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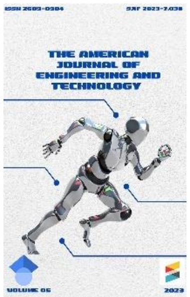

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Research Article

SOME ASPECTS OF DEFINITION OF THE CONCEPT "A COMPLEX SYSTEM"

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ABSTRACT

The article analyzes some provisions regarding complex systems. The concepts of a complex system from the point of view of an observer, researcher and manager (subject of management), structural and dynamic complexity of the system are given. Based on material from various sources, the requirements for the concept of system complexity are considered.

KEYWORDS

Complex systems, structural complexity, static complexity, dynamic complexity.

INTRODUCTION

The interpretation of the system from a theoretical point of view is based on the definitions given in classical sources on general systems theory [1-7]. In these works, the following were studied as fundamental properties of systems:

- Emergence;
- Equifinality;
- Integrity;
- Organization;
- Functionality;
- Structuring;
- Adaptability;
- Multidimensionality;
- Nonlinearity, etc.

The listed properties of the system by default imply its complexities associated with its fundamental properties.

In addition, any system in the direction of the final goal is in various states, differing in quantity and quality over time, and moves from one state to another. The

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set of important properties of the system that appear at a given moment in time is called the state of the system and in a certain time interval represent a complexity associated with the space of temporary states.

Of particular note is the structural complexity of systems that characterize a high degree of structural holiness. The structural complexity of systems is manifested in the following features of various systems:

- Availability of integrated functional complexes (subsystems);
- Availability of internal and external feedback;
- Hierarchical structure.

Let us note one more factor in the complexity of the system. It is a representation of the system from the point of view of an external observer, researcher or manager.

From the point of view of an observer, a system is not complex if the nature of its behavior and the ultimate goal of the observed system are clear to him, otherwise it is complex.

From the researcher's point of view, a system is complex if for him this system is an object of study, i.e. Any system subject to research is a complex system. Otherwise, there is no point in studying this system.

From the point of view of the manager (the subject of management), the managed object is a complex system. Since, it is necessary to make a number of decisions to transfer the controlled object from the initial state to the final state, along one of the trajectories of the phase space of possible states of the object. In this case, it is necessary to determine the target trajectory in the phase space of possible states of the object; the object is influenced by the external environment, which in itself is complex; decision-making process, which also presents a certain complexity, etc.

One more aspect of the complexity of the system can be highlighted - this is the complexity associated with the limited resources for its functioning. A system with limited resources requires optimization of the structure, parameters and/or trajectory.

Systems that are difficult to formalize or cannot be formalized mathematically are clearly complex. This is where artificial intelligence with fuzzy logic comes into play. An intelligent system itself is complex due to the complexity of understanding the mechanism of functioning of neural networks.

As the scientific worldview develops, approaches to understanding the nature of the "system" as a separate object of research undergoes changes. In this regard, various interpretations are given [8-14] regarding the complexity of the "system", which allows the accumulation of knowledge not only regarding the "system" itself, but also the world around it. From this point of view, it can be argued that studying the complexity of a system is one of the methods of cognition.

In Fig. 1 presents examples of complex systems that are currently being researched, designed, and managed. This list can be continued. At the same time, it is possible to challenge it. For example, open systems are also dynamic systems, etc. The names of the systems depend on the aspect in which the system is being researched or designed.

