

Robotics: from cybernetics first to third order.

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ABSTRACT

The general principles of various orders cybernetics were formulated half a century ago. However, the principles of these orders have been used in philosophy, sociology, biology, economics and similar fields. Engineering specialists practically did not use these principles in their works. In this article, an attempt is made to consider and formulate the basic principles in the problems of robotic systems control in terms of the first, second and third orders cybernetics. A new classification principle of robotic systems is proposed, which is based on linking to cybernetic orders.

1 INTRODUCTION

Division into "orders" in Cybernetics, which in the most general form can be defined as the science of managing systems based on the processing of information about their state. This is a very conditional definition, but it allows you to highlight the main features of the research subject and the tools used for this purpose.

The purpose of this article is to consider and formulate the basic principles and controlling tasks the class of robotic complexes (RC) in terms of various orders cybernetic RCs belong to complex cyber-physical systems, and in this area, in my opinion, all the most complex, at the given time, cybernetic theories and methods used in practical projects are concentrated. When considering the RC class, it should immediately be specified that the methods and algorithms that are used in the design of the RC control system will be considered. It should be noted that many principles and approaches to their design and implementation, which turn out to belong to Cybernetics of different orders, were developed by scientists and engineers without any consideration for the problems of Cybernetics of different orders. Therefore, it is interesting to analyze, generalize and make sense of this experience in terms of understanding the problems facing Cybernetics of the first, second and third orders.

2 Cybernetics of the first, second and third orders

Despite the fact that the idea of dividing cybernetics into generations arose in the 70s of the last century, there are no de facto standard definitions of the essence of these cybernetics.

First order Cybernetics. Classical cybernetics, as Norbert Wiener defined it, is the science of the general laws of the control processes and transmission of information in machines, living organisms and society [1]. It is important to emphasize that in N. Wiener, in the definition of cybernetics, "machines" are in the first place, and only then "living organisms and society". N. Wiener was a mathematician and worked on projects for technical systems. Second and third order cybernetics were not determined by scientific and technical workers! Despite the "classical definition" of cybernetics in various articles, quite different interpretations of this definition can be found. Below are some examples.

"The definition of the essence of classical cybernetics, which is based on the ideas of classical scientific rationality" [5].

"Cybernetics of the first order corresponds to classical scientific rationality, is based on the paradigm of "subject - object" [6].

Second order cybernetics. The creators of the second order cybernetics paradigm in the 50s of the last century are considered to be quite serious and well-known scientists: A.S. Bee (operations research, social systems), W.R. Ashby, (psychiatrist, cybernetic), W.S. McCulloch (neurophysiologist, neural networks, one of the creators of cybernetics) began to develop "second-order cybernetics" that differs from the classical cybernetics of N. Wiener [2]. Later, H.von Foerster (physicist, mathematician, cybernetic), and G. Bateson (philosopher, cybernetic, sociologist, anthropologist) continued this development [3]. In the new cybernetics, the ideology of classical cybernetics is reoriented towards the nature of biological cognition and orientation toward the subject.

Since even in the definition of classical cybernetics there are quite different interpretations of it, then in defining second-order cybernetics, all the more, there is no single formal clear definition

Third Order Cybernetics. A relatively new paradigm that formulates an updated understanding, methodology and the range of tasks that modern cybernetics deals with, for example [4-7].

In third-order cybernetics, the first place goes: the intellectual component of the system, the active participation of a person in its functioning, and, importantly, not only as an operator, but also as a partner. Third-order cybernetics considers the system more as an active interactive element in a complex control scheme. Currently, the main works on third-order cybernetics are carried out by scientists from the fields of sociology, biology, economics, psychology of emotions, art theory and philosophy. There are very few examples of the use of this paradigm in the field of technical and engineering sciences.

In Russia, methodological ideas of third-order cybernetics are developed in the works of academicians of the RAS V.S. Stepin, V.A. Lektorsky and professor V.E. Lepsky [6, 7], which are the main popularizers of this paradigm in Russia. Their publications and speeches primarily discuss the philosophical and methodological foundations of this paradigm. In the works of V.E. Lepsky, in particular, a number of examples of the use of this methodology in the economics field are given.

