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SELF-ORGANIZATION AND EVOLUTION SYSTEM SIMULATION BY THE CONTINUOUS NONSYNCHRONIZING CELLULAR AUTOMATA

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Abstract: *This paper deals with the modeling of the same systems on the base of nonsynchronizing cellular automata. This approach have been approved for the exponential dependencies, heat transfer, diffusion and wave interference, discrete system, like Conway's Game of Life, behavior. The modeling of the evolution of the wave-like system also has been carrying out. The proposed method has been modified for the modeling of the evolution processes. This modification consists in algorithm, which taking into account the difference between local interactions rules.*

Key words: *cellular automata, self-organizing, evolution, modeling, nonlinear dynamics.*

The usual cellular automata (CA) are the discrete dynamical systems, which depends only on local interaction rules, common for every cell. Despite the CA comparative simplicity, such models can describe rather complex and interesting dynamics. The main purpose of this paper is the CA models elaboration, which can demonstrate the qualitative evolution dynamics of the different systems.

The simulation process consists on 3 steps.

1. The coordinates c^i of the cell i are determined by random procedure. The probability of each cell choice is equal.
2. The coordinates of another cell for interaction are determined also by random procedure. We can use the different neighbourhood scheme (such as 4-, 6-,8-cells and others).
3. Both cells are interacts each other. That means that output characteristics (at the next time moment *t+1*) calculates with the help of interaction rules and input characteristics (at the time moment *t*).

The main difference of proposed simulation method is the peculiarities of the local interaction rules. We can represent the interaction rules as the system of iteration functions like

$$\begin{cases} c_j^i = F_j^i(c_1^i, c_2^i, \dots, c_N^i, c_1^k, c_2^k, \dots, c_N^k) \\ c_j^k = F_j^k(c_1^i, c_2^i, \dots, c_N^i, c_1^k, c_2^k, \dots, c_N^k) \end{cases},$$

where $j = 1,2,\dots,N$. The F-functions specific form depends on the system nature and possibility to decompose the complex system on the elementary interaction acts. So, in the common case, we need to define the F-functions as the superposition of the elementary interaction acts, which have a specific physical nature.

To demonstrate the abilities of the continuous nonsynchronizing CA we try to elaborate such CA models of the well-known systems such as: exponential dependencies, heat transfer, discrete and continuous diffusion, wave interference from two oscillation sources, discrete system, like Conway's Game of Life, behavior.

In all cases we obtain the results, which agree well with the classical methods (for example the solution of simple differential equations) or simple interference picture from two wave sources.

Like discrete system we've choose the "turbine" model and have obtained the usual step by step transformations. For this case the interaction rules have a form:

$$\begin{cases} c_1^i = c_1^i + c_1^i \cdot F1(c_2^i) \cdot P(c_3^i) + (1 - c_1^i) \cdot F2(c_2^i) \cdot P(c_3^i) \\ c_2^i = (c_2^i + c_1^{i+s}) \cdot (1 - P(c_3^i)) \\ c_3^i = (c_3^i + 1) \cdot (1 - P(c_3^i)) + 0.5 \cdot s \cdot (c_3^2 - c_3^1) \cdot D(c_3^1) \end{cases}$$

where F1 is the birth and F2 – destruction functions; P and D – time synchronization functions. We use only three layers for such systems simulation. The first layer describes the cells birth/destruction. The neighbour quantity is calculated in the layer two and the third layer used for time synchronization.

The next step in our calculations is the modification of classical “predator-pray” model to extend the functional possibilities of local interactions. Let us to consider the soil water as nutrition for the “predators” (i.e. “pray”). As a “predators” will be the individuals, which only consume the water to reproduction. Let us to consider the spontaneous soil water increase as the nutrition increase and the gradient water flow as the reason of the “predators” transference. Also the “predators” can bury oneself and soil can “fly level” than quicker, than faster “predators” buried. We provide also the competition mechanism, which consist of the better survival of those “predators”, which more effective bury in the soil. Without competition system dynamics will have wave-like character. With presence of the competition mechanism the system became the stationary character as a porous structure.

Emphasize, that procedure of the F-function specific form being, and parameters in the function are the empirical problem. The simulation success depends on the understanding of the system nature, decomposition possibilities and local interaction rules determination.

To conclude we can say that proposed model is the very useful method for dynamic system, self-organizing and evolution simulation. The main application of such approach is the open systems simulation. The physical properties of the system particles may the different character.