de Broglie Waves and a Complexity Definition

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Abstract

Today, the binary understanding of reality is increasingly significant. It is also the starting point for many theoretical considerations (mainly in the area of digital physics) describing the structure of the universe. What is lacking is an experimental confirmation of the binary nature of reality.

This article proposes an idea for an experiment that possibly would confirm the following hypothesis: Electromagnetic waves in the form of binary signals of appropriate complexity and other parameters are capable of creating observable, material objects.

Also suggested is the use of an Abstract Complexity Definition (derived from aesthetic field), presented in the Supplementary Material section.

Introduction

When in the past I dealt with visual perceptions,[1] I didn't suppose analyses of visual structures would take me for formulating the binary model of visual impacts and the complexity definition of a binary structure. It was surprising that the complexity of the visual structures expressed itself in such an abstract way. Then the idea arose that our entire reality (the universe) could have a binary structure.

As a result of a further search I learned that the binaryness of reality today is seriously considered by many prominent theoreticians; many speculations and hypotheses concerning the structure of the universe exist, mainly based on its binary-ness. (A brief overview of these views is presented herein.)

An attempt at experimentally confirming the binary character of reality was made recently. Raig Hogan has designed a device to detect the bit structure of space-time and measure its grain.[2]

The present article is also an attempt to share an idea for experimental confirmation of reality binary-ness.

Binary Understanding of Reality

Binary understanding of reality has a long history and it can be found in numerous philosophies, including Chinese Buddhism (Yin-Yang doctrine)[3] or, more contemporarily, in the philosophy of Leibnitz, who is also the creator of a binary system.[4]

I also investigated the views of contemporary theorists regarding this issue. Today, the binary construction of reality becomes increasingly significant, mostly due to the rapid development of information theory, quantum physics and cosmology. It is also in those areas where attempts have been made to provide comprehensive description of reality based primarily on its binary conception.

The possibility of associating binary structures with reality was already discussed by L. Bertalanffy in 1960.[5] According to Bertalanffy:

> Using the Turing machine, which is an abstract machine capable of printing or deleting 1 and 0 signs on an infinitely long tape, it can be demonstrated that it is possible to simulate any process of any complexity provided only that such process can be represented using a finite number of logical operations.

Stephen Wolfram believes today that it is possible to simulate any physical system provided a computer with sufficient computing power is used.[6] That view is also shared by many well-known physicists, especially those associated with digital physics.

Digital physics is a theory that suggests there exists, at least in principle, a program for a universal computer which computes the dynamic evolution of our world. For example, the computer could be a huge cellular automaton, as suggested by Zuse (1967),[7] or a universal Turing machine as suggested by Schmidhuber (1997),[8] who pointed out that there is a very short program that computes all possible computable universes in an asymptotically optimal way.

An advanced reality model based on binary archetypal objects was proposed by Carl Friedrich von Weizsäcker in his Theory of ur-alternatives (archetypal objects),[9] first publicized in his book *The Unity of Nature* (1980), and further developed through the 1990s.[10] This is also a kind of digital physics as it axiomatically constructs quantum physics from the distinction between empirically observable, binary alternatives.

Physicist Holger Lyre in his article "Quantum Theory of Ur-Objects as a Theory of Information" has interpreted Weizsäcker's theory in terms of information theory. Here information is taken to be the fundamental physical substance, whereas matter and energy are considered to be condensates of information.[11]

Some physicists (Ed Fredkin, Tom Toffoli) express the view that physical and computing processes are one and the same and that the universe simulates itself as a huge cellular automaton (Toffoli).[12] Frank Tipler is also in favor of identifying the universe with its own simulation.[13]

Nevertheless, contemporary physics theories do no resemble computer algorithms, because the variables found in them are subject to continous change. In particular, space and time are deemed to be continuous.

Richard Feynman[14] explains:

> The possibility for an accurate simulation to exist, for the computer to do the same as Nature does requires that everything taking place within a limited space and time be capable of exact analysis using a limited number of logical operations. Currently theories of physics do not satisfy that condition. They treat space as infinitely divisible.

