An Approach on Information from Topological View via Complex Systems Theory

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Abstract: In this paper, we highlight the fact that information represents informational energy in the sense of Onicescu. Information is expressed by topological patterns and configurations that are scale invariant and also by dimensional levels. Together with substance and energy, information represents an ontological triad. The topological patterns can be found in a fractal form in the substance structure (through a spatial metric) and in the corresponding spectral field (through an angular metric).

Key–Words: Information; Topology; Complex systems theory; Fractal; Energy.

1 Introduction

In an etymological sense, 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 as heterogenous as possible. The concept of information is 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.

Information is concentrated in the wave phase, in the complex plane of the magnetic vector, where it is connected with the complex space which in our view is a physical space, not an abstract one. Here, all Universes information can be found in a potential form. In the real space, any corpuscular network is doubled by a spectral one, with whom it is coherent. In consequence, the neuronal network is doubled by a spectral one. The dynamics between them gives the mental function. The mind-brain duality becomes two aspects of the same physical phenomenon, the neuronal network and the corresponding spectral one. Information gives the dynamics between the two networks and it represents what we call consciousness (see Crumpei *et al*. [8] for more details).

2 What is information

The theory of information is connected to Shannon and Weaver [10], who defined information as an entity which is neither true nor false, neither significant nor insignificant, neither credible nor doubtful, neither accepted nor rejected. As a result, it is not worth studying anything else than a quantitative component of information, but not also the semantic part, which allows for the association of information with the second theory of thermodynamics, with entropy, the information or the quantity of information being in inverse ratio with it.

Weaver connected Shannon's mathematical theory with the second thermodynamic law and asserted that entropy is the one which determines the information generation ratio.

The formula of information is identical to the one of entropy elaborated by Boltzmann, but considered with a minus sign, where p represents the probability

of an element or event k within the system

$$H = -\sum_{k=1}^{i} p_k \log p_k$$

Information is thus entropy. Onicescu [9] also formulated the hypothesis regarding the fact that the degree of organizing a system can be measured with the help of informational energy, thus defined, where p represents the probability of appearance of event A.

$$E = -\sum_{j=1}^{n} p_j^2(A)$$

This quantitative approach of information is applied in the field of telecommunication and of information technology. The qualitative aspect of information is generated by topology which organizes the informational dynamics and explains the unity of reality from the informational point of view since topology is scale invariant.

From the qualitative point of view, information is made up of energy patterns situated at different topological configurations. According to the quantitative approach, besides entropic elements, information is implied in fractal dynamics, the topology of geometrical space interfering in dimensional change.

In our opinion, topology is implied in all scales and reality levels using string theory and quantum physics. This offers a new perspective of wave-corpuscle duality, as well as considering the molecular, biochemical, biological and mental levels. Information is permanently retrieved within topological dynamics.

To define information is not easy task due to the diverse forms in which it can be expressed and identified. Information represents codified energy expressed as pattern, structure templates, innitiated by attractors which are active in the phase space, between the chaotic part and the structured one. Information lies stored in the spectral space. It expresses the patterns in the structure of atoms, molecules, macromolecules and cells. It has a potential existence, expressed by substance and energy under certain conditions of local coherence (see Agop *et al*. [1-6] for more details).

3 The place of information in the wave-corpuscle duality. Informational non-differentiable entropy

The analysis of wave-corpuscle duality in de Broglie's [7] theory involves the simultaneous existence of two types of motions: a deterministic, predictable one, associated to a continuous motion of hydrodynamic type along a continuous line, specific to the corpuscle character, and a zig-zag, random and unpredictable motion, specific to the wave.

de Broglie's model [7] introduces the two types of motion as hypotheses. The real problem, how much it is wave, how much corpuscle, as well as the wave-corpuscle structural compatibility (the structure of the wave should be compatible with the corpuscle structure) has not been solved yet.

A new approach of the problems involved in the wave-corpuscle duality resides in supposing that the motion of a particle takes place along continuous and non-differentiable curves. This means passing from a classical approach of movement within an Euclidean space to a non-conventional, non-standard approach, with the assumption that the motion takes place within a fractal space-time.

The mean value of the non-differentiable potential - the imaginary part of the scalar potential of the complex speed,

$$\phi_N = \Im\mathrm{m}\,\Phi = D(dt)^{(\frac{2}{D_F})-1} S_Q,$$

can identified, without a constant factor, with the informational non-differentiable entropy

$$I_N = \langle \phi_N \rangle = \int \exp S_Q \cdot S_Q d\mathbf{r}$$

The correlation between informational non-differentiable entropy and informational non-differentiable energy implies specific uncertainty relations through a maximization principle of the informational non-differentiable entropy and for a constant value of the informational non-differentiable energy.

Accepting a maximization principle for the informational non-differentiable entropy

$$\delta I_N = \delta \int \exp S_Q \cdot S_Q d\mathbf{r} = 0,$$

for constraints with radial symmetry, we get

$$\exp S_Q = \exp(-\frac{r}{r_0}),$$

with $r_0 = \text{const.}$

In a fractal space-time, substituting this value in the expression $-\nabla Q$, with Q the specific fractal potential (the specific non-differentiable potential), we find the force:

$$F(r) = -\nabla Q(r) = -\frac{4m_0 D^2 (dt)^{(\frac{4}{D_F})-2}}{r_0} \frac{1}{r^2}$$

Therefore, the informational non-differentiable entropy stores and transmits interactions in the form of forces through a maximization principle.

