

The Emergence and Development of Theoretical Informatics

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Abstract : *At present, information technology is developing very rapidly. Numerous traditional disciplines have to be informationized and domain informatics derived from it. It calls for the emergence of theoretical informatics because of the need of domain informatics, National Informatization and the transformation of industrial society to an information society. However, present information theory has limitation, for example, the Shannon communication theory only applies to communications. In this paper, we use the system engineering theory. Firstly we study the background of the theoretical informatics. Secondly we analyze the status of it and the limitation of present information theory. And then we discuss the hotspots of the theoretical informatics both at home and abroad. At last, we point out that the development of it should break out the shackles of theoretical paradigms.*

Keywords: Theoretical Informatics, Domain Informatics, Shannon Communication Theory, Unified Information Theory

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1. Introduction

In the history of the development of science, the crisis of the basic theory is a common phenomenon on the road of subject's process. There were three times of crisis of the basic

theory in the flush development of Math¹. On the road of the development of information science, we are experiencing the most serious crisis of basic theory in the human civilization and the history of scientific development.

¹ Zhang Shun-yan. (2003). *the Sources and Flow of Mathematics* . Beijing : Higher Education Press.

There are not only scientific crisis, the scientific paradigm crisis, but also a crisis of Philosophy, the world outlook and methodology crisis. The establishment and improvement of theoretical informatics, which acts as the basic theory of the whole information science, is the main symbol of the development and maturity of knowledge system of information science. Because the complete knowledge system of information science has not been established in our information society; meanwhile, the research objects of present domain informatics are special and the throughway is limited by physical paradigm, it is impossible to uncover the general principals of different information phenomenon. So the development of the theoretical informatics is the despairing need of the development of science and the progress of society². What is the theoretical informatics? How did it engender? What is the current development of it? All of the above problems were expatiated in this paper.

2. The overview of theoretical informatics

The research object of theoretical informatics is information and information energy of general meaning, its research content is the regulation in cosmos which function in the whole information phenomenon, its research method is the procedure and the rule which can universally apply in all kinds of information processes, its research target is to establish public theoretical foundation for domain informatics to lay foundation for the whole information science and also provide science

² Yan Xue-shan. (1999). Some Viewpoints on the Development of Information Science in the 21st Century . *Science and Technology Review*, (8):3-6.

reference for information philosophy³.

3. The background of the engenderer of theoretical informatics

3.1 Numerous domain informatics needs common theoretical foundation

In the process of constructing theoretical system of domain informatics, the first problem we met is the definition of domain information which is distinguished from particularity of general information definition. The second problem is the expression of basic principle of domain informatics, which is the start of the theories or pre-established problems. The resolution of these issues is subject to the development of theoretical informatics⁴.

3.2 "National Informatization" requires theoretical informatics

In the 1960s, the scholar in countries like America and Japan propose a theory and method of measuring economic informatization, which lay the foundation for the quantitative research on informatization development⁵. Compared with developed countries, the informatization construction in our country started late. It just began at the middle of 1980s to do the research on the theory of informatization and the method of measuring its development.

From comparison of informatization research between China and the United

³ Li Zong-rong. (2004). The Concepts, Principles and Methodology of Theoretical Informatics . *Medical Information*, 17(12): 783.

⁴ Li Zong-rong, Chen Ze-sheng, Ren Gong-yue Etc. (1991). *Introduction to Medical Information* . Wuhan : Wuhan University Press, 4.

⁵ Wang Ai-lan. (2004). Exploration of How to Perfect the Measurement Index System of National Informatization Level . *Theoretical Exploration*, (5): 484-487.

States, it can be seen that we must seize its connotation in two aspects for the informatization construction of a country. One is the specific process of informatization; second is its idealistic process. There is no a good idealistic guidelines on informatization, there is no an efficient process of informatization. The informatization to the idea is subject to the development of theoretical informatics. So “National Informatization” requires theoretical informatics.

