Systems Analysis of the Foundations for the Formation of new Paradigms of Control

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Abstract: At the beginning of the 21st century, an unsystematic variety of paradigms and ontologies of cybernetics is growing, which complicates the improvement of control mechanisms and the implementation of digital technologies and artificial intelligence. We propose systemic foundations that will allow the systematization of the developed and future paradigms and ontologies of cybernetics. The analysis of separate paradigms of cybernetics of the second and third order is carried out. The evolution of paradigms of cybernetics is considered on the basis of modern concepts of scientific rationality, and an adequate form of third-order cybernetics of self-developing poly-subject (reflexive-active) environments is substantiated. The system of principles and trends in the control of social systems is proposed as an additional tool for analyzing new paradigms of cybernetics.

Keywords: control, cybernetics, philosophy of science, scientific rationality, paradigm.

1. INTRODUCTION

The formation and development of paradigms and ontologies of control is inextricably linked with the development of the corresponding paradigms and ontologies of cybernetics. At the end of the 20th century and the beginning of the 21st century, cybernetics developed intensively in the context of the control of social systems. Along with the classical cybernetics of N. Wiener (Novikov, 2016), which has proven itself well in the control of technical systems, cybernetics of the second, third and fourth orders were proposed. Moreover, each of these types of cybernetics has numerous interpretations (Umpleby, 2019). As a result, it turned out to be extremely difficult to answer the question: "What is cybernetics?" A haphazard variety of paradigms and ontologies of cybernetics and control emerged. This makes their practical use extremely difficult, and the situation is complicated due to the rapid pace of implementation of digital technologies and artificial intelligence in the field of control.

The main reason for this situation is the methodological chaos of the formation of new paradigms of cybernetics and control. The purpose of the article is to analyze the formation of paradigms of cybernetics and propose systemic foundations that will allow the systematization of the developed and future paradigms and ontologies of cybernetics. The methodological foundations are based on the provisions of the philosophy of science on the formation of new scientific paradigms, on modern ideas about scientific rationality (classical, non-classical, post-non-classical), as well as on the analysis of the experience of the methodology of the development of natural sciences.

2. THE BASIC PRINCIPLE AND CERTAIN ASPECTS OF THE FORMATION OF NEW SCIENTIFIC PARADIGMS

Based on the analysis of the development of physics, Niels Bohr formulated the most important basic criterion for the development of scientific paradigms. This is Bohr's correspondence principle (Bohr, 1976). The essence of the principle is that old paradigms retain their significance as a special case of new, more general ones. This principle determines the requirement for qualitatively new stages in the development of scientific knowledge.

Similar requirements were formulated in the philosophy of science by T.S. Kuhn (Kuhn, 1962):

- firstly, the new paradigm must solve some controversial and generally recognized problem that cannot be solved in any other way;
- secondly, the new paradigm should promise to a large extent preserve the real ability to solve the problems accumulated in science thanks to the previous paradigms.

In fact, these requirements are associated with ensuring the continuity of scientific knowledge in the development of scientific fields of knowledge. They are important for the formation of new stages in the development of science. In particular, during the formation of cybernetics of the first, second and subsequent orders.

Let us consider three important aspects of the formation of new scientific paradigms proposed in the philosophy of science.

First, the implicit or explicit formation of new paradigms. On the basis of intrascientific trends and ideas of development, or on the basis of an external, social request.

Secondly, the use of cross-cutting thematic structures in new paradigms as peculiar trajectories of the historical development of science (Holton, 1993).

Third, the degree of influence on the creation of new paradigms of the implicit, personal knowledge of the creators of these paradigms (Polanyi, 1964).

3. ANALYSIS OF THE FORMATION OF CERTAIN PARADIGMS OF CYBERNETICS

An important stage in the development of cybernetics is the formation of second order cybernetics. The evolution of cybernetics is presented as an ascent from the methodology of "observable systems" (Wiener, 1948) to the methodology of "observing systems" (Foerster, 1979). The formation of second-order cybernetics is associated with the transition from the “subject-object” control paradigm to the “subject-subject” control paradigm. It is important to note that the old paradigm is included in the new one as a particular paradigm (Lefebvre, 1986). The transition to second-order cybernetics satisfies Bohr’s Correspondence Principle.

Let us consider the foundations of the formation of new paradigms of cybernetics on the examples of paradigms of third-order cybernetics.

Example 1. (Johannssen, 1994). The author proposes to consider the relationship between observers in the network as the basis for understanding third-order cybernetics. To study the relationship between communications and organizational changes, the author has developed the special cognitive approach. Such an understanding of cybernetics does not fundamentally go beyond the framework of ideas about second-order cybernetics and cannot pretend to the next qualitatively new stage of cybernetics.

Example 2. (Mancilla R.G., 2011). The paper develops the above-mention approach (represented in Johannssen, J., Hauan, A., 1994). In the third-order cybernetics proposed by the author, the organization of machines consists of language, and the structure consists of speech acts. To set the material space of being, biological cognitive processes are used based on self-conscious autopoietic systems. Such an understanding of cybernetics also fundamentally does not go beyond the concepts of second order cybernetics.

