Cellular automata as a model of reality

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Abstract. The article examines cellular automata as a model of reality. From our point of view, cellular automata represent the most adequate ontology of the Universe, including the processes in which we participate, as well as the processes that we are.

Keywords: cellular automaton, strange attractors, Zeno's level, physical vacuum, the second law of thermodynamics, Turing's problem of undecidability.

Methods: the article uses the method of historical reconstruction of the formation of the theory of cellular automata, the conceptual apparatus of synergetics, the methodological ideas of S.Ya. Berkovich and S. Wolfram.

In the XX century, the theory of cellular automata began to be used to describe physical reality. The cellular automaton itself is a mathematical construction that resembles a cell. Most often, a two-dimensional grid is used to analyze a cellular automaton, but a cellular automaton can also be multidimensional. Each cell of the grid is influenced by neighboring cells, so that it seems that all the cells form a simple network. John von Neumann analyzed grid cells with twenty-nine states, and proved that this number of cells is enough to create a UTM (universal Turing machine). The topic of cellular automata was also addressed by the German engineer Konrad Zuse, who wrote the book "Computational Space" in 1969, dedicated to this topic [1].

In this book, Konrad Zuse opened up the field of digital physics - explaining the behavior and laws of the universe in terms of computability.

Traditionally, it is argued that the laws of physics are continuous: it is assumed that such physical concepts as distance, speed, etc. best expressed in terms of numbers and differential equations.

Quantum theory assumes a discrete and digital nature of the universe, from this point of view, the continuous nature of the real world is an illusion. The question arises: is reality digital, analog or hybrid?

To analyze the laws of physics from the point of view of digital physics, Zuse created digital particles controlled according to the rules of cellular automata, since the development of the Universe is similar to cellular automata.

The action of cellular automata is described in terms of local dependence, the action of continuous dynamical systems is described in a similar way, which gives grounds to assert that cellular automata in informatics are analogous to the concept of "field" in physics.

A cellular automaton can also be represented as a world in which space is a uniform grid, each cell of which contains a certain number of data bits, the time is discrete, and the cells determine their own state by the states of the cells nearest to it.

The laws of the system are local and the same: local in the sense that long-range action is not allowed, the state of a cell is determined by the nearest cells; sameness means the same operation of laws regardless of place or landscape.

Given the rules, a simple mechanism is sufficient for the stable existence of structures and phenomena. Models created with cellular automata are used in natural sciences as well as in combinatorial mathematics. Cellular automata form a parallel computing paradigm, similar to Turing machines [2].

In the forties of the last century, Stanislav Ulam and John von Neumann created a modeling method known as cellular automata, with the help of which S. Ulam studied the growth of crystals, and J. von Neumann - the self-reproduction of complex systems.

John von Neumann in his work "General and logical theory of automata" put forward the idea of the existence of a threshold for the complexity of the system. Below this threshold, the system is not capable of sufficiently complex functions, and under certain conditions it only degrades, that is, it reduces its complexity. Above this threshold, the system becomes self-sustaining, capable of performing highly complex functions. In particular, the ability to reproduce itself arises here, which does not imply a simple duplication of itself. The system must become redundant compared to the simple requirement of replicating a system of similar complexity or adapting to the environment. Overcoming the threshold of complexity is associated with the production of systems of greater complexity than the original.

Von Neumann's concept also refers to the possibility of different ways of describing a system. While the system is not complicated, the description of its functions is simpler than the description of the system itself, but for more complex systems it is much more difficult to figure out what an object is capable of doing than to build the object itself.

Cellular automata models describe a class of situations that is described by differential equations. The use of cellular automata does not require knowledge of any equations describing the situation, does not require superpowerful computers, allowing one to obtain a result, while the sought solution is presented in a graphical form.

The principle of "successive expansion of scientific interest" is characteristic of modern philosophy. It is associated with the influence of a complex of sciences, in particular, cognitive science, on the research field of a philosopher.

Modern science is characterized by a transition to the knowledge of multilevel hierarchical self-organizing systems, considered in the context of their formation, the potential multivariance of their evolution.