On the other hand, the continuity of space and of time are just postulates. They cannot be proven, since we will be never sure that at some even lower scale, far below our observation capacities, space and time are nevertheless discrete. The connection between natural and computing processes is further strengthened by the quantum theory, which reveals that many physical variables, believed earlier to be continuous, are, in fact, discrete.

The binary understanding of reality, either as computing processes simulating reality or as binary objects forming basic components of the universe and matter, underline all the views presented here.

Applying the Complexity Definition to Confirm the Hypothesis

Now let us consider the following hypothesis: Electromagnetic waves in the form of binary signals of appropriate complexity and other parameters are capable of creating observable, material objects. This hypothesis is based on the assumption that reality is binary in nature and that the binary structure (string of zeroes and ones) is its model. If the assumption is correct, there may be a transition from the abstract model to material reality.

Let's try to make such a transition from the binary structure to the material object. To make the structure real and useful, it would be necessary to impart some energy to it. Such energy-bearing binary structures already exist. These are digital signals that are used for data transmission in, for example, telecommunications. These waves, however, carry only binary codes—the sets of contract sequences of zeroes and ones. To make the wave structure more closely resemble the reality structure, it should be treated as an autonomous system of a certain complexity. However, it would be still an electromagnetic wave and not a material object. The de Broglie hypothesis[15-18] is useful. If in accordance with the de Broglie hyphothesis the wave was treated as a wave of matter, we might begin to wonder what criteria must be met in order to become a distinguishable material object. Apart from the basic wave parameters—such as length, frequency, amplitude, energy—one should also take into account the complexity that responds to the complexity of the material object associated with it. Material objects are still more or less complex systems.

At this point, I would suggest the use of the Abstract Complexity Definition, which seems to be the most useful. This definition, although abstract, stems from the perception of visual structures and therefore has a relationship with reality. It also complies with all the intuitive criteria related to the complexity meaning and lets us create binary structures of any complexity using appropriate algorithms. (The full definition can be found in the Supplementary Material that follows.) The experiment that confirms the hypothesis would be to issue waves of varying complexity (and other parameters) and subject them to observation for material objects.

Conclusion

I realize that the idea of experiment presented here is general and the experiment preparation wouldn't be easy. However, this concept could be a starting point to move on with the possibility of using the suggested complexity definition as a tool.

What degree of complexity and other parameters of the wave emitted would make it possible for us to observe some material objects? Perhaps a series of properly prepared experiments could provide the answer. In order to design and conduct such experiments, it would be necessary to secure the participation of experts, primarily from the fields of quantum physics and information theory.

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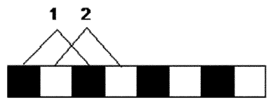
Abstract Complexity Definition (Supplementary Material)

Introduction

The complexity definition has appeared during my analysis of visual structure perception (Stanowski, 2005). The binary model of visual impacts finding was essential here for a possibility of the general (abstract) research. The Abstract Complexity Definition is one of the research results.

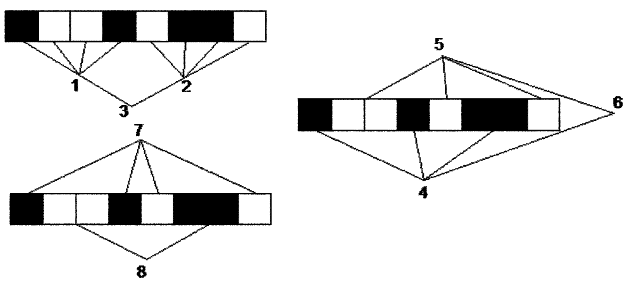
The difficulty of defining complexity is well characterized by Francis Heylighen (1999). Complexity has turned out to

I.



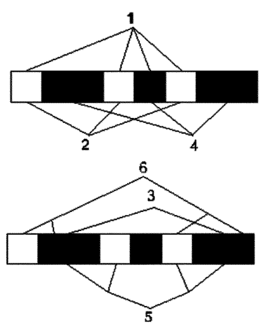
In structure I
1. black elements
2. white elements

II.



