On the World’s Information Complexity

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Abstract

This article represents an attempt to formulate and to research the world’s information paradigm, which views the world as an information system, as an alternative to the material paradigm. We provide definition of the “information system”. After that, we use information models in an attempt to determine how these systems function. This analysis results in the definition of consciousness. Interaction between the information paradigm and the philosophy of idealism is studied. A definition of the complex information world is given, and this definition is used to formulate an information-based interpretation of quantum mechanics. In the end, we focus our attention on group evolution. We make a conclusion that this process represents an evolutionary explosion. We put forward a hypothesis that this can actually explain the rapid acceleration of development during the Cambrian explosion and now. We hypothesize that the planetary consciousness is about to emerge.

The World’s Material Paradigm

We use the term “material paradigm” to refer to a concept of the world as a combination of material objects in a three-dimensional space. Each such object in each moment of time has a limited, rigidly fixed set of attributes, such as mass, impulse, charge, position in space etc. This set clearly defines a material object. All changes of the object (attributes) are continuous and affected by forces (fields), acting in accord with the nature’s universal laws. We also suggest that a principle of locality is observed, when the object is influenced by its immediate environment.

In order to describe the world’s information paradigm, let’s start from a definition of the information system.

Information System

An information system, first of all, has memory – a combination of certain information units that are somehow addressed – memory cells, each of which may exist in one of the multiple states (for instance, 0 or 1). We will refer to the content of this memory as “the data”. Memory addressability – access to a certain memory cell at its address allows to change its content with a code: a set of instructions, implementing a certain data change algorithm. Accordingly, the information system must have a code execution system. Generally, the code may be stored in the information system’s memory and represent the data. From now forward, we will be looking precisely at these systems.

As a generalized characteristic of the information system, it is natural to introduce the idea of system’s resources, which we will understand as the amount of the system’s memory, containing the data (and the code). Additionally, the information complexity of the system is an extremely important feature of the information system.

In the algorithmic information theory, there is a concept of the object’s Kolmogorov complexity, which represents an amount of resources required for accurate description of this object. For x binary line – it is a length of the shortest p program, generating x. For instance, of two lines 64 symbols long:

```
abababababababababababababababababababababababababababababababab
4c1j5b2p0cv4w1x8rx2y39umgw5q85s7uraqbjfdppa0q7nieieqe9noc4cvafzf
```

the complexity of the first line is smaller, as there is a description, which is 10 symbols long: `ab 32` times. While for the second line, there isn't a shorter description than the line itself.

We use the idea of the information system's information complexity to refer to the length of the minimal program, able to generate the data, stored in the system's memory. In fact, it is an evaluation of the lower limit of the memory (resource) capacity, required for accurate reproduction of this system – such reproduction is impossible for the system with less resources.

The World's Information Paradigm

Within the framework of the information paradigm, we will view the world as an information system. In accordance with the above description of the information system, the world is a memory that stores the addressed data and an executable code that modifies this data. The definition of the information system also leads us to conclusion that any changes in the system are discrete, as they represent a transition between different states of memory.

We have covered all definitions and may now start our research of the world within the framework of this paradigm. However, we should say that this task is very complicated. This is because the real world is incredibly difficult, and, what is more, the person is an information object of the world that is directly involved in it. Besides, human consciousness is not adjusted to perceive the information, stored directly in any memory. For instance, if we open a file, containing a more-or-less elaborate photograph in a binary form in any editor, we will hardly find a person who, having recognized the format of the image, will tell us that these groups of zeros and ones represent a dog, and those ones – a ball. However, if we open the same file in any image viewer, anyone will immediately recognize the photo on the screen. This is in spite of the fact that perception of the image on the screen is a very complicated process per se. When the brain receives multiple nervous impulses from the retina's photoreception cells, which represent the result of transformation of electromagnetic radiation that reach it from a monitor screen, these nervous impulses are analyzed and interpreted by the brain. This example illustrates that, in fact, the information paradigm itself is absolutely not intuitive.

Therefore, in order to develop the information paradigm, we will use the method, which, for purposes hereof, we will call the "information reduction". To do that, we will use the most general ideas to project the simplest world, which we will try to analyze and then generalize. We do this hoping that there are some general regularities that govern the information systems.