Example 3. (Kenny V., 2009). As a basis for third-order cybernetics, the author proposes to pay attention to the subjectivity of the observer, which is problematic from his point of view. In this he believes there is a fundamental difference from second-order cybernetics, in which this aspect remains out of attention. Such the understanding of third-order cybernetics forms a gap in the logic of the development of cybernetics. Third-order cybernetics has to include first and second order cybernetics as particular paradigms.

The proposed approaches are original and focused on improving particular areas of cybernetics. However, they do not have substantiated grounds for a qualitatively new step in the development of cybernetics, which could be third-order cybernetics. These examples clearly demonstrate the underestimation of the experience of the development of new paradigms in the philosophy of science and natural sciences.

So, to make a conclusion, there is a methodological crisis in cybernetics. One of the reasons for this is the influence of postmodern ideas and insufficient attention to the philosophy of science.

For a more complete systematization of the paradigms of cybernetics and the identification of directions of development, it is necessary to use the philosophical and methodological foundations of analysis, for which Bohr’s correspondence principle is fulfilled (Lepskiy, 2018). This requirement is met by three types of scientific rationality: classical, non-classical, post-non-classical (Stepin, 2005).

4. THREE TYPES OF SCIENTIFIC RATIONALITY THAT FULFILL BOHR’S CORRESPONDENCE PRINCIPLE

Bohr’s correspondence principle is satisfied by the system of three types of scientific rationality: classical, non-classical, post-non-classical (Stepin, 2005). These types of scientific rationality define three stages in the evolution of scientific knowledge. The emergence of a new type of scientific rationality does not reject the previous ones, but includes their new research context. The selection of types of scientific rationality is based on the triad "subject - means - object".

The classical type of scientific rationality, concentrating attention on the object, in theoretical description and explanation, tends to eliminate everything, that refers to the subject, means and operations of the activity.

The focus of non-classical scientific rationality is the relationship between the study of an object and the means and operations used for this.

The post-non-classical type of scientific rationality focuses on reflexion on research activities. This type of rationality interprets the knowledge gained, both taking into account the characteristics of the means and operations used by the researcher, and taking into account the value-oriented structures. It is important to note that, along with internal scientific values, external social values are also becoming the focus of attention (Fig.1).

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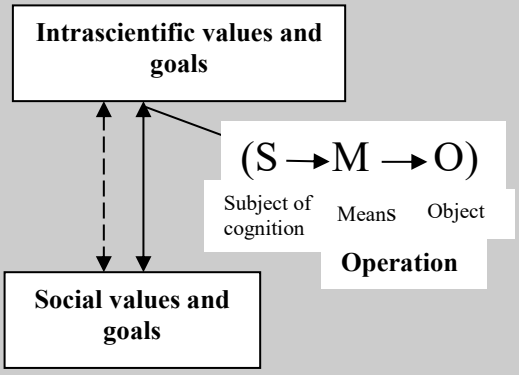

Fig.1 The post-non-classical type of scientific rationality

The philosophical and methodological basis for the formation of ideas about the three types of scientific rationality were the ideas of scientific revolutions and scientific paradigms (Kuhn, 1962), as well as the ideas of scientific programs (Lakatos, 1978).

These types of scientific rationality set a logically grounded line of development of scientific knowledge and satisfy Bohr's principle of correspondence. They can be used to systematize and form ideas for new paradigms of cybernetics.

5. EVOLUTION OF PARADIGMS OF CYBERNETICS AND SCIENTIFIC RATIONALITY

Philosophical and methodological analysis of the evolution of cybernetics made it possible to conclude that the basic types of cybernetics correspond to three types of scientific rationality (Lepskiy, 2018). The evolution of cybernetics is presented as an ascent from the methodology of "observable systems" (N. Wiener), which corresponds to the classical scientific rationality, to the methodology of "observing systems" (Von Foerster), which corresponds to non-classical scientific rationality, to the methodology self-developing reflexive-active environments, which corresponds to post-non-classical scientific rationality.

An example of the formation of new paradigms of cybernetics based on ideas about scientific rationality is the cybernetics of self-developing poly-subject (reflexive-active) environments developed by us, which can claim the role of third-order cybernetics (Lepskiy, 2018; Umpleby, Medvedeva, Lepskiy, 2019; Espejo, 2021).

Table 1. Evolution of paradigms of cybernetics and scientific rationality

Type of scientific rationality	Basic approaches	Basic paradigms	Basic areas of knowledge
Classical	Positivism	"Subject – Object"	Cybernetics
Non-classical	Constructivism	"Subject – Subject"	Second-order cybernetics
Post-non-classical	Humanistic constructivism	"Subject – Meta-Subject"	Third-order cybernetics

In the proposed third-order cybernetics, the ascent from the "subject – object" paradigm to the "subject – subject" paradigm and further to the "subject – meta-subject" paradigm is carried out. In this case, the previous paradigms are included as private in the paradigms of a higher level.