3.3 It needs theoretical informatics to transfer industrial society to an information society

In a certain sense, the stage transition from the industrial society to an information society in broadly can be divided into three basic stages: economic restructuring, scientific transition and philosophy transition. In the daily work, study and life, we easily realize that something we feel but can't immediately comprehend. Computer culture becomes the basis of modern human civilization. Information products and information services are indispensable to us. No matter when and where the contemporary people go, they will talk of information. We need the unified theory on the information phenomenon of the universe to further understand of natural and society; we need theoretical informatics to adapt to the transition from the industrial society to an information society.

4. The engenderer of theoretical informatics

Generally speaking, theoretical informatics is the basic part of total

information science. Since 1920s, the knowledge system concerning information has developed quickly, which is called communication theory or information theory. At the beginning the foundation concerning this knowledge system is considered to be mathematics theory concerning communication. As a result, some scholars concentrate on expanding Shannon theory in order to build up generalized informatics, or even that of information science. Afterwards, the computer science and technology are developing prosperously and widely used. People think that the computer can handle the whole information problems omnipotent, and then they rename computer science to information science. The computer is considered to be calculator tool and thinking model, which is applied to natural science and social science, urging the born of a large number of domain informatics. At the time, theoretical computer academics is certainly the foundation of information science. So computer medical application can be considered to be the crossed research between information science and medical science and so on. After putting forward the establishment of Unified Theory of Information (UTI , Unified Theory of Information) in 1994, the scholars finally can distinct problems of individuality and commonness, thinking that the communication, control and calculations of information all belong to artificial information process, which can't cover natural information phenomenon and life information phenomenon obviously. Just at this time, the basic research of information knowledge system promotes to a new level of Theoretical Informatics.

5. The status of theoretical informatics

A great majority of information science researchers in the domestic and international didn't think the theoretical construction of information science had been already completed. On the contrary, a widespread viewpoint is that the research on the foundation theories of information science or the theoretical informatics has just started.^{6,7} There is never a national convention on the subject of the foundation theories of information science and there are only 3 times international meetings of small scales. From the above discussion, we can see that domain informatics, such as the communication informatics, the computer informatics, the library informatics, the bioinformatics and the medical informatics, which had already progressed to own a flourishing information technology, abundant information product and prosperous information market didn't have theoretical foundation.

6. The limitation of present information theory

6.1 The application ranges of Shannon communication theory

Based on the viewpoint of information science, the eye-catcher of communication science theory in the past is the statistical theory of information transmission

developed by Shannon. It together with cybernetics developed by Wiener affected many disciplines newly developed after the middle of twentieth century. In fact, Shannon didn't declare that a sort of information theory had been founded. On the contrary, Shannon himself thought of the foundation of communication theory (that is to say the information transmission theory) as his contribution⁸. Shannon's famous work is *The Mathematic Theory on Communication*. The techniques applied in his study and description is physical and mathematical methods. Generally speaking, the existence and movement of information at least includes the processes of apperceive, recognizing, attainment, description, measurement, storage, transformation, transmission, exchange, regeneration and controlling of information. For the physical transport mediums, there is no need to consider the content and utility of information. It only needs us to concentrate on the analog signals and digital signals on the physical transmission medium, just as the process of the ground layer (physical layer) in the ISO/OSI protocol⁹. Information transmission theory is just a part of information theory. Regarding Shannon communication theory as information theory is as wrong as regarding algebra as mathematics. It is almost impossible to generalize Shannon's theory to other types of information processes, so is applying mechanically the physical and mathematical methods in the information processes. Basically because of the continuative use of

⁶ T . Stonier. (1997). *Information and Meaning——an Evolutionary Perspective* . Gateshead (UK): Springerer, 219.

⁷ Li Zong-rong, Tian Ai-jing. (2002). Problems in the Research of the Foundation of Information Science: Some Comments on Some Viewpoints about the Development of Information Science during the Beginning of 21st Century. *Science and Technology Review*, (4): 3–6.