The summary result of the brief review is presented in Table 1.

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Cybernetics order	Main signs	Areas of use in humanitarian sphere	Areas of use in engineering - technical sphere
cybernetic first order	general laws of the control processes and transmission of information; observable systems; machines; classical scientific rationality;	relationship in societies;	observable systems; computer communication control
cybernetic second order	paradigm "subject - object"; cybernetics observing systems; response to trends in the object of management; integration-training-adaptation; homeostasis support and self-organization	management of bio- and noosphere objects; relationship management in societies; people	control of cyber-physical systems using mutable programs or using an operator
cybernetic third order	self-developing polysubjective (reflective-active) environment; attention to the intellectual component; empirical generalization of large data volumes; Power, Culture and Institutions.	sociology; political science; economy; culture	intellectual component of cyber-physical systems
cybernetic fourth order	???	???	???

The main conclusions that can be drawn from the analysis of Table 1:

- cybernetics of various orders in the humanitarian sphere are used much more often than in engineering-technical sphere;
 - the formulations of the orders of cybernetics for the humanitarian areas are more "blurred" than for engineering - technical sphere.
- The main disadvantage of such classifications: the general principle is that they are based only on a reference to a time period, that is, to specific technologies and, in fact, consider the development of robotics in the historical plane. This is a simple and convenient principle, but it does not take into account the complexity and ways of managing the RC. Therefore, such a classification is not interesting to the scientific and engineering community!

3. Cybernetic orders in scientific and engineering projects

There are very few examples of the cybernetic orders use in scientific and engineering projects. If we look at the application of the various orders cybernetics in the engineering and technical field, then the main class of their applications should be the class of cyber-physical systems. However, you can find only a few examples of the use of orders in the description of scientific and technical projects.

In the preprint [4], the authors, one of the few, consider third order cybernetics in relation to the problem of modeling antagonistic conflicts, using the third order cybernetics paradigm as a new approach to solving the problem based on game theory. There are also shown works that solve a similar problem using the theory of finite automata.

Proposed classification system for Robotic Complex

It is proposed to consider generations of RC based on the principle of their linking to generations of cybernetic systems. It appears that this will be a more objective classification of existing robotic systems. In this regard, we can consider, for example, the next 4 generations of RC.

Table 2 summarizes the proposed classification of RCs based on the order of cybernetics. The main features and typical examples given in this table can be easily expanded and adjusted. This table illustrates the proposed principle and is not final.

Robot Generations	Name	Main features	Typical examples
Robots of the first generation	programmed robots	hard-coded simple robots	robot manipulators, robots
Robots of the second generation	adaptive robots	limited autonomy; principle: finite operator-one robot	robot manipulators, humanoid, collaborative robot or robots, drones
Robots of the third generation	intellectual robots	semi-autonomous robots with a high degree of autonomy, teams of robots and people	exoprostheses, service robots, operating indoors and serving a heterogeneous group of rehabilitation - medical center users (patients, health workers, visitors), humanoid, cybernetic prostheses, cybernetic prostheses, cybernetic prostheses, cybernetic prostheses, cybernetic prostheses
Robots of the fourth generation	independent robotic complexes (RC)	full autonomy, self-reproduction	examples are ???

Proposed classification system for RC

Currently, the practical activities for the development and operation of the RC can be found in robots of all four generations listed. In some cases, they are mass products and are used in large enough quantities, while in other cases, they are prototypes that are not yet a commercial product. This applies primarily to robots of 3-4 generations, but all this is already a reality of today!

5 CONCLUSIONS

- The proposed classification is based on cybernetic orders. In practice, this means that it is based on the complexity and intelligence of the RC control system.
- This classification is independent of the technology used to manufacture the RC.
- This classification is independent of the RC mechatronic circuit used.
- This classification does not depend on the "world of the robot" and the type of its purpose: stationary, mobile, ground, copter or UAV (drone), surface, underwater, space, alien, etc.
- This classification is independent of the types of sensors and actuators used in a particular RC.
- Of course, the proposed principle can be clarified and requires further detailing.
- Many ideas and thoughts that are presented in the article are found in some works. But the author of this article thinks that these principles should be "fixed" more rigidly and concretely.