In the process of using cellular automata, a breakthrough occurred, which is associated with work that looked at physical theories from an algorithmic point of view. The cellular automaton approach is not an end in itself, but a means of understanding and explaining the reality that surrounds us. This is an attempt to reinterpret the picture of physical reality together with the cognizing observer included in it.

From the point of view of the cellular information approach, physical reality is a set of information structures, which is analogous to Hegel's idealism in philosophy. The informational reality created by the model of cellular automata can be demonstrated by an example with light bulbs: light bulbs that light up or go out in a certain sequence create the effect of movement, but information actually moves, creating the illusion of physical movement.

S.Ya. Berkovich called such a model the Zeno level in connection with the apparent nature of the movement [3].

A new ontology is emerging, which includes the following provisions:

1) in the traditional sense, unit cells are not physical objects; they constitute a qualitatively different level of the Universe underlying the physical level;

2) the topology of the cellular automaton network generates protospace, and the cycles of elementary counters - prototime, which then develop into physical space and time;

3) physical vacuum - a transmitting layer between elementary particles and core-like collective excitations. The level of these arousals underlies the physical layer;

4) in a physical vacuum, the cellular automaton protospace and prototime are transformed into physical space/time. Core-like collective excitations generate

elementary particles, following the symmetry of a network of cellular automata that develop into the known physical symmetries of the Universe. [4]

The concept of the physical vacuum as a special form of the cellular automaton is based on the ability of the cellular automaton to create formations with unusual behavior, which is similar to the behavior of elementary particles of matter.

The cellular automata model represents material formations as propagating wave solutions: cellular automata generate diffuse activities that can participate in information processing.

The consequence of this possibility is the possibility of the existence of a cognitive information processor outside the brain, using the cellular-automatic background of the physical world as a holographic medium.

According to Stephen Wolfram, computer experiments generate the following classes of attractors to which cellular structures tend to evolve.

Systems of class 1 after several steps reach a homogeneous equilibrium state regardless of the initial conditions. This corresponds to an attractor of the fixed point type.

A class 2 system shows a periodic pattern that is relatively independent of the initial conditions; specific parts of the structure, but not the entire structure, depend on the initial conditions.

Cellular automata of class 3 systems create configurations that seem random and scattered.

Class 4 system. Evolving configurations with random quasi-organic and locally complex structures can be observed here.

Class 3 automata are very sensitive to small changes in the initial conditions; they are characterized by a long process of information transfer. Changes of local character are transmitted globally to distant areas with a butterfly effect.

Class 4 automata transmits information over long distances, but sometimes it is limited to structures localized in space and time.

In random configurations of class 3, evolution is irreversible due to the fact that all correlations decrease; complex structures of class 4 have a chance of strange or chaotic attractors, which are complex interconnected objects.

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For computational irreversibility, there is no method for predicting the behavior of a system, except for taking all the steps of actual development. According to historians of science, knowledge of laws allows predicting the future, but if we assume the possibility of chance, then there is no other way but actual evolution.

According to Stephen Wolfram, the sciences of complexity are characterized by computational irreversibility, and therefore the shortest way to find out the state of the system under study is to consistently simulate its evolution. Even if all the laws of behavior at the micro level are known, it is impossible to predict the development of the system at the macro level.

The brain is defined at the micro-level of neurons by simple rules for synapses, but it is impossible to calculate the formation of structures in neurons.

It can be assumed that computational irreversibility and computational irreducibility support personal individuality. A person's personal life is influenced by random events. K. Mainzer believes: "The structure of our way of life is highly nonlinear, complex and random. There is no shortcut to predicting life. If we want to find out the meaning and result of our life, we must live it." [5]

Conclusions:

The theory of cellular automata is a rational interpretation of Karl Popper's "third world".

An unusual aspect of the supposed new paradigm of brain functioning is that information is processed outside the brain, in this case, the functional role of the material formations of the brain is to organize access to these processing facilities, that is, to connect to the "third world", which is materially organized in the form of a cellular -automatic background.

2. Based on this, the anthropic principle becomes more obvious, according to which the Universe is arranged in such a way that it contributes to the emergence of intelligent life.

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