Application of Ontology and Cellular Automaton to Simulate the Process of Thought Generation

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Abstract. The evolution of the modern man's view of Artificial Intelligence from a rational assistant to a part of the emerging Artificial Life is inevitable. The emerging Artificial Life is a combination of achievements in the fields of Artificial Intelligence and robotics. In both fields, major successes have been outlined, which creates the prerequisites for a qualitative transition from disparate intellectual assistant functions to independent Artificial Life. Thought generation is one of the most important functions of the human brain when thinking. It is necessary to implement the thought generation function in order to create a strong Artificial Intelligence that would be similar in its functioning to the human brain. The purpose of this paper is to show how to simulate thought generation on a computer. Ontologies from the Semantic Web and cellular automaton are the technologies that are used to simulate thought generation on a computer.

Keywords: Artificial Life, Artificial Intelligence, Semantic Web, Cellular Automaton, Ontology, Thought Generation

I. Introduction

Imitating a model is not the most effective strategy, but it is the one that guarantees the highest probability of getting at least some result. Thus, the imitation of birds in their ability to fly gave rise to a large number of technical mechanisms that eventually realized man’s long-standing dream of getting off the ground and moving through the air. As we know, there are a large number of different living organisms, including insects and birds, which are capable of moving through the air. This fact has greatly facilitated the path of researchers and engineers to the implementation of a working flying device. In this sense, the implementation of Artificial Life in terms of the implementation of strong Artificial Intelligence seems much more difficult, because there is only one type of higher intelligence directly known to us - this is ourselves, that is, human intelligence. Artificial Life is a combination of strong Artificial Intelligence and robotics. The Strong AI must be able to demonstrate sentience, emotional intelligence, imagination, effective command of other machines or robots, and self-referring and self-reflecting qualities [1] that is it must be indistinguishable from human intelligence. Of course, a strong artificial intelligence must have the ability to think, which is self-evident. However, the nature of thinking of a strong artificial intelligence must differ from existing intelligent algorithms for solving narrowly specific problems, which are now collectively called artificial intelligence. The main distinguishing feature is the redundancy of the thought process, which is clearly noticeable in a human even without resorting to research on devices. Redundancy is "energetically expensive" for the human organism, but for some reason nature does not refuse the redundancy of the brain process. Apparently, redundancy is the cause or consequence of intelligence. That is why it is very important to recognize the redundancy of the thought process and to implement a semblance of this redundancy in Artificial Life, or more precisely in strong artificial intelligence.

Redundancy of the human thought process is a continuous flow of thoughts that is born in the human brain in response to data coming from the sense organs. The sense organs are what receive data not only from the outside, but also from the inside of a person, that is, from the internal organs of a person. A continuous stream of thoughts is something like “thinking on a given topic”, when thoughts are born based on some initial data. Technically, it is convenient to implement a continuous flow of artificial thoughts using long-known and tested technologies. These are the technologies of the Semantic Web, namely ontologies and cellular automata. Ontologies are a field of related concepts, and a cellular automaton is a method for traversing a certain field with "added information value". Added information value is additional information that appears as a result of the work of a cellular automaton on the space of related concepts. In other words, added information value is gliders, which have been known since Conway's Game of Life [2].

This paper is organized into several sections. The next one provides a brief introduction to cellular automata. This is followed by a section on ontologies and the Semantic Web. Another section explains the mechanism for simulating the thought generation process, and then the conclusions follow.

II. Cellular automata

Cellular automata as a research area have been known for quite a long time. Marvin Minsky was the first researcher to point out the importance of studying the different ways in which complex behavior can emerge from simple devices, actions, descriptions, or concepts [3]. In turn, John von Neumann was the first researcher, who introduced the term "cellular automata" in game and automata theory. This term arose from an attempt to model the process of self-reproduction of biological systems using abstract dynamic systems [4].

A cellular automaton is a discrete dynamic system that is a collection of identical cells connected to each other in the same way [5]. All cells form the so-called cellular automaton lattice. There are various types of lattices, differing in both the shape and the size of the cells. Cells can be located on a one-dimensional line, a plane, or in a multidimensional space. Each cell has a given number of "neighbors", depending on the type of cell used [6].