The Developing World

For this purpose, let's consider the world that is a square, mapped with a net of a certain interval, having two dots in the nods – a red one and a green one. We will consider the green dot to be "alive". By "alive" we understand the following: it can move on the square in a certain time interval to one of the neighboring nods and experience "pain" when colliding with a red dot, a certain "uncomfortable feeling", the origin of which is initially unknown to the green dot. Moreover, it has a primitive perception system – it knows its position in the world at each moment of time. Now let's analyze what other properties the green dot has to learn to avoid pain. To do that, the green dot must, first of all, understand the reason of pain. Seemingly, the simplest solution is for it to remember the state of its internal world at each moment of time, such state defined by its position in the world and whether it feels pain at that moment or not. In other words, it must have a memory. This solution, in addition to being the simplest, is also the most general one. In this case, in certain time, the memory will accumulate the statistics, which would allow to recognize the reason of pain – the collision with a red dot. However, to do that, a certain recognition algorithm is required to make a selection from the memory of entries, where there is pain, and determine that the pain comes, when the green dot collides with a red dot. Now we need to preserve this knowledge in the dot's memory. Therefore, our dot knows the reason of pain (it understood the meaning that we assigned to the red dot), but still can't avoid it. In order to cope with this problem, it needs imagination, implemented via behavior planning algorithm. In this case – it is a simple search of possible future situations, where the internal world property values are generated for each imagined position, and the subsequent behavior is determined.

In fact, it is quite simple to program such a system, to write a computer program. When this program is launched, the operating system will allocate some random-access memory for its data, then the processor will start executing the code's instructions implementing the above-described algorithm, and these instructions will modify the data. This will result in our green dot living in its two-dimensional world. Its life will be a continuous stream of consciousness – a time cycle, when the information coming from outside will be interpreted, using its knowledge of the environment. The planning algorithm is used to select an optimal behavior in this situation and the memory will preserve the state of its internal world. When encountering the unknown phenomena of the external world, the recognition algorithm will be activated, which will use the memory to generate new knowledge on the environment and correct the behavior based on this knowledge.

Now, in order to provide a full description of the green dot, we should also add that it knows the reason of pain. That is to say, its information complexity increased.

We argue that the world in the information paradigm may evolve if it contains information subsystems, able to increase their information complexity through an inductive inference. And we also argue that such subsystems have consciousness.

Therefore, consciousness is an information system, which is a subsystem of another information system – the world it exists in. And which, in addition to other attributes of such system, may have interface procedures, providing access to some external memory. As well as the private part – a part of internal memory that can be changed only by the external world, which generates meanings and forms the attitude of consciousness to its environment.

The Information Paradigm and Berkeley's Subjective Idealism

Interestingly, our generalization of the model led us to the world that is very close to George Berkeley's philosophy.

Berkeley is one of the most consistent philosophers (he had a reason to claim that his philosophy is a philosophy of common sense). Berkeley's philosophical ideas are traditionally called subjective idealism. This definition of his philosophy is grounded on its central idea that all that exists – exists only in the spirits: the Divine and the human. Notably, the ideas (or what he normally refers to as things) exist in the Divine spirit in the permanent mode [1].

Berkley is confident of the following: the ultimately perfect God, who gives us our perceptions, is a credible source and criterion of objective veracity of our cognition. However, this doesn't mean that God introduces each and every idea in the human cognition. He puts in our soul all the elements of true ideas, i.e. a system of mutually agreeable basic concepts. However, the combination of these elements in complex representations according to the laws of association is a result of free activities of our mind, and it depends on us, whether to be wrong or to perceive in a true way, to realize or not to realize, which representations are reconciled with the general system of God-granted ideas and which are not. What we see in things as the acts of mechanical causality, is, in fact, caused by theological (purposeful) work of God's free will [2].

Here we see analogies between

- the spirit of the Divine and the human on the one hand, and the world as an information system with its memory and algorithms that change the state of this memory continuously, and the consciousness, which is also an information system,
- with ideas that exist in spirits and the information objects, stored in the world's and the consciousness's memory,
- by God that contributes all the elements of true ideas in human souls and gives food for the free thought, and the world – an information system that generates meanings, used by the consciousness to create the image of it in its memory through the process of cognition.

Therefore, despite of the fact that Berkeley's philosophy is a higher level of abstraction, despite the difference in approaches, the time of development etc., the common fundamental principles of the world's functioning are observed both in Berkeley's philosophy and in the information paradigm. We may even suggest that the information technologies and the information disciplines, such as the algorithmic information theory, are connected to the philosophy of idealism in the same way as physics is connected to the philosophy of materialism.

Complex Information World

Above we designed a world, where the consciousness has enough resources to cognize the world-generated meanings. We will now look at the situation when the world's information complexity exceeds the consciousness's resources significantly. It results in the fact that the consciousness can't construct an accurate image of the world. Henceforth, we will refer to such world as a complex information one in relation to consciousness, or, for the sake of brevity, a complex information world.