In structure II
1. symmetrical elements marked 1
2. symmetrical elements marked 2
3. 1 and 2 symmetrical to 3
4. black elements
5. white elements
6. 5 and 4 show symmetry of black and white ones
7. single elements
8. double elements

III.



In structure III
1. single elements
2. white elements
3. double elements
4. black elements
5. symmetry - two black ones and one white
6. same two elements

Figure 1. Counting substructures in three binary structures basic elements) composed of black and white squares

be very difficult to define. The dozens of definitions that have been offered all fall short in one respect or another, classifying something as complex which we intuitively would see as simple, or denying an obviously complex phenomenon the label of complexity. Moreover, these definitions are either only applicable to a very restricted domain, such as computer algorithms or genomes, or so vague as to be almost meaningless. Edmonds (1996) gives a good review of the different definitions and their shortcomings, concluding that complexity necessarily depends on the language that is used to model the system. Still, I believe there is a common, "objective" core in the different concepts of complexity (Heylighen, 1999, p. 3).

Binary Model of Visual Impacts

In my analyses I have been investigating the impact (the effects) of visual structures using examples characterized by various complexities (Stanowski, 2010). Despite a great diversity of impacts analyzed in them, all of them conformed to the same principle of contrast. I looked for an example which could provide a representative model for these impacts. Such an example was found among the most simple and abstract structures, that is structures made up exclusively of two different types of elements, *i.e.* binary structures.

Let me define more precisely the necessary meanings concerning a binary structure:

1. *Binary structure* (binary string) – sequence of 0's and 1's, *e.g.* 101101110011101101.
2. *Basic element* – each 0 or 1. There are 18 basic elements in the structure.
3. *Element* – distinctive basic element or group of basic elements, *e.g.* *1*011*0*11100*111*01101.
4. *Substructure* – distinctive group or arrangement of elements, *e.g.* distinctive group of double elements: 10*11*0111*00*1110*11*01, increasing arrangement of elements: *10110111*0011101101. In a particular case, when only one element has a particular feature, *e.g.* single: 1100*1*00111000, we count it also as substructure.

What makes any substructure distinctive is that all elements of the substructure have the same (common) feature. That is, elements which are double (*e.g.*, 11 or 00) have the feature "double" or "doubleness" and belong to substructure "double elements."

Elements which consist of zeros (*e.g.*, 0, 00 or 000) have the feature "zero" or, let's say, "zeroness" and belong to substructure "zero elements." For example: substructure "double elements" in the structure 101101110011101101 (below), contains all those elements which are "double," while substructure "zero-elements" in the same structure contains all those elements which consist of only zeros. One may notice that element 00 belongs to both substructures because it has the features "double" and "zero." We can also say that the element 00 connects these two structures. For a better understanding, let's count all the substructures in the structure: 101101110011101101.

1. Single elements *1*011*0*1110011*0*110*1*
2. Double elements 10*11*0111*00*1110*11*01
3. Triple elements 10110*111*00*111*01101
4. Elements "0" 1*0*11*0*111*00*111*0*11*0*1
5. Elements "1" *101101110011101101*
6. Increasing arrangement in *10110111*0011101101 the first eight basic elements
7. Decreasing arrangement in 1011011100*11101101* the last eight basic elements
8. Symmetry of the structure 101101110 011101101

There are eight substructures in the structure. Notice that the number of substructures is the same as the number of features of the structure.

Consider another example: we may count the substructures present in three binary structures (each with eight basic elements) composed of black and white squares (Figure 1). Structure II has the most substructures, *i.e.* as many as eight. This is due to this structure's having the greatest number of linkages, and arguably the optimal organization of elements. Note: The method of counting substructures presented should be treated as merely an approximation because it fails to account for the degree of distinctiveness of particular arrangements. Nevertheless, it is sufficient for our purposes.

Abstract Complexity Definition

By limiting the inquiry to the simplest abstract binary structures, it is possible to unambiguously determine the number of substructures within these structures. Once the number of substructures is known, it is possible to also specify the degree of complexity of the structure.

