

TOPOLOGY AND THE INFORMATION STRUCTURING

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Abstract: In this paper, we aim at a dynamical, structurally-phenomenological approach, from a multidisciplinary point of view, starting from today's information technology and from the last theories of the second half of the 20th century, which are connected to non-linear dynamics, fractal geometry, topology and complex systems theory. Shannon and Weaver's information theory grasps only the quantitative aspect, through associating information to entropy and the second law of thermodynamics, so that only artificial languages and information technology finally implement the qualitative aspect of information. The proof that information is involved in all the processes, at all scales and levels of reality, is the very difficulty of defining information. The network topology, just as the knot theory in the information technology, highlight an apparently surprising aspect, that is, topology is the suitable mathematical instrument for formalizing information. Topology of information might represent the modality of grasping information in its qualitative form, as the way to unify reality, and reality with cognition, through information.

Key-Words: Information, topology, reality, cognition, energy, brain.

1 Introduction

With the development of Information Technology, a paradox is more and more outlined in the epistemology of the last decades. For over a hundred years, we continue to speak about substance and energy, wave and corpuscle, we built numerous hypotheses and theories, but we always had the feeling that there is something which eludes our grasp. The hypotheses of hidden variables, of quantum potential, of sub-quantum potential, of the fractal potential, the conservation law, the spontaneous symmetry breaking, the complex systems dynamics and the nature of the emergence

phenomenon are all concepts which cannot be well-defined without the involvement of information, as an essential component, along with substance and energy in the structuring of reality.

Since the middle of the last century, the theory of information formulated by Shannon and Weaver [12] identifies only the quantitative aspect, through the association of information to entropy and the second law of Thermodynamics, so that only artificial languages and Information Technology really raise the profile of the qualitative aspect of information. The proof that information is involved in all

processes, at all scales and reality levels, is the very difficulty in defining information.

Surprisingly though, at the same time with the discovery of the importance of information in the last half of the 20th century, another mathematical concept was developed, namely Topology. Although the bases of Topology were laid in the 18th century by Euler and although it was used by all the greatest mathematicians, it was only the Bourbaki Group that highlighted the importance of the topological approach, starting from the 1950s.

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2 Information. Definitions

In an etimological sense, the information is what gives shape to the spirit. It comes from the Latin verb *informare*, which means "to give shape" or "to form an idea on something". The perception on the information is heterogenous, the concept of information being a subject for reflection and analysis in information theory, communication theory, knowledge theory, logics, semantics, philosophy, theology etc. Mainly, data forms information and information constitutes knowledge. Actually, the phenomena is not reduced only to an inclusion of a field into another. The information needs data and operation and memory systems, whereas knowledge supposes an accumulation of information, but also of superior psychological systems, such as generalization, abstractization, synthesis, correlation and significance. This diversity under which information is presented determines both the defining difficulty and a unitary understanding of its significance at different levels of reality.

Upon attempting to structure the multiple informational approaches, Introna [6] distinguishes two archetypes: the informational and the communicational one. The first was patented with the explosive development of informational technology and is connected to the making (development) of "productive" informational systems. The second has its origins in the communicational frame of Shannon and Weaver [12], being less important in the informational system field, but it is more widely accepted in the communication theories. Similarly, Stonier [9] considers that the fundamental aspect of information is connected to the fact that this is not a mental construction, but a fundamental property of the Universe. Any general theory of information must start with the study of the physical properties of information, as it is manifested in the Universe. This action must be taken before attempting to understand the variants and the more complex forms of human information. The next step must involve the examination of the evolution of informational systems beyond the physical systems, first in biology, then in human, cultural area.

A fundamental trait of information is connected to its subjectivity. Whatever can be information for a person can mean nothing to other people. Whatever is considered as information for a person can be data for another person. On the other hand, starting from the same set of data, different individuals, through different processing, can infer different information. If the data has a physical, tangible existence, the information exists only with the receptor, thus it is intangible. Information is the product of human or artificial intelligence and what constitutes information for one person can represent mere data for another person.

