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Researches on Three Laws of Theoretical Informatics

Liu Jun-feng，Gao Hong，Jin Xin-zheng

Medical information department, Tongji Medical College, Huazhong University of Science and Technology, wuhan430030, China

windygh@163.com

Abstract: *This paper conducts the researches on the three laws of informatics proposed by Zong-Rong LI using the method of analogy with thermodynamics. The three laws of theoretical informatics are: the information being nonconservation; information energy increasing with time; information increasing with no upper limit. These three laws are keys of the information ontology research. They show up the character and relationship of information, entropy, negentropy, and information energy.*

Keywords: Informatics, Information energy, Entropy, Negentropy

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1. Introduction

Bioinformatics, chemical informatics, medical informatics, computer informatics etc. domain informatics are proposed and develop rapidly with the requirement of each subject, but the theory of informatics lag behind badly. At today's perspective, the history of information research has emerged at least three kinds of information science, and they are: "Computer and Information Science", "Library Information Science" and "information science theory of probability." Now, every subject of “information science” is developing, but from the perspective of axiomatics, none of them have established a convincing theory of information. The above is the theory of information science research status in quo [1]. This status restricts the development of the informatics, and also domain informatics without guide theory and research method can’t develop further.

[1] Yan Xues-han. (1999). Some Viewpoints on the Development of Information Science in the 21st Century. *Science and Technology Review,* (8):3-6.

2. Informatics analogy with thermodynamics

It may get a certain rational knowledge on unknown object easily by compare it to the more familiar one. This is a common soft science research method, analogy.

Thermodynamics developed from the late 18th century. Energy exists in many forms, such as heat, light, chemical energy, and electrical energy. Energy is the ability to bring about change or to do work. Thermodynamics is the study of energy. As a basic theoretical subject, it sets the physical limits for the evolution of and the developments in the world around us. Wiener proposed the triadic theory, that is, material, energy and information are the three elements of the universe. Thermodynamics discussed the material and energy and the trend of heat energy evolution reflects the direction of universe evolution to a certain extent. However, informatics discussed information and energy, and information evolution is the essence of the whole universe evolution. Therefore, we can study informatics by analogy with thermodynamics.

The researches of carrying on the analogy of informatics and thermodynamics are so many. A famous research is information entropy proposed by Shannon, also called Shannon entropy, which is got by comparing with thermal entropy. Entropy in thermodynamics is a total number of energy that can't work in the dynamics, also used to calculate the disorder and complexity of a system. The concept of entropy first created in thermodynamics in 1864 by Clausius, and later, it was first introduced to the information theory in 1948 by Shannon. In information theory, it means an uncertain extent of a matter. Its formula is $I = \lg(p)$. p is probability of a matter. Oded Kafri said, "A unification of thermodynamics and information theory is proposed."[2]

3. First Law of Informatics: information being nonconservation

3.1. The first law of informatics

The First Law of Thermodynamics says, energy can be changed from one form to another, but it cannot be created or destroyed. The total amount of energy and matter in the Universe remains constant, merely changing from one form to another. In the basis of the analogy with reverse thinking way, we can get the First Law of Informatics. Information and information processing ability is nonconservation. This conclusion can be validated by the history of nature and human. Arcady R. Mushegian and Eugene V. Koonin report that gene order is not conserved in bacterial evolution in 1996[3]. The evolution of kinds of species, the increase of the hereditary information in DNA, the advancement of civilization of human, the creation of language and letter, which show the process of information from null to being. However, the extinct race and passed history validate the information from being to null, which is representative of the disappearance of information.

3.2. The increase of information

American scientist Derek John de Solla Price proposed quantitative measures of the development of science, and used the

[2] Oded Kafri. (2007). *The Second Law and Informatics.*
[3] Arcady R. Mushegian. (1996). Eugene V. Koonin. Gene order is not Conserved in Bacterial Evolution. *Trends in Genetics,* 12 (8):289-290.

exponential curve to describe the model of scientific growth[4,5]. According to the statistics of science and technology intelligence system of world “by UNESCO ", it finds that the annual growth rate of science knowledge was 9.5% in the 50s, 10.6% in the 60s, 12.5% in the 70s, and more at present. The quantity of science and technology literature double per 7–10 years, and the tip sciences and technologies such as the quantity of microelectronic technical literature, double in two or three years. Also, from the appearance of cells to the production of multicellular organism, the birth of animal, the higher animal and human, the growth of life information appears a exponential curve.