We consider the probability density in the phase space, $\exp S_Q(p,q)$ with the constraints

$$\begin{aligned}
\iint q \exp S_Q(p,q)dpdq &= \overline{q} \\
\iint p \exp S_Q(p,q)dpdq &= \overline{p} \\
\iint (q-\overline{q}) \exp S_Q(p,q)dpdq &= (\delta q)^2 \\
\iint (p-\overline{p}) \exp S_Q(p,q)dpdq &= (\delta p)^2 \\
\iint (q-\overline{q})(p-\overline{p}) \exp S_Q(p,q)dpdq &= cov(p,q).
\end{aligned}$$

We introduce the informational non-differentiable entropy

$$I_N = \iint \exp S_Q(p,q) S_Q dpdq$$

Using the principle of maximum informational non-differentiable entropy with the above constraints, we get the normalized Gaussian distribution

$$\begin{aligned}
&\exp S_Q(p-\overline{p}, q-\overline{q}) \\
&= \frac{\sqrt{ac-b^2}}{2\pi} \exp[-H(p-\overline{p}, q-\overline{q})] \\
&H(p-\overline{p}, q-\overline{q}) \\
&= \frac{1}{2}[a(p-\overline{p})^2 + 2b(p-\overline{p})(q-\overline{q}) + c(q-\overline{q})^2] \\
&a = \frac{(\delta q)^2}{\Delta}, b = -\frac{cov(p,q)}{\Delta}, c = \frac{(\delta p)^2}{\Delta} \\
&\Delta = (\delta p)^2(\delta q)^2 - cov^2(p,q)
\end{aligned}$$

In this way, the set of parameters (a,b,c) has statistical significance.

For the informational non-differentiable energy, we use a generalization of Onicescu's relation

$$E = \int\limits_{-\infty}^{\infty}\int\limits \exp 2S_Q(p,q)dpdq$$

In such context, the informational non-differentiable energy corresponding to the normalized Gaussian distribution becomes

$$E(a,b,c) = \int\limits_{-\infty}^{\infty}\int\limits \exp 2S_Q(p,q)dpdq$$

where $H(p,q) > 0$ is a condition imposed by the integral.

We get

$$E(a,b,c) = \frac{\sqrt{a\,c-b^2}}{2\pi}$$

and, therefore, if H has energetic significance, it results that the informational non-differentiable energy is an indication of the dispersion distribution, since the quantity $A = \frac{2\pi}{\sqrt{a\,c-b^2}}$ is a measure of ellipse areas of equal probability (or of equal non-differentiable entropy) $\exp S_Q = \text{const.}$

If the informational non-differentiable energy is constant, we get the egalitarian uncertainty relation

$$(\delta p)^2(\delta q)^2 = \frac{1}{4\pi^2 E^2(a,b,c)} + cov^2(p,q)$$

or the non-egalitarian one

$$\delta p \delta q \geq \frac{1}{2\pi E(a,b,c)}$$

On the basis of the non-predictable component, one can define a fractal entropy in Shannon's sense and a fractal informational energy in the sense of Onicescu.

Using a maximization principle of fractal entropy in Shannon's sense, one can demonstrate that if the fractal informational energy in Onicescu sense is constant, the ratio between the corpuscle energy and the frequency of the associated wave is a constant at any resolution scale.

As a result, the wave-corpuscle duality is achieved through motions on curves of informational energy constant in Onicescu's approach (see Agop *et al.* [1-6] for more details).

4 Information as an expression of topological transformations. Different levels of reality

Topology studies the deformations of the space 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.

Applications of topology appear in chaos theory, quantum fields theory, molecular biology, where the description and analysis of twists and deformations of the DNA molecule needs topological concepts. The topology of knots enables us to understand the way

in which the two spiral chains which make the double helicoidal structure of the DNA molecule can be unfolded when the genetic plan controls the development of the living being.

The topological transformations are scale invariant. The topological transformations represent energy patterns, configurations through which information is expressed. Irrespectively of the level of reality and of scale, the information has as an underlayer these topological transformations. There exists a 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 is the place where information gains diversity, whereas energy gains a qualitative character. The whole collection of the analyzers manages the transfer of information from its wave form into the corpuscular form.

The information processing is accomplished in a corpuscular, (neuronal) network, but also in a spectral network, of the coherent field associated to the neuronal network.

The complex systems dynamics and especially that of the complex and of the real space (from the inner part of the systems) explains the structure of psyche and its functioning.

Through the waves of the spectral field, the dynamical link to the complex space is realized. This allows for the occurrence of the superior psychic processes, which are specific to the human being and which need multidimensional development in order to be formed, a situation which is only allowed by the complex space.

The mental reality represents thus the permanent dynamics between the neuronal network, the associated spectral field (the fractal potential) and the infinite dimensional complex space.

5 Conclusion

The complex systems theory sustains the hypothesis of the complex space as a physical one.

Information can be correlated to substance and energy by applying the complex system theory, complex analysis and topology. Information can be found in the complex space of the wave phase spectral field. As a result, this complex space can be found anywhere and at every level of the reality. In our view, it is infinite dimensional, as it can contain all the information in the Universe. The real space is included in and intertwined with the complex space generated by the electromagnetic waves.

At quantum level, this intertwining can be achieved by the collapsing of the wave formula into the complex space of the wave phase and it can be transmitted into the complex space of the spin rotation, by transferring the whole information.

This phenomenon is specific to reality at the level of the whole knowable universe, as everywhere there are electromagnetic waves and also at every level of the reality, including the human brain. There is a deeper layer in quantum mechanics, which makes possible a deeper physical description of the world based on information (i.e., the spectral information network) and which has an important role in highly organized complex life systems. The consequence is the ubiquity of information, just as the substance and energy, both at the level of microcosm and at macrocosm level.

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