To illustrate that, let's again design another very simple world. It will again be a square, placed on the plane, mapped with a net of a certain interval. It will contain a broken curve that will approximate, say, a spiral that passes through N number of nodes and certain stretches – objects of consciousness that move around the square chaotically. When we say that the stretches are the objects of consciousness, we mean that they have memory, which keeps the data and the code, and this memory is very small. Small to such an extent that the memory, designed to accommodate the state of their internal world, is enough only to store the coordinates of the two nods on the net and a relation between the object of consciousness to the current situation. This relation is formed by the world and is at its maximum when the stretch aligns with one of the edges of the spiral. It is evident that in some time all the stretches will be positioned along the curve.

It is also evident that the consciousness in the complex information world interprets such world as one of its edges. Notably, this interpretation depends on the current situation and its uniqueness increases with the complexity of the world. In other words, the consciousness in this world is subjective.

The World's Information Paradigm and Quantum Mechanics

The effects, related to the world's information organization, may be seen at the quantum level.

First of all, it is manifested in quantization of the energy, discovered by Planck. In 1900, explaining the effects of black body radiation, Planck suggested that the electromagnetic radiation is released in the form of separate energy portions – quanta, the size of which is proportional to the radiation energy. This supposition is in perfect contradiction with the classical ideas – the world's material paradigm. However, it is perfectly natural for the information world, where all the changes are discrete as they represent a transition between different states of memory.

Besides, there are well-known non-locality effects, researched by Bell as part of his EPR experiment. Yet again, this non-locality is perfectly natural for the information world, where access to the information objects is performed using an address.

There is also an interesting interpretation of quantum mechanics by David Bohm. Bohm looks for the solution to the Schrödinger equation in polar coordinates. In this case, the Schrödinger's equation is split in two equations, one of which is a classical Hamilton–Jacobi equation, which, along with the classical potential, also contains another summand. David Bohm refers to this summand as a quantum potential that contributes to the system's behavior. For the case of a system with one particle, it means that its movement may largely depend on its distant environment. But for the case with two particles, in addition to dependence on the environment, there may be a strong connection between the remote particles. This interaction between them may be described as non-locality. Further elaborating this analysis, David Bohm concludes that the world is objectively integral (undivided) [3]. His book is called in this way – "The Undivided Universe". If we take into account that the evolution of the information world is implemented in a certain algorithm that changes the state of memory, we can argue that the concept of integrity applies to it in full extent.

But the most interesting thing is something called "wave function collapse". The theoretical quantum mechanics postulates that each physical value may be represented by a linear operator [4]. And that the measurement of the physical value, represented by such operator, may result only in one of the eigenvalues of this operator. Quantum mechanics suggests that the combination of eigenfunctions of any physical value creates a complete system. This means that any continuous function may be broken down by eigenfunctions with respective ratios. And if we break down the psi-function of a certain state of system, being the solution to the Schrödinger equation, by the operator's eigenfunctions, the measurement of this value will result in one of the operator's eigenvalues, and the probability of such result equals to squared absolute value with a respective eigenfunction in psi-function breakdown. In other words, psi-function, when measured, collapses to one of its eigenfunctions and a respective eigenvalue appears. Therefore, there is a significant difference between the quantum and the classical levels. On the one hand, we have a quantum world, described by a rigidly determined Schrödinger's equation. On the other hand, a classical probabilistic world. There are many interpretations of quantum mechanics, dedicated to explanation of this phenomenon.

We argue that the information paradigm allows to explain it in the most natural way. The information world has two types of systems and the corresponding processes. On the one hand, it is information processes of the world, strictly determined by its algorithms. On the other hand, it is processes of the consciousness, where the consciousness constructs an image of the external world, using the resources available. If the world is a complex information one in relation to consciousness, it is unavoidable that the objects of this world will be interpreted in the probabilistic way. In this case, the probabilistic nature of the results of measurement of the state of an elementary particle can be explained by the fact that the elementary particle represents a complex information object in relation to individual human consciousness, to the effect that it doesn't have sufficient resources to interpret it fully and unambiguously.

As we see the world's information paradigm as an alternative to the material one, we also consider a many-worlds interpretation of quantum mechanics, suggested by Everett in 1957, relevant for our analysis.