The transition of control to the "subject – meta-subject" paradigm led to the formation of new types of control. Control through the mechanisms of a self-developing environment becomes dominant. This is reflected in the control of various types of social systems (economy, military sphere, education, etc.).

Consideration of the evolution of control of social systems in the context of the development of scientific rationality makes it possible to systematize the principles and trends in the development of control. These principles and trends can be helpful in assessing new paradigms of cybernetics.

6. BASIC PRINCIPLES OF THE SELF-DEVELOPING POLY-SUBJECT (REFLEXIVE-ACTIVE) ENVIRONMENTS

Our proposed methodology for organizing self-developing poly-subject (reflexive-active) environments is based on the structure of the basic principles. System integration of principles is based on a subject-oriented approach.

Worldview principles are focused on overcoming the crisis of technogenic civilization.

The principles of subjectness are focused on harmony and assembly of the subjects of development.

The principles of synergetics provide the basis for the development of a system of ontologies for the existence of subjects.

The principles of organizing socio-technical systems ensure the vital activity and development of hybrid reality environments.

General scientific principles are focused on the inclusion of science in self-developing environments.

The philosophical and methodological foundations of the proposed structure of principles are based on post-non-class scientific rationality (Stepin, 2005).

The structure of principles proposed by us sets the grounds for ensuring social responsibility in self-developing environments. It is important to note that conditions are being created to overcome the limitations of corporate social responsibility (Lefebvre, 2010). The key landmarks are:

- overcoming selfishness;
- dominance of cooperation over competition;
- the superiority of the spiritual over the material (creating an alternative to the consumer society);
- striving for the implementation of the principle of non-violence;
- creating conditions for the harmony of traditions and development;
- elimination of the dominance of economic and financial reductionism in development;
- overcoming the crisis of the model of technogenic civilization;
- subjectness as a system-forming factor;
- legalization of subjective realities through reflexivity;
- personalization in ensuring the activity, communicative and reflexive activity of the subjects;
- from information and data to subject-oriented organization of knowledge;
- convergence of digital twin, digital subject and digital meta-subject models in self-developing environments of hybrid reality.

7. SOCIO-HUMANITARIAN TRENDS IN SOCIAL SYSTEMS CONTROL

Philosophical and methodological analysis of the evolution of cybernetics and management problems, including the management of social systems, made it possible to identify basic trends and order them in the context of types of scientific rationality and cybernetics. These trends should also be taken into account when creating new paradigms of cybernetics:

- *philosophical approaches* (positivism – philosophical constructivism – humanistic interpretation of philosophical constructivism);
- *paradigms of control* ("subject – object" – "subject – subject" – "subject – meta-subject");
- *positions of the observer in control* (external observer – external and built-in observer-actors – external, built-in and distributed observer-actors);
- *approaches to the representation of control activity and its subjects* (activity – subject-activity – subject-oriented);
- *types of activity of control subjects* (activity – communicative – reflexive);
- *understanding of control objects* (complex systems – active systems – self-developing environments);
- *types of control* (classical – reflexive control, etc. – control through environments);
- *models in control* (analytical – simulation, multi-agent – human-sized);
- *control mechanisms A* (feedbacks – communications – environmental interactions);
- *control mechanisms B* (hierarchical structures – network structures – self-developing environments);
- *reflexion* (personal, over-situational reflexion – communicative reflexion – meta-reflexion);
- *representations of knowledge in control* (information – personal knowledge, subject-related knowledge – active knowledge of real and virtual subjects);
- *ethical regulators in control* (ethics of goals – communicative ethics – ethics of strategic subjects);
- *social responsibility* (social responsibility is the outcome of outside control activities – communicative networks of social responsibility – social responsibility of poly-subject environments (meta-subjects);
- *approaches to the integration of fields of knowledge and subjects in control* (monodisciplinary – interdisciplinary – transdisciplinary).

The presented systematization of trends in the control of social systems makes it possible to form a holistic view of the development of problems in the control of social and technical systems. It provides the processes of convergence and development of natural science and humanitarian tools for control social systems within the framework of post-non-classical scientific rationality and third-order cybernetics.

8. CONCLUSIONS

At the beginning of the XXI century, an unsystematic variety of paradigms and ontologies of cybernetics and control is growing like an avalanche. The situation is aggravated by the rapid pace of implementation of digital technologies and artificial intelligence in control. The main reason is associated with the lagging behind the philosophical and methodological support of control sciences.

The article analyzes the formation of paradigms of cybernetics and proposes systemic foundations that will allow the systematization of the developed and future paradigms and ontologies of cybernetics. As the basic we use philosophical and methodological foundations, along with the classical ideas of the philosophy of science on the development of scientific knowledge, ideas about three types of scientific rationality (classic, non-classical, post-non-classical). This made it possible to systematize the evolutionary processes of cybernetics and highlight the basic principles and trends in the control of social systems.

The results obtained will make it possible to introduce qualitative criteria for assessing new paradigms in cybernetics and in general in control and to stimulate the processes of convergence of the natural sciences and the humanities in improving the control processes of socio-technical systems.

9. ACKNOWLEDGMENTS

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