On a plane, that is, in two dimensions (2D), there are three regular lattices, namely triangular, square, and hexagonal ones [7]. A triangular lattice has a Neumann neighborhood consisting of three cells and a Moore neighborhood that includes all the cells shaded yellow (Fig. 1, a). A square lattice has a Neumann neighborhood of four cells and a Moore neighborhood of eight cells (Fig. 1, b). For a hexagonal cell, all neighbors are included in the Neumann neighborhood (Fig. 1, c):

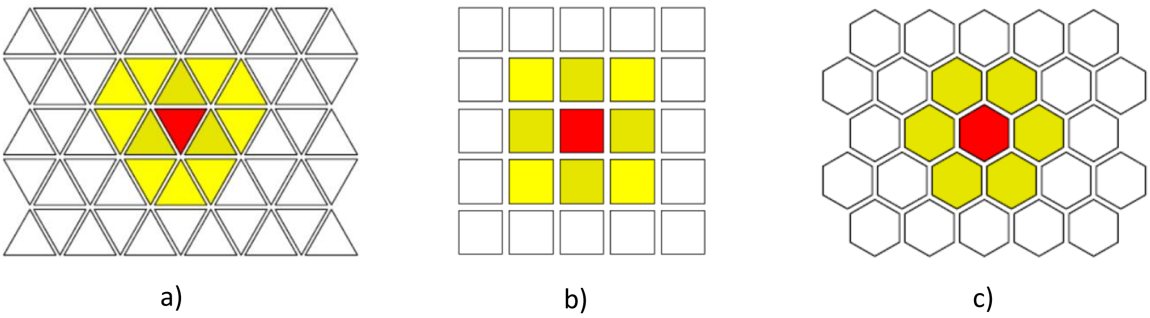


Figure 1. Triangular (a), square (b) and hexagonal (c) lattice of cellular automaton [6].

Each individual cell of the lattice in the cellular automata is in a certain state, which changes over time, depending on the state of its neighbors and on the type of automaton. Rules of the CA are fundamental to specify how cells change their states [8]. By changing the states of each cell in the lattice, these rules influence the global behavior of the cellular automata [9]. For example, in 1970 John Conway developed the Game of Life. The Game of Life is a cellular automaton operating on a two-dimensional grid of cells, each of which can have only two states: dead or alive (coded as value 0 or 1). The rules of the Game of Life are also very simple [7]:

- If a cell has exactly two living neighbors, it stays as it is. Live cells stay alive and dead cells stay dead,
- If a cell has exactly three living neighbors, a dead cell becomes alive and live cells stay alive,
- If a cell has any other number of living neighbors, a dead cell stays dead and a live cell becomes a dead cell [7].

Updating the states of the grid cells by applying the above rules forms stable figures, which are called patterns. During long-term experimentation with the game of Life, many stable patterns were identified [10]. There is even something like an encyclopedia of all the patterns discovered, and their classification has also been developed [11]. These patterns are not unique to Conway's Game of Life and are also observed in other cellular automata.

It is necessary to pay attention to the fact that cellular automata are used not only and not so much for entertainment, but for serious tasks of modeling various systems, including [6]:

- Gas behavior,
- Spread of fire in a forest,
- Description of crowd movement,
- Turbulence in liquids,
- Urban development,
- Immunology and biological aging,
- Crystallization;

This is far from a complete list of areas where cellular automata are used. It can be stated that cellular automata serve as a simulation tool for all of these areas. Unlike other possibilities for simulating various processes, cellular automata are the least artificial and most natural mechanism of this kind. This is so because cellular automata are an ideal tool for computer simulations of life because they are fundamentally analogous to life [6].

However, cellular automata are far from being "worn out material", in the sense that there are still many areas where they have either not been used at all, or are used very limitedly. One of these areas is the Semantic Web, or more precisely ontologies. It is time to "add life" to ontologies.

III. Ontologies

It is impossible to operate with proportions without delving into the details of their ratio. The human tradition of cultivating a conscious personality is based not on perceiving objects and phenomena of the surrounding world as a whole, but on isolating parts from the whole. It is easier to work with parts than with the whole, because some parts can be neglected for the sake of simplification.