3.3. The aging of information

With the new information created continually, the old information is incessant aging and washed out in the end. The expression ‘half-life’, borrowed from physics, has appeared quite frequently in the literature on documentation since 1960, when an article by Burton and Kebler on The ‘half-life’ of some scientific and technical literatures was published, although it had certainly been used previously. Burton and Kebler point out that literature becomes obsolescent rather than disintegrating (as in its original meaning), so that ‘half-life’ means ‘half the active life’, and this is commonly understood as meaning the time during which one-half of the currently active literature was published. Numerous studies have been carried out, mainly by the analysis of citations, to establish obsolescence rates of the literature of different subjects. The statistics shows, at the beginning of the 20th century, the half life of new technology and new product was 40 years, about 15 years in the 50s, 8-9 years in the 70s, and much shorter in the 80s.

3.4. The replication of information

Basically, any information are found in a particular carrier. So, as long as the materials which store information are replicated, the information can be replicated and conserved too. In the nature, the duplication of DNA keeps the biology information to transmit to the descent.

4. Second Law of informatics: information energy increasing with time

4.1. Entropy and Negentropy

The Second Law of Thermodynamics can state in three equivalent forms: 1.Heat flows spontaneously from a hot body to a cool one. 2. One can’t convert heat completely into useful work. 3. Every isolated system becomes disordered in time. In the thermodynamics, there is a value judgment “energy depletion leads to entropy increase”. Excessive entropy production is reflected in natural disorders such as the greenhouse effect, ozone holes, environmental pollution, etc. In 1943 Erwin Schrödinger used the concept of “negative entropy” in his popular-science book named “What is life?”. In which he writes, "It is by avoiding the rapid decay into the inert state of 'equilibrium' that an organism appears so enigmatic....What an organism feeds upon is negative entropy.[6]" Schrödinger uses it to identify the

[4] D. J. de S. Price.(1951).Quantitatives Measures of the Development of Science. *Archives Internationales d´Histoire des Sciences,* (14): 85-93.

[5] D. J. de S. Price. (1956).The Exponential Curve of Science. *Discovery,* (17): 240-243.

[6] E. Schrödinger. (1944).*What is Life-the Physical*

remarkable ability of the living system, not only to avoid the effects of entropy production - as dictated by the second law - but to do just the opposite, to increase organization, which intuitively, seems like the converse of entropy.. The term, “negative entropy” was later shortened into “negentropy” by Leon Brilloui[7]. A meaningful interpretation of negentropy is that it measures the complexity of a physical structure in which quantities of energy are invested, e.g., buildings, technical devices, organisms but also atomic reactor fuel, the infrastructure of a society. In this sense organisms may be said to become more complex by feeding not on energy but on negentropy.

4.2. The Negentropy Principle of Information

The statistical definition of information is compared with Boltzmann's formula for entropy.

$$I=k\ln\left(\frac{\Omega_0}{\Omega_1}\right)=S_0-S \qquad (1)$$

$$S=S_0-I \qquad (2)$$

The immediate result is that information I corresponds to a negative term in the total entropy S of a system [7]. A generalized second principle states that S must always increase. If an experiment yields an increase ΔI of the information concerning a physical system, it must be paid for by a larger increase $\Delta S0$ in the entropy of the system and its surrounding laboratory. The efficiency ϵ of the experiment is defined as

$$\epsilon=\Delta I/\Delta S_0 \leq 1 \qquad (3)$$

Moreover, there is a lower limit kln2 (k, Boltzmann's constant) for the $\Delta S0$ required in an observation. Some specific examples are discussed: length or distance measurements, time measurements, observations under a microscope. In all cases it is found that higher accuracy always means lower efficiency. The information ΔI increases as the logarithm of the accuracy, while $\Delta S0$ goes up faster than the accuracy itself. Exceptional circumstances arise when extremely small distances (of the order of nuclear dimensions) have to be measured, in which case the efficiency drops to exceedingly low values. This stupendous increase in the cost of observation is a new factor that should probably be included in the quantum theory.