The scientific approach of the information theory starts from the classical opinion that mathematics is the general language of nature. The structure of the Universe is written in the mathematical language, and its letters are geometric forms, symbols and mathematical relations. Tegmark [10] considers that at the basis of reality there are mathematical structures and the relationships between them and that elementary particles are mathematical structures which can be perfectly described only by mathematical properties. Thus, these mathematical structures and the relationships among them define what we call today information, whereas science does not do anything else but decypher the information contained in the structure of the matter,

by physical-mathematical modeling. According to this paradigm, information is to be found in nature, outside of, beyond and independently of the observer. As a consequence, information must have existed before the appearance of human conscience.

To put it different, information is the fundamental component of reality, such as matter and energy, as the nature is filled with information. On a larger scale, information exists before, or, in other words, knowledge is "more fundamental" than its observer and interpreter. Thus, the reunited concepts of matter (substance and energy) and information can explain the emergence, the forming, structure and dynamics of mind and knowledge, but also of the whole structure of the Universe. Information has an objective natural existence; people absorb it in their minds and the computer memory modifies and multiplies it through thought and bring it to society via the language.

No matter how difficult the definition and significance of information is, a possible modality of understanding what information represents in its essence is to be able to define the connection between energy, substance and information.

3 Information and topology

Topology studies the space deformations through continuous transformation, practically-speaking the properties of sets which remain unchanged at some transformations. Motion is a fundamental aspect of the real world and any elaborate study of dynamics leads to topology, which has many subfields:

- *General topology* - establishes the foundational aspects of topology and investigates properties of topological spaces and concepts inherent to topological spaces. It includes point-set topology, which is the foundational topology used in all other branches;
- *Algebraic topology* - measures degrees of connectivity using algebraic constructs such as homology and homotopy groups;
- *Differential topology* - deals with differentiable functions on differentiable manifolds. It is closely related to differential geometry and together they make up the geometric theory of differentiable manifolds;
- *Geometric topology* - primarily studies manifolds and their embeddings in other manifolds. A particularly active area is low-dimensional topology, which studies manifolds of four or

fewer dimensions. This includes knot theory, i.e., the study of mathematical knots.

Topology can be expressed in different ways in: topological quantum field theory: Quantum topology, Topological defect, Topological entropy in physics, Topological order, Topological quantum number, Topological string theory, Arithmetic topology etc.

Applications of the topological ideas appear in chaos theory, molecular biology, where the description and analysis of twists and deformations of the DNA molecule needs topological concepts. More specifically, the so-called knot theory facilitates the understanding of the way in which the two spiral chains (that make the double helicoidal structure of the DNA molecule) can be unfolded when the genetic plan controls the development of the living being.

Starting from quantum microcosm towards our Newtonian reality, we find the information under the same topological forms at every scale. Atoms form molecules and macromolecules, whose spatial configuration suffers topological modifications which grant them some properties. Organic macromolecules in protein and enzyme form "ship" the information to cellular receptors, under the form of topological structures. Any modified radical determines a reconfiguration of spatial structures, which generates a certain property necessary in the chain of metabolic transformations which in this way are topologically equivalent, as they are obtained through topological transformations.

Any biochemical structure represents a graph, every cellular structure represents a network which forms knots and whose dynamics can be described by the network topology, which explicitly mentions the vicinities of every point. All this information comes from the structure of the DNA. The latter, apart from the succession of nitrate bases which form the genes, has a topologically-complex structure, in agglomerations which form the chromosomes, but which also influence the coding functions. The same information transmission mechanisms from DNA to RNA messenger and RNA ribosome and the constituting of protein and neurotransmitters we can also find within the structuring and functioning of the nervous system. Here we find networks, knots, graphs, thus topological transformations. All these represent only one part of the reality. According to wave-corpucle duality, atoms, molecules, macromolecules etc. have also a wave part, they are

practically doubled by a spectral reality, of the electromagnetic field.