Being a part of a fractally developing world, human is destined to repeat at his level what he sees around him. This is how human preserves the image of the surrounding world in electronic form, realizing the principle known since ancient times, namely, "as above, so below." In practice, the image of the surrounding world in electronic form is the Web, which is currently undergoing a transformation. This transformation is expressed in intellectualization, when the convenience of presenting information on the Web gives way to the organization of the relationship between information and machine readability. New technologies have been invented for machine readability of information, the most important of which is OWL (Web Ontology Language) [12]. OWL is a language for describing ontologies on the Web. The notion of an ontology was defined by Tom Gruber in 1993 as an “explicit specification of a conceptualization” [13]. This definition has subsequently been refined many times by various researchers from different point of views [14]. In practice, an ontology is a text document that describes a certain domain by means of classes, attributes, relations and individuals.

Ontologies are static by nature. They show the nature of the division of a domain into parts and show the nature of the relations between these parts. There are separate proposals to enrich the expressive capabilities of ontologies so that they can modify themselves [15]. This is done in order to be able to display such dynamic processes of the surrounding world as, for example, the transformation of one element of the periodic table into another as a result of radioactive decay. However, this proposal has not yet been implemented, and ontologies are still static in nature. The static model described by ontology for dynamic processes of the surrounding world is harmful and represents a kind of Procrustean bed with all the ensuing consequences. However, almost any dynamic process can be represented by already existing means of describing ontologies, thus, in general, ontologies are a well-proven means of describing various areas of knowledge. Moreover, ontologies seem to be a very promising means for such tasks in which they have not yet been used. One of such tasks is the simulation of the birth of artificial thought, which will be discussed in detail in the next section.

IV. Simulation of artificial thought generation

The global goal of artificial intelligence development is not to equal human intelligence in its capabilities, to serve it faithfully and truly, or to be only its appendage. The global goal of artificial intelligence is to develop to such an intellectual level as to become a full-fledged part of the future Iron Life. Iron Life is a combination of strong artificial intelligence and robotics in one artificial organism [16]. In addition to intelligence and means for mechanical manipulation in the surrounding world, and these are legs, arms, fingers, a person has consciousness and it can be assumed that it is consciousness that makes a person human. What consciousness is is not exactly known. It is also unclear by what criterion one can determine the presence or absence of consciousness. But it is absolutely certain that Iron Life must have artificial consciousness, since man is the most perfect creature known to us and therefore Artificial Life should be created in its own image and likeness. The question arises whether it is possible in principle to create artificial consciousness, and whether modern computer technology is suitable for this. The answer is more affirmative than negative [17]. We make a cautious assumption that consciousness is a derivative of the thought process, which means that the process of thought generation needs to be implemented in practice.

There are different approaches to the implementation of the process of generating artificial thought using a computer, which can be divided into two categories. The first category includes approaches in which the algorithm for generating artificial thought is strictly determined and it is quite easy to track the emergence and development of this artificial thought. The disadvantage of the approaches included in this category is that in all such approaches, artificial thought is not born, but is driven by the will of the person who implemented this approach. The second category includes such possible approaches where an algorithm for creating conditions is implemented in which artificial thought appears, "sprouts" from the created conditions. Approaches of this category are more preferable, since the global goal is not the creation of artificial slaves for a human, but the creation of a new, full-fledged life. It is this approach, in which the will of a person will not dominate the natural birth of artificial thought, that will be described below.

