language of science, scientific reasoning is expressed. Such reasoning is presented as a sequence of judgments. It should also be noted that the process of scientific reasoning serves as the establishment of logical connections. Scientific inquiry has a specific orientation for solving a particular task (Ruzavin, 2004). It is important to note that a key part of this process is logical reasoning-an ordered set of transitions from one group of judgments to another. For us, the advantage of logical analysis in scientific reasoning lies in the idea of clarity, correctness of conclusions, and reliable proof (Chen' & Li, 1983). For example, the concept of deduction can be defined as follows: A1...An is a set of statements, then the deduction of a new statement B from A1...An is a sequence of statements, each of which is either an axiom or follows from previous statements according to one of the rules of inference. It is known that the construction of logical conclusions is the main component of all reasoning in the search for scientific truth. At the same time, the reasoning and conclusions that take place in the process of scientific inquiry are also constructed within the framework of one logical theory or system, where the initial concepts and their relationships to logical foundations are defined. It should be noted that the traditional way of defining a logical system is axiomatic. According to this, one can select a finite set of appropriate types of expressions as axioms and the basic rule of inference, known as modus ponens. That is, if A holds and also A Ɔ B holds, then B follows. All conclusions in the axiomatic system are constructed by synthesis: new statements are built on top of axioms until the desired result is obtained.

1. Main part

The logical analysis of the principles for constructing valid judgments is not exhausted by the axiomatic system. It should be noted that logical systems can also be defined in a sequential form. A sequence refers to an expression of the form: (A1 ... An) → (B1 ... Bm), which means that from (A1 ... An), B1...Bm can be deduced, or a disjunction formed from any statements on the right of the arrow. It should be noted that the process of constructing conclusions in the sequential version of logic models the procedures of reasoning about the relationship between statements. The proof-building procedure ends when the analysis reaches trivial elementary propositions like A → A (from A follows A), which are considered axioms.

From this, it follows that sequential deduction reflects the entire picture of the analysis of the desired proposition (Puankare, 1983). It is important to note that sequential methods of constructing logical reasoning are significant because they perform a methodological function. Their analytical properties allow not only making deductions but also investigating the dynamics of the reasoning process, identifying which means are most effective. From the point of view of logical analysis, natural logical systems (also known as natural deduction systems) are of great interest in the process of scientific inquiry. In them, the character of natural reasoning, which occurs in scientific practice, is most adequately reflected. Based on this, we can conclude that the natural deduction system is a logical model of the hypothetico-deductive method and deserves special attention.

When analyzing the process of scientific inquiry using rational means, it is necessary to focus on the stage where logical connections between already formulated assumptions and especially hypotheses, as well as the justification of new statements, are sought, their formation, and the derivation of new judgments. To solve this task, it is necessary to build a chain of reasoning leading from existing data to the initial result. How to search for this logical path? (Boole,1954). One can postulate that logical operations model the "technique" of human thinking in a certain way (Lebedeva, 2006). However, it is still a widespread belief that the logical apparatus only models the mechanism of formalizing the results of intellectual operations. According to V.A. Karpunin, *"... proof, as a coherent chain of logically interconnected judgments, the conclusion of which is the proven thesis, is rather the result, the outcome of the work of a mathematician than the tool for searching for truth*" (Ruzavin, 2004,p. 27).

For a long time, logic was limited to questions like: "What reasoning is correct?" "What is a proof?" The situation began to change in the 20th century when the German mathematician and logician G. Gentzen formulated predicate calculus in the form of a sequential system within natural deduction. This shows that "the development of logic has developed means for logically posing the problem of searching for a proof". Thus, the modern logic apparatus models not only what "is true, what is a proof, but also, to some extent, how the brain discovers the truth."

In this regard, in the system of modern logic, there is currently a research direction focused on the theory of searching for logical conclusions. "The very formulation of the central question of the theory of search for inference is aimed at identifying how one could discover some truth" (Maslov, 1985). Based on this, it can be asserted that the problem of finding the solution to a specific scientific problem acquires, in a certain sense, the character of a logical problem.