⁸ T . Stonier. (1997). *Information and the Internal Structure of the Universe : An Exploration into Information Physics* . UK: Springer, 13.

⁹ Xie Xi-ren. (2003). *Computer Network*. Beijing: Publishing House of Electronics Industry, 14.

reductionism mode in material science, there is nearly no notable progress in the information science constructed on the Shannon theory since half a century before. The wrong ideology leads to the disagreements of generalized informatics and truly information science on the aspects of concepts, principles and methods.

In fact, Shannon himself was worried about that informatics is becoming the most popular discipline and unusually flourishing. In 1956, he indicated that the essence of informatics is a branch of mathematics and it has rigorous deductive system; meanwhile, its results aim at some very special problems. "Exaggerating informatics and paying too much attention to it will induce a kind of risk". "Once people realized just some appealing wordings, such as information, entropy and redundancy, can not resolve all the problems, they will be disappointed and the man-made flourish will break down over one night". Originally, information of different fields is concrete and easy to manipulate.

6.2 Computer technology and facilities: discretization and formalization

If computer science was classified into theoretical computer science and applied computer science, the former is about the theory of man-made tools (computer), and the latter is about the computer technology and its application in different fields. Calculability, computational model, computational complexity, modal language and auto-machine are all the basis of computer science. No discretization or formalization, there will be no the invention of computer, and just because of the two

characters of discreteness and formulation of artificial compute, the nondiscretization and nonformalization of the compute is impossible. But there are great amount of nondiscrete and nonformal processes existing in nature, biology and human society, which still can not be simulated and replaced by computer. If all the processes were regarded as "compute" (generalized compute), the objects computed by computer are still very limited. Set the brain computing process as an example, there are a great amount of nonnumerical and alogical information processes, (such as synthesis and conclusion; intuition and inspiration) except the numerical and symbolic processes. Apparently, the development of theoretical computer science relies on the establishment of theoretical informatics. The reason is theoretical informatics not only studies on the artificial information phenomenon but also the information phenomenon in nature, biology and human society and it is more generalized and universal information theory. Computer, as the core of artificial information system, successfully simulates the symbolic process of human thought and catches the essential characters of natural information processes, so the theoretical computer scientists can act a special role in the foundation of general information theory.

6.3 The limitation of Domain Informatics

6.3.1 Domain Informatics in natural science

Communication Science and Compute Science both belong to special tool informatics, which is about artificial

information phenomenon. Their theory can not directly act as the contents of Theoretical Informatics, not to mention as the whole of Information Science. But they are tool disciplines of other Domain Informatics, so the concepts and principles included in the two disciplines have some general adaptability.

Other domain informatics, such as Quantum Informatics, Bioinformatics, Medical Informatics, Management Informatics, Economical Informatics and Ethnology, is a kind of knowledge system which just plays relevant roles in some special fields. They can not resolve the general problems about information phenomenon, not to mention the philosophy ontological problems of Informatics. So there is a despairing need to establish a new discipline called "Theoretical Informatics", and then the entire informatics knowledge system can be formed.

6.3.2 Domain Informatics in Literate Humaniores and Social Science

Literate Humaniores studies human thought, culture, value and spirit, and it includes literature, history, linguistics, philosophy, religion, archaeology, art, music, dance, drama, etc. Social Science studies the relationship among the human, and it includes economics, politics, sociology, law, anthropology, management, psychology, demology, etc. In some sense, the whole of Literate Humaniores and Social Science is a group of disciplines of Informatics. Among all the disciplines, Tool Informatics is widely applied, but information concepts and methods are relatively rarely applied to observe information phenomenon and

extract information movement laws. In other words, although some disciplines of Literate Humaniores and Social Science indeed uncover some intrinsic of social information phenomenon, they don't use the concepts and methods of informatics, so it is lack of universalities.