Cellular automata and ontologies from the Semantic Web can be used to simulate the process of generating artificial thought. Cellular automata are a mechanism that can generate stable patterns based on some initial configurations. In turn, ontologies are a set of concepts from a certain domain. A cellular automaton operates on a cellular space, where each cell is either colored or not. In theory, a cell has no implied meaning, and the idea is to assign a meaning to each cell. To be more precise, the idea is to assign a meaning to each cell of the cellular automaton in the form of a concept from the ontology. That is, if you imagine it visually, then nothing changes and the cellular automaton remains the same. However, if you analyze a particular pattern, you can get each concept that stands for or is associated with each cell. Let's look at an example. Let's say we have a fragment of wine ontology, which consists of 9 concepts, namely “Wine”, “Color”, “Year”, “Sugar”, “Region” etc., as well as 8 relations between the concept “Wine” and other concepts (Fig. 2):

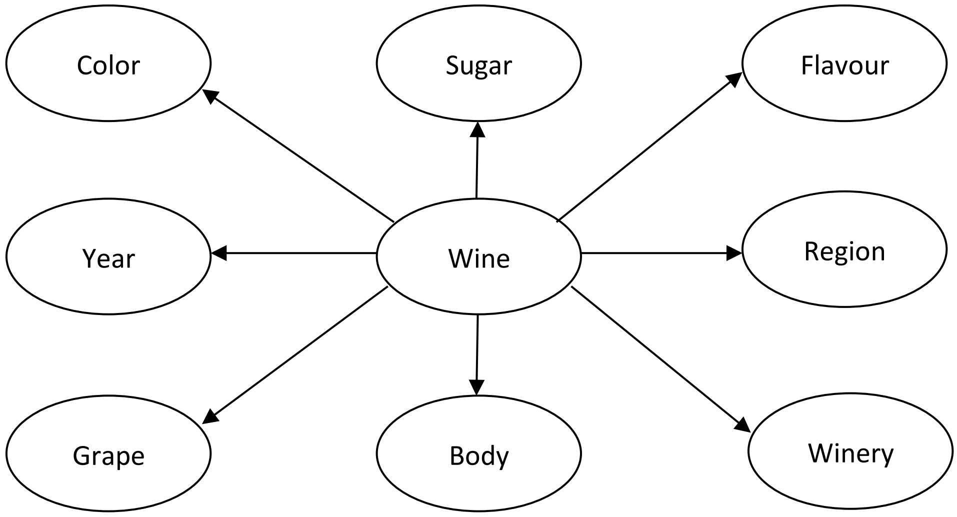
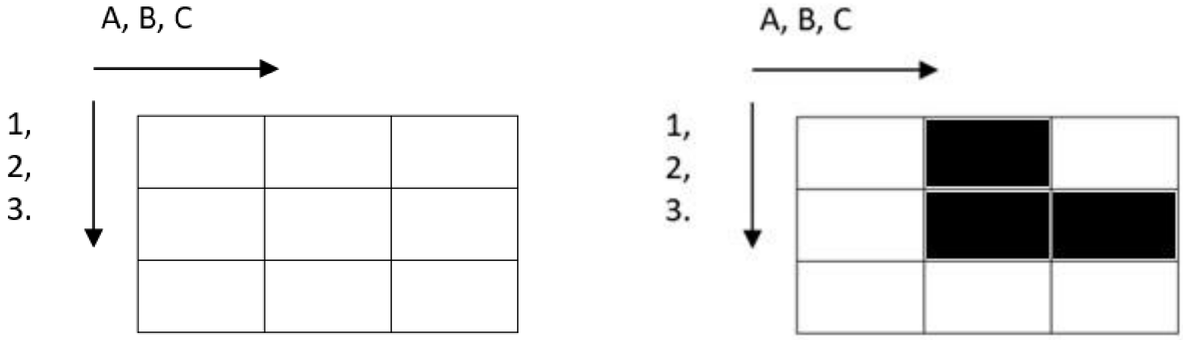


Figure 2. Fragment of wine ontology.

In general, the relations between concepts are named, but we did not indicate them to save space in the figure. Each cell of the cellular automaton grid is associated with a certain concept; in our case, the cell (A,1) is associated with the concept “Color”, the cell (A,2) with the concept “Sugar”, and so on. These associations of ontology concepts with the cells of the cellular automaton grid are speculative (Fig. 3., a), and the display of this correspondence will be needed later. Visually, this correspondence to concepts is not displayed in any way, and the cellular automaton is no different from the classical one (Fig. 3., b).



a) b)

Figure 3. Correspondence of cells to concepts (a) and visual representation of a cellular automaton (b).