It is known that the initial stage of developing the theory of searching for logical conclusions is the study of the properties of conclusions in sequential systems. Initially, such systems were not oriented toward finding conclusions. Their corresponding modifications allow for precise determination and investigation of such search options. This possibility opens up a remarkable property of subformula rules of inference used in sequential systems. Expressions in the premises serve as components of expressions that are conclusions of corresponding rules. The only rule of sequential systems that does not possess such a property is cut. Accordingly, let us present its scheme:

A – a statement, and a Γ, Θ, ∆, Z – sequences or sets of statements

$$\frac{\Gamma \rightarrow \Theta, \mathrm{A} \qquad A, \Delta \rightarrow \mathrm{Z}}{\Gamma, \Delta \rightarrow \Theta, Z}$$

This rule is similar to the aforementioned modus ponens rule in axiomatic systems. The application of cut also implies a creative search for a formula (in the scheme, formula A) that is "cut out" and does not participate in further inference but thereby contributes to obtaining the required expression, the conclusion of the rule. However, it has been established (proven by Gentzen) that cut is an "excessive" rule of inference in the sense that everything that can be obtained using this rule can also be obtained without it by reconstructing the proof. Moreover, within the framework of predicate calculus, one can identify a system of reductions or transformations such that by using them, one can achieve a normal inference without applying the cut rules. A normal inference means that it does not contain "circular" paths. In other words, it uses only the means that are truly necessary to achieve the desired result. It should be noted that the theoretical development of the method for searching for results is still under development. At the moment, all these methods are more or less significant modifications of the so-called resolution method. In other words, the essence of the resolution method lies in its use in constructing an inference, searching for the logical rule analog. It should be noted that the development of proof-searching problems is an important part of artificial intelligence research. Creating question-answer systems, automated expert systems, developing deductive databases, analyzing and synthesizing computer programs, robotics technology, and creating task-solving systems are just a few areas where theoretical logic is needed to reveal the structure of meaningful reasoning.

In modern times, logic science has achieved significant success in researching a broader range of reasoning than logical proofs in the accepted sense. Exact logical-mathematical variants are used to analyze so-called truth-like reasoning, inductive transformations, and thus take into account the pragmatic aspects of thought activity, along with characteristics as the scope of knowledge, entire attitudes, and purposeful settings of the subject. This suggests a considerable amount of material for philosophical-methodological research, as well as for understanding and refining the principles of thought that form the foundation of scientific search (Ismayilov, Islamov, Yusifova, 2024).

Conclusion

The above-mentioned explanation aims to clarify that one of the promising developments of the scientific search problem is the effective transition from the general philosophical level of analysis of the scientific creative process to identifying specific tools and methods used in this process. An inseparable part of this process is precisely constructed logical reasoning, which contributes to establishing new truths. It is also important to note that studying the laws of constructing new systems, which in turn reflect and build new reasoning, particularly using the mathematical theory of logical inference, can provide not only clarifications and confirmations but also show a constructive nature. Another important feature should be emphasized: any construction in logical systems of various ways of constructing logical inferences is modeled by the technique of substantive thinking and reflects the basic principles of thought activity, which are significant when determining a scientific problem. The principles of constructing natural-scientific inference and sequential systems allow for the precise identification of methods that are inevitably used in the process of scientific reasoning. The problem of scientific search is directly related to the expression of the problem of searching for logical inferences (Puankare, 1983). The consequences of this are of great importance for the problem of modeling creative processes, or more precisely, in the field of research in artificial intelligence. The logical analysis of the search for new truths is aimed not at realizing and clarifying how this could be invented but at opening up the possibility of searching-what methods of search are used, what their power, complexity, and effectiveness are. This has significant importance for creating theoretical models for scientific creativity.

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