Topology is used also for establishing the projecting manner of a network. In order to highlight the physical (real) and logical (virtual) inter-connections between the knots, one can distinguish two corresponding types of topologies: a physical and a logical one, respectively. The physical topology of the network refers to the configuration of the transmission environments, of computers and peripheral devices, whereas the logical topology represents the method used to transfer information from one computer to another. Domain theory developed within lattices represents a modality of modeling the topological concepts in a computational form, which allows for the processing of information.

4 The role of topology in the triad substance, energy, information

Coming back to the wave-corpuscule problem, an analysis of the particle behavior can be made from the fractal space-time perspective, with the unpredictable and non-linear evolution, allowing that, on the basis of Shannon's informational theory, we connect it to entropy and further, through a maximizing process, to the informational energy in the Onicescu's sense [8] (see also Agop *et al.* [1]). There still remains an essential question: where can we find information in quantum dynamics (Heisenberg [5]). It must be present both in the wave structure and in the particle properties. This connection cannot be made otherwise than in the phasic component of the wave, which is to be found in the spinning of the particle and which allows for the transfer of information from the spectral reality to the corpuscular reality, as it is demonstrated by the Fourier transform and the inverse Fourier transform. The phase is given by the magnetic component of the electromagnetic field and it represents the unpredictable, potential part, described by the complex function of Schrödinger's wave formula, as these characteristics can be explained both through the fractal theory and through the topological transformations supported by the phase from the electromagnetic wave, respectively by the spin from the particle description.

The spinning motion is mathematically modeled using complex analysis. This model is dynamic, as it undergoes transformations at the level of topological

dimensions through the successive passage from the topological dimension 0 (of the point) to the topological dimension 1 (of the line) etc. Thus, a complex, infinitely-dimensional space is obtained, which explains the difficulty of highlighting the informational component. The successive passage through Euclidean, fractal and topological dimensions determines a quantitative, but also qualitative dynamics of energy. The moment in which this qualitative diversity is expressed is given by the moment of the topological transformations at every dimension. This diversity which is practically unlimited renders quality, apart from quantity, to energy in its dynamics. From the complex systems perspective we can find, in the statements above, the main characteristics specific to complex systems: non-linear dynamics, fractal geometry, with a latent informational energy which is potential, along with a dynamics of a practically infinite diversity, obtained by topological transformations in the phase complex space.

Obviously, there exists structural information which, along with energy and substance, structures the matter at different scales and aggregation states. It is a structural information, which is achieved through topological transformations in fractal dynamics and even in Euclidean dynamics. The topological space represents the place where information gains diversity, whereas energy gains a qualitative character. Qualitative variations of energy appear here, which constitute the informational energy or the psychological energy at mental level. Jung [7] (on unconscious and archetypes) considers that the psychological energy is a form of energy described through qualitative, not through quantitative ones, as physical energy was described.

5 Information and topology – involved in brain functioning

Information represents codified energy, expressed as pattern, structure templates, initiated by attractors which are active in the phase space, between the chaotic part and the structured one. Information is stored in the spectral space and it expresses the patterns in the structure of atoms, molecules, macromolecules and cells, organized as networks (Barabasi [2]). It has a potential existence expressed by substance and energy under conditions of local coherence.