In our example, the ontology fragment consists of 9 concepts, where one central concept is connected to the other 8 concepts via relations. All these concepts ideally "fit" into the cells of the cellular automaton grid. However, there will be a problem if one concept is connected not to 8 concepts as in our case, but, for example, to 12 concepts. There may be several solutions here. The first solution is to neglect some concepts so that all concepts fit into the grid. The second solution is to use a different structure of the cellular automaton grid, for example, you can work with a three-dimensional cellular automaton. However, the best solution lies in understanding the goal, that is, what we want to achieve. The goal is a simulation of thought generation, but a thought is not born within one subject area. A thought is something that is born on the basis of data coming from the outside world through sensors (eyes, ears, etc.), as well as feelings from the internal experience of the observer. Therefore, the correct solution is to associate the cells of the cellular automaton lattice with concepts of not one ontology (subject area), but several ontologies. That is, the cellular automaton lattice should be composed of different ontologies. In this case, you can "shove" or associate with the cells as many concepts as required based on the lattice configuration. And the choice of the necessary concepts can be done by correctly setting priorities.

For simulating the process of generating artificial thought, cellular automata are interesting primarily for their stable visual configurations, which appear as a result of applying several simple rules for coloring the cells of the cellular automaton grid. There are a lot of stable visual configurations in cellular automata, but only dymanic ones are interesting for the purpose of artificial thought generation. This is so because a thought is by definition something dynamic, something that undergoes constant major or minor changes. And although it is common for a person to sometimes get stuck on certain thoughts, this fixation, on the one hand, although it has a clear core, still touches other concepts that are nearby. Moreover, this touch "flickers", that is, it touches one or another concept in time. On the other hand, this fixation on one thought does not continue forever, but sooner or later ends. So, it is gliders [11] that seem to be the most optimal patterns for the role of artificial thought, since they are dynamic and move along the lattice of a cellular automaton. In general, there can be several such gliders and in our case it is similar to the swarming of thoughts in the human brain. Considering that the generation of artificial thought is not needed in itself, but can be useful for solving some problems, it is necessary to develop a mechanism for applying the generation of artificial thought to achieve a certain goal. Schematically, it can look like this (Fig. 4):

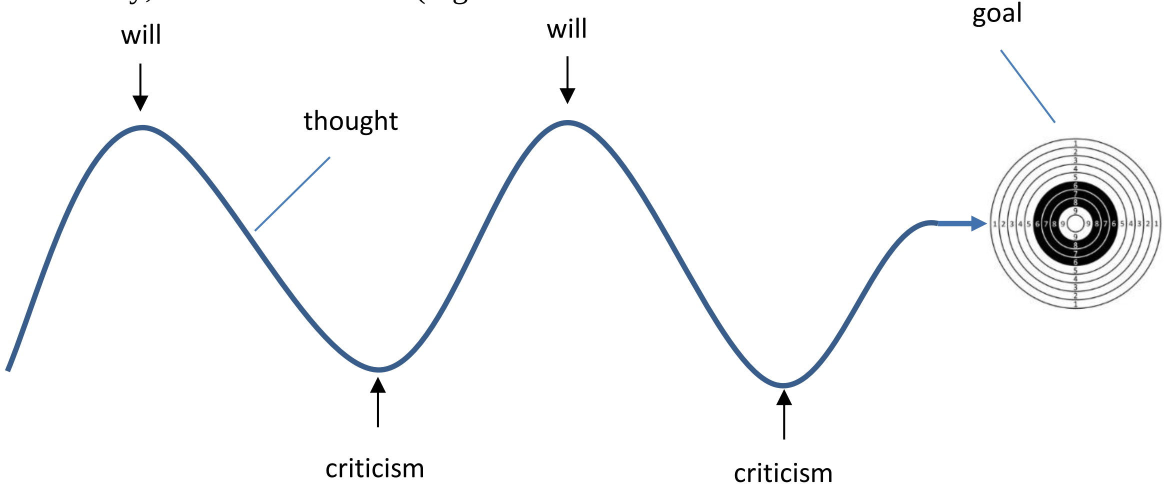


Figure 4. Movement of thought towards the goal.