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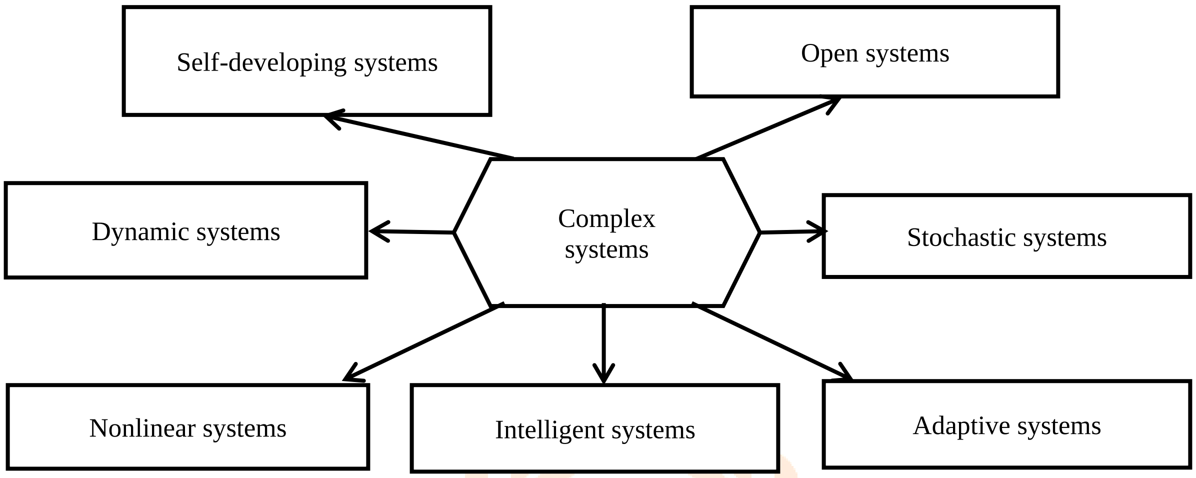

Fig. 1. Examples of complex systems.

Based on the above, the following aspects of complex systems can be distinguished:

- complexity associated with fundamental properties;
- complexity associated with determining the optimal trajectory in the state space;
- structural complexity;
- difficulties from the point of view of an external observer, researcher or manager;
- systems with limited resources;
- difficult to formalize systems;
- complexity associated with the intellectualization of the system (for example, technical systems);
- complexity associated with the human factor: lack of experience in design and/or management.

In Fig. 2 shows the structural complexity of the system as an example.

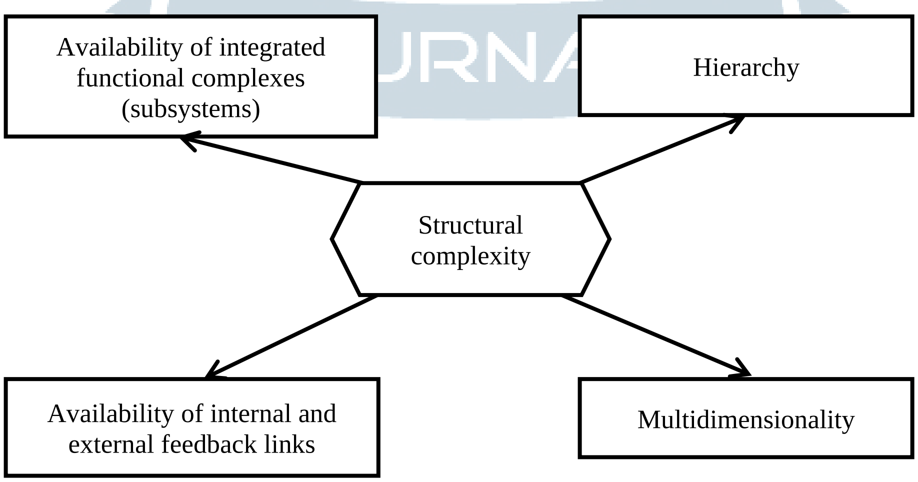

Fig. 2. Structural complexity of the system.

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In a primary approximation, formally the various properties of the complexity of the system can be represented in the following form (a simple enumeration of the complexities):

$$S = \{X_N^T, A_K^R, W_{N\times M}^T, Y_M^T\}, \qquad (1)$$

where, X_N^T – change in the influence of the external environment on the system over the period T of its operation, N – number of environmental variables, A_K^R – many elements integrated into complexes (subsystems) K, R – structural connectivity of the system; $W_{N\times M}^T$ – system transfer function, Y_M^T – vector of target states (reactions) of the system, for the period T of operation, $N \times M$ – mutual correspondence of influences and reactions. Each of these variables reflects different aspects of the complexity of the system. From expression (1) we can distinguish the static and dynamic complexity of the system.

The static complexity of a system reflects its structural complexity, since the structure of the system represents its static model: $S_{\text{ст}} = \{A_K^R\}$. (2)

The dynamic complexity of a system is represented through its input, transfer function and output (Fig. 3):

$$S_{\text{дин}} = \{X_N^T, W_{N\times M}^T, Y_M^T\}. \qquad (3)$$

As a conclusion, we note that a system isolated from the external environment is studied, designed and managed. All this requires:

• solving many problems of varying complexity;

• temporary, intellectual and material resources, the limitations of which present certain difficulties.

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