Everett argues that measurement doesn't result in selection of one of the possible results of the measurement and rejection of others. All alternative measurement results, foretold by quantum mechanics, remain equally valid, but each of them is implemented in its classical world, one of the many co-existing worlds (hence the name – "many-worlds interpretation"). That said, the observer's consciousness generates an image of only one of these worlds, or, in other words, only one of the many classical realities. The observer lives in one of the Everett's world and doesn't perceive the other worlds directly. However, each of these worlds (each of the classical realities) has a sort of a "twin" of this observer. To put it into a more correct way, the observer's consciousness is divided between the Everett's worlds (the classical realities) [5].

So there is a dichotomy: on the one hand, there is a multiple, possibly infinite, number of classical worlds, on the other hand – one, incredibly complicated information world. Considering this dichotomy, we should keep in mind the Occam's razor, which dictates that "Entities must not be multiplied beyond necessity."

Evolution of Consciousness

As we view the world as an information system, such world must comply with the principle of internal logical consistency. As programmers know well, such internal inconsistencies may lead to many troubles, such as infinite looping and even shutdown and crash of the system. Something that we never observe in the real world. Possibly, this explains the monumental part that mathematics plays in world cognition. This is because the proof of the consistency of statements principle forms the basis of the mathematics.

Additionally, as consciousness algorithms can be perfectly primitive at the lowest levels of the evolution, up to generation of random hypotheses on the world, it is inevitable that inconsistencies accumulate, which eventually must be solved by all means. This can be a profound, fundamental reason of natural selection. Additionally, in an infinitely complex world, rigidly focused on evolution, the exhaustibility of limited resources of consciousness naturally results in the finite time of its existence. So death is a natural consequence of the world's information complexity.

Now we will look at the group evolution of the objects of consciousness [6]. Let's imagine we have a group of similar objects of consciousness with unique resources and similar algorithms. In the diverse, changing world of complex information, the objects with a similar value system, (generated by the world), will aspire to position themselves in space in such a way as to make their emotional state the best. In other words, it is possible to speak on emergence of a range of similar objects – a space domain with their maximum concentration.

The external world of the object from this range will also consist from alike objects and, therefore, their cognition of the world will cover cognition of these objects, which means that a connection will be established between its emotional state and their behavior. Hence, it is possible to speak of the information exchange between them at the emotional level. Then, for instance, if a danger emerges somewhere at the periphery of a group of objects of the range (deterioration of the emotional state of the objects there), the whole group gets warned of the danger and seeks to avoid it. As a result, the emotional state of the object of this group will exceed the emotional state of a single object. This will lead to emergence of the group's system of values (aspiration to belong to the group), which will determine the behavior of its members. This will result in a more intensive rallying of the group and, naturally, in intensification of the mutual cognition process. Hence, this group may be seen as an object with primitive consciousness, whose system of values consists in aspiration to preserve their integrity.

The mutual cognition of the group of objects reaches its limit when there appears information exchange at the level of inner world concepts. In this case, a discovery made by one objects is used by others to plan their behavior (asynchrony of discovery generation is assumed based on their subjective consciousness). As a result, we will observe a rapid acceleration of development of the group's objects (proportional to the number of members). But imperfection, restricted algorithmic complexity of the mechanisms of the objects' consciousness (their inert nature, limited memory capacity, limited bandwidth of the perception mechanism), as well as their different position in the group (central and peripheral objects) will lead to their specialization. Which, in turn, will lead to a bigger influence of the group's system of values. Further development of the group and increase of specialization may result in appearance, for instance, of an organ (of a specialized subgroup of objects), which will be able to perceive the world at a different level. So it is possible that mechanisms of the group's consciousness may emerge, the development of which will be based on generation of discoveries by the objects, which form this organ (the system of values of these objects, conditional upon the group's influence, will be aspiring to maximize the efficiency of a respective mechanism).

Now we will try to provide numerical evaluation of the speed of the group's evolution in the complex information world. We will assume that the efficiency of the consciousness mechanisms increases with each discovery in proportion to the coefficient that is bigger than one. It means that the exponential increase of efficiency (on the assumption of permanent speed of discovery generation and growth ratio), i.e. this process, represents an evolutionary explosion.

It is possible that this may be used to explain the rapid acceleration of evolution at the time of emergence of multi-cellular organisms during the Cambrian explosion, approximately 542 million years ago. As well as the processes that take place on Earth nowadays (in particular, Moore's law).

Conclusion

In this article, we formulated and analyzed the world’s information paradigm. In contrast to the material world, the evolution of which represents a mechanical interaction of material objects, the information world, despite the simplicity of its organization (memory and algorithms, modifying the state of memory), is infinitely richer. It generates infinite ranges of meanings, which results in incredibly complex information processes that now lead to emergence of the Planetary Consciousness.

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