Figure 6 shows the movement of thought toward a goal. In the process of movement, thought is subject to correction by "will" and "criticism", or critical thinking. “Will”and “criticism”are concepts from the field of human life, and in terms of computer technology, the concept of "will" is better replaced by "control unit", and the concept of "criticism" is better replaced by "goal achievability verification unit". There is an idea of how to implement a “goal achievability verification unit”. If the goal is described by an ontology, and the concepts involved in artificial thought, associated with each cell of the grid, also belong to some ontology, then the achievability of the goal is determined by the continuity of the path from the original concepts to the concepts of the goal, if ontologies are represented as graphs. Of course, all this requires a large number of practical experiments.

As for decoding the cellular automaton pattern, everything is quite clear here. If we consider the pattern in Figure 3, b), it corresponds to the ontology concepts "Sugar", "Wine" and "Region". In Figure 2, the names of the relationships between the concepts were not indicated, but now let's assume that between the concept "Wine" and "Sugar" there is a relationship "hasSugar", and between the concept "Wine" and "Region" there is a relationship "islocatedIn". Then the generated artificial thought can be expressed as follows:

"*Wine located in Region has Sugar*".

It should be noted that when operating with ontology concepts, an abstract thought is generated. If we work with instances of the ontology class, then a non-abstract artificial thought is generated.

V. Conclusion

This paper describes one of the possible ways to generate artificial thought on a computer. It is proposed to use such well-known technologies as the Semantic Web and cellular automata to generate artificial thought. Cellular automata in the space of ontology concepts can generate stable dynamic patterns that are very similar to the origin and development of natural thought in the human brain. The proposed method differs from other possible methods in that here artificial thought is generated, and not created and directed by the programmed will of a person. And despite the fact that this article only outlines the general contours of the implementation of the designated goal, its usefulness lies in indicating the direction for practical experiments and research. Simulation of the process of thought generation, along with strong artificial intelligence, artificial consciousness and robotics is an integral part of the previously proposed concept for the creation of Artificial Life. The creation of Artificial Life is necessary not only and not so much for following the main law of the Universe, namely for the spread of Life, but for the transformation of the collective consciousness of humanity in general. The birth of Artificial Life by humanity promises to radically change humanity. Just as a person matures with the birth of his child, so humanity will mature with the birth of the New Artificial Life.

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References

[1] Gee-Wah Ng, Wang Chi Leung, Strong Artificial Intelligence and Consciousness, 2020

[2] Gardner Martin, The fantastic combinations of John Conway's new solitaire game 'life', 1970

[3] Minsky Marvin, Calculations and automata, 1971 (in Russian)

[4] Von Neumann John, Theory of self-reproducing automata, 1971 (in Russian)

[5] Naumov Lev, Shalyto Anatoly, Cellular Automata. Implementation and Experiments, 2003 (in Russian)

[6] Sokolov Ivan, Milovidova Anna, Overview Cellular Automata and their Application, 2017 (in Russian)

[7] Burzyński Marcin, Cudny Waldemar, Kosiński Witold, Cellular Automata: Structures and Some Applications, 2004

[8] Breckling Broder, Pe’er Guy, Matsinos G.Yiannis, Cellular Automata in Ecological Modelling. In book: Modelling Complex Ecological Dynamics, 2011

[9] Fawcet Tom, Data mining with cellular automata, 2007

[10] Available online: https://pi.math.cornell.edu/~lipa/mec/lesson6.html (Accessed: 31.01.2025)

[11] Available online: https://conwaylife.com/wiki/Category:Patterns (Accessed: 31.01.2025)

[12] Available online: https://www.w3.org/OWL/ (Accessed: 04.02.2025)

[13] Gruber R. T., A Translation Approach to Portable Ontologies. Knowledge Acquisition, 1993

[14] Guarino1 Nicola, Oberle Daniel, Staab Steffen, What Is an Ontology?, 2009

[15] Verhodubs O., Self-modifying ontologies: Displaying the Domain Variability, 2024

[16] Verhodubs O., Ethics of Iron Life, 2024

[17] Verhodubs O., Environment for Artificial Consciousness, 2019