In everyday life, today, in the information technology era, the information is transmitted via waves, by their analogical transformation into waves which modulate a carrying wave. Modulation can be of the amplitude (little employed because it is too easily affected by noise, but anyway the amplitude is in inverse ratio to frequency), the generally-employed modality is that of angle modulation, which presupposes a modulation of either the frequency or of the phase, which is finally transmitted to the modulation of the magnetic vector angle. The phase is known as an imaginary, complex component of the wave formula. The movement of the magnetic wave described by complex equations generate a complex plan, which connects the wave to the complex space and allows for the storage of information in the topological modifications from this infinitely-dimensional space. To put it different, the information in the complex systems is to be found in the complex space, which gives the characteristics of potentiality, non-differentiability, a-causality from the description of complex systems. Coming back to the plasma tubes, the privacy of the system from which information comes is represented by the coherent wave phase with every particle (the wave corresponding to every particle from the wave-particle duality) which represents the connection to the complex space, where the whole physical reality is to be found at the potential mode, under the form of information. This is the consequence of permanent dynamics between the complex and the real space, by means of information. Depending on the system's constraints from the complex space through the wave phase, the information which reaches the particle generating the auto-structuring patterns is undertaken.

In the complex systems' structure there is a potential part with a chaotic aspect and a structured, causal, newtonian part, as well as different intermediary phases. It results that a certain uncertainty exists in all the structure of reality. Moreover, we find the uncertainty principle (Heisenberg [5]) in Gabor's theory of communication (the information quanta). At brain level, the non-linear, potential, apparently chaotic part corresponds to the unconscious, whereas the structured, causal part corresponds to the conscious; the intermediary parts, as well as the structures which process both the information from reality and from the unconscious, all are represented by what Freud called SuperEgo.

The chaotic part is structured via attractors, depending on the constraints of the system (for example, the way in which some physiological needs generate, during the dream, a certain structure). During the wakefulness there is a dynamics with the chaotic, potentially unconscious part in the background and which allows accessing the information, the memories, the logical links (for example, a discourse) (see Crumpei *et al.* [4]).

We must therefore accept that, also in the living world, including the brain functioning, there exists a spectral, wave component and the transmission of senses is achieved spectrally, by vibrations (de Valois and de Valois [11]). Thus, a reality which coexists with us is the a-spatial a-temporal one, described by the wave formula and which is involved in the visual perception phenomenon, in which the undertaking of the spatial-temporal information is made by light through modulation of its frequency, a phenomenon which is described by the Fourier transform, while the stimulation of the retina involves the collapse of the wave formula and the emergence of corpuscles which stimulate the retina cells using the inverse of the Fourier transform. As a result, all we look at and see, in order to be seen, goes through an a-temporal and a-spatial phase, in the interval necessary for the light to reach from the object to us. This interval can be billion of light years for cosmic objects or minutely small fractions of a second when we look at our friends, our home or our garden.

A virtual, Newtonian reality as projection of physical reality is completed by the unstructured, a-causal, apparently chaotic component: the imagination, the dream, the failed acts, the subliminal mechanisms, the unconscious etc., which can be associated with the causal, potential, unstructured and non-differentiable component of complex systems, the source of inspiration, of creation and of access to non-Euclidean realities to holospace.

These potentialities can become conscious through patterns (see Jung's archetypes and collective unconscious [7]). They can be found in logical, algorithmic, organized and systematic form in everything that is creation (from making a speech, conversation, improvisation, to creating new musical pieces, new artistic work, new scientific work).

The chaotic, unpredictable part does not only contain the Newtonian reality to which we have access, but more, maybe even the structure of the whole Universe, at informational potential level. The

brain has access to the implicit part (Bohm's implicit reality [3]), if we associate this part to what is called

unconscious.

6 Conclusion

Nowadays, the topological approach is used starting with the string theory to the quantum field theory, in the fluid and complex systems dynamics and to the relativist theories which assume a differential, Riemannian topology, whereas in Mathematics, both Algebra and Differential Geometry are involved in Analysis. Practically speaking, just as information, topology is present at all scales and levels of reality. Network topology, the knot theory of the Information Technology highlights an apparently surprising aspect, the fact that topology is the mathematical instrument suitable for the formalization of information. That is the reason why defining the topology of information could represent the modality of encompassing information under its qualitative aspect and a way of unifying reality through information.

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