7. Home and abroad research on theoretical informatics

7.1 United States and Europe unified information theory research

At the international level, the corresponding theoretical informatics research has several different names: Unity Information Theory (UTI), general information, etc. Its purpose is to unify all domain informatics (such as economic informatics, management informatics, bioinformatics, medical informatics, cultural informatics, etc.) and build up a widespread used information concept, principle and method. There are a number of international magazines entitled Information Science, but it is difficult to find a paper in which the information science discussed as a subject or subjects. The contents in which are basically placed in the layer of domain informatics, such as International Journal of Medical Informatics. A small amount of journals about Philosophy information considers on the information theory, but usually lack the background and scientific basis of domain informatics.

The scholars of the international academic community who are interested in the basis of information science held three times seminars in Madrid, Vienna and Paris (1994, 1996, 2005), and two times Email

pens to talk (2002). The purpose of the three times international conference is to union those factions concerned with information processing but widely distributed in many disciplines, launching interdisciplinary studies. Their research mainly involved three topics: (1) Methodological issues: which philosophy and (or) formal scientific assumptions is the most suitable foundation of the unified information theory? (2) Basic theoretical issue: what is the origin of the information handles system in the realm of the inorganic matter, life and the society. What is the uniqueness of its structure? How common link with particularity? (3) The issue of the practical application: In order to resolve issues the mankind facing in the economic, political, cultural, environmental and others in the information society, what can be concluded from these theoretical understanding to guide the practice¹⁰?

7.2 Chinese scholars conduct basic research in information science

Despite Chinese information technology and products were behind Western developed countries, but at the aspect of the generalization and theory refining of the domain informatics, now we keep ahead. Because the basic material used as a higher level synthesis is the same, and our research is mainly large-span compositing the facts of evolution of material and information along the evolutionary chain; meanwhile, achieving inter-level synthesis among the level of applied informatics method, theoretical informatics method and

information philosophy method, that can lead to scientific innovation with methodological innovation.

Domestic discussions on the information theory issues heat for a time from the 1980s to the early 1990s. It mainly introduced overseas situation and explained it. The most influencing researchers include Zhou Gui-ru, Miao Dong-sheng, Li Ming, Wu Kun, Feng Guo-rui, etc. In 2000, Peking University initiated and organized a series of cross-information science seminars by Ma Ai-nai, Feng Guo-rui and Yan Xue-shan. The participants include experts from main institutions of higher education in Beijing, and scholars from Hubei, Hong Kong and Taiwan.

Professor Li Zong-rong achieved fruitful harvest in the theoretical informatics. Li Zong-rong transferred from computer software engineering to the combination of computer science, medicine and biology in 1987. During the three-year study in the United States, he entered into the realm of management, psychology and philosophy from computers and artificial intelligence. Under the guidance of Professor J. Beane, he accessed the understanding of the essence and laws of information, and the academic front of Ontological philosophy. Since 2002, under the leadership and support of Zhang Yong-chuan, Wang Cheng, Zhou Jian-zhong and Lian Xiao-hu from Institute of Systems Science in Huazhong University of Science and Technology, he held a series of reports on theoretical informatics, and undertaking three report tasks. Li Zong-rong had completed his doctoral thesis about Theoretical Informatics: Concepts, Principles and Methodology. It

¹⁰ W. Hofkirchner. (1999). *the Quest of the Second International Conference on the Foundations of Information Science*. Amsterdam : Gordon and Breach Publishers, 1-5.

was published in series in magazine *Medical Information* in 2004.

8. Conclusions

As mentioned earlier, the development of domain informatics such as bioinformatics, need theoretical support from theoretical informatics. However, the

research of theoretical informatics is still in the initial stage. A large number of researchers are still under the shackles of physical scientific paradigms. There is no breakthrough in physical scientific paradigms; there is no development of theoretical informatics.

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