It is intuitively obvious that a structure which has more substructures but the same number of basic elements is a more complex one. As a measure of the degree of complexity, it is therefore possible to use the ratio of the number of substructures of a given structure to the number of its basic elements.

$$D = \frac{N}{n}$$

D – degree of complexity of structure
N – number of substructures of a given structure
n – number of basic elements

According to Heylighen (1999, p.3), one of the important criteria of complexity is that "a system would be more complex if more parts could be distinguished, and if more connections between them existed."

The degree of complexity (D) relates to better organization (number of connections), while the number of substructures/parts (N) relates to the number of distinguished parts. Consequently, the complexity (C) of a structure would depend on the degree of complexity (D) and number of substructures (N).

$$C = \frac{N}{n}\ N = \frac{N^2}{n}$$

C - complexity of a structure

I call the complexity (C) Abstract Complexity (*i.e.*, the product of the degree of complexity and the number of substructures/features).

Returning to the Heylighen (1999) article: Let us go back to the original Latin word complexus, which signifies "entwined," "twisted together." This may be interpreted in the following way: in order to have a complex you need two or more components which are joined in such a way that it is difficult to separate them. Similarly, the *Oxford Dictionary* defines something as "complex" if it is "made of (usually several) closely connected parts." Here one finds the basic duality between parts which are at the same time distinct and connected. Intuitively then, a system would be more complex if more parts could be distinguished, and if more connections between them existed.

More parts to be represented means more extensive models, which require more time to be searched or computed. Since the components of a complex cannot be separated without destroying it, the method of analysis or decomposition into independent modules cannot be used to develop or simplify such models. This implies that complex entities will be difficult to model, that eventual models will be difficult to use for prediction or control, and that problems will be difficult to solve. This accounts for the connotation of difficult, which the word "complex" has received in later periods.

The aspects of distinction and connection determine two dimensions characterizing complexity. Distinction corresponds to variety, to heterogeneity, to the fact that different parts of the complex behave differently. Connection corresponds to constraint, to redundancy, to the fact that different parts are not independent, but that the knowledge of one part allows the determination of features of the other parts. Distinction leads in the limit to disorder, chaos or entropy, like in a gas, where the position of any gas molecule is completely independent of the position of the other molecules. Connection leads to order or negentropy, like in a perfect crystal, where the position of a molecule is completely determined by the positions of the neighboring molecules to which it is bound. Complexity can only exist if both aspects are present: neither perfect disorder (which can be described statistically through the law of large numbers), nor perfect order (which can be described by traditional deterministic methods) are complex. It thus can be said that complexity is situated between order and disorder, or, using a recently fashionable expression, "on the edge of chaos" (Heylighen, 1999, p.3).

Let's consider the characteristics. What is suggested is that the parts/substructure distinction is in opposition to their connections or even exclude each other: quite independent gas molecules can't be completely bound crystal molecules at the same time. Only the compromise "the edge of chaos" could be possible here. Our considerations deny such reasoning.

In our analyses distinguished parts/substructures such as white elements, double elements, symmetry of elements etc., comprise what we can call connections between them. Connection of elements is not in opposition to their distinction, but makes the distinction even stronger. Consider two elements which have common and different features, *e.g.* substructure of double elements connect different elements which have the common feature "doubleness. The common features attract those elements making the different features of the contrasting elements stronger. Without connection different features wouldn't even be noticed.

In the example of structure II (Figure 1): substructure "double elements" connects substructure "white elements" and substructure "black elements" (directly double white and double black, and indirectly single white and single black); "symmetrical elements marked 1" connects substructures "single black," "single white" and "double white," indirectly also substructure "double black."

It is also easy to see how components are "entwined" here, and how difficult it is to separate them without destroying the structure.

One can also see duality between parts which are at the same time distinct and connected. Such duality is possible because each element belongs to more than one substructure (has more than one feature).

Conclusion

The definition is not a speculative one. It is based on the model of visual impacts which is directly connected with nature of our perception.

The field of visual perception has been not explored yet enough, but it seems to be very useful and profitable for further analyses, for such fields as language, biology, society and physics.

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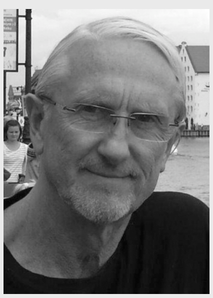

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