4.3. The Second Law of informatics

The information energy can be regarded as the useful information obtained from a fuzzy set. This concept was first introduced by Dumitrescu[8] in 1977. The information energy of a fuzzy set is a local measure, since it is an integral in a considered interval. The larger the size of the considered interval, the more we get from the interval for the information energy.[9] On the basis of the discussions of the previous sections, the second law of informatics said negentropy increase in an open system, the information energy is increasing with time too.

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[8] D. Dumitrescu. (1997). A Definition of an Informational of Energy in Fuzzy Sets Theory. *MathSciNet,* (22):57–59.

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4.4. The ability of self-organization of information

4.4.1. Self-organiztion in physics

Dr. Prigogine's dissipative structure theory shows that the condition of self-organization in physics is in an open system[10]. Only in open system condition, there is entropy exchange between system and external environment, and when external world inputs enough negentropy to system, the total entropy of system decrease, then the system moves towards a more order state, which is a process of self-organization. Synergetic theory established by Hermann Haken involves more inherent mechanisms of self-organization structure: competition and co-operations among related parameters domination factors. There are frequently competitions and co-operations among many elements in the open system and these interactions change the order degree continuously, which is called self-organization.

4.4.2. Self-organization in biology

Self-organization in biology is the organism controlling its body and physiological reaction by itself, in here, the organism is a system. For example, DNA transmits its information to descent and leads the protein to synthesize through the process of copy, transcription and translation. The whole process is controlled by the complicated hereditary information on the DNA. Self-organization and self-adaptation of unicellular organism were all finished independently by itself. Multicellular organism forms an integrated mechanism of self-organization, self-adaptation and self-creation, which is on the basis of self-organization and self-adaptation of a single cell.

4.4.3. Self-organization in sociology

In fact, the self-organization in sociology is culture. Human information can be divided into two levels, signal and symbol. The signal was used by all living beings, but the symbol is peculiar to human being. Culture can be isolated from human organism and be process alone. It has particular courses and laws of its evolutionary process, which are store, duplication, transmission and innovation. This process is self-organization in sociology and it is controlled by the symbol information[11].

4.5. The ability of self- adaptability of information

The self-adaptability means to adapt the environment through evolving the structure and function of body. Organism has strong self-adaptability. The key of the process of self-adaptability is information and feedback. And the nerve is just the carrier of information in organism.

Look at the neural developing history: The protozoon does not include the neural composition at all, and just relies on plasm to experience stimulation directly, transmit information and react. Coelenterate, for example hydra has differentiation of sense cell and effector cell, and gangliocyte between them. Gangliocytes combine together into a neural network by its filamentous synapse. The annelid

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represented by earthworm, has a pair of big nerve node on head, called ganglion suprapharyngeale. And it's the initial form of brain. Nervous system is the leader of whole organism on vertebrate. The evolution of brain is shown as the development of cortex. The cerebral cortex is divided into new and old cortex and they control the different function respectively. In higher mammal, especially the mankind, the development of brain is nearly explosive, and almost reaches the peak of perfection.

The evolution course of nervous system reveals it evolve from nonexistence to existence, from simplicity to complexity, from decentralization to concentration, then concentrate towards head, then cortex, until corticalization. It is obvious to find that the requirements of information processing are the motivity of evolution.

5. Third Law of Informatics: information increasing with no upper limit

The Third Law of Thermodynamics refers to a state known as "absolute zero." This is the bottom point on the Kelvin temperature scale and is mathematically the lowest possible temperature in the universe. The third Law of Informatics says any information content can be reached. In another words, information can increase with no absolute upper limit. This statement is similar to the first one. But it is more definite to describe the trend of quantity of information.

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About the author

Liu Jun-feng

a second-year graduate student of Huazhong University of Science and Technology of China.
Address for correspondence：
Medical information department, Tongji Medical College, Huazhong University of Science and Technology
Wuhan, Hubei 430030
People's Republic of China
E-mail: liujunfeng0628@163.com
Tel: (86) 027-83692526