Research of Information Science as Viewed from System Science

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Abstract：*Making researches on information which is regarded as a state variable of system from the perspective of system science can promote the development of information science. In the framework of system science model, the analysis of relations among three system attributes which are information, matter (mass) and energy is to the benefit of understanding the connotation of information better. Furthermore, for the different range of researches of theoretical informatics and subject informatics, we hold that the priority should be given to the development of subject informatics to strengthen the research of information science at this stage. And based on the difference between natural information and language and word information, a trend of the research of theoretical informatics is proposed.*

Keywords：Information, Information Science, System, System Science

1. Introduction

With the development of computer technology, the research contents and methods of many basic subjects including system science have changed a lot. From 1960s to 1970s, the self-organization theory put forward by Prigogine and Haken et al. applied differential equations to discuss the evolution of simple giant systems and has gained good results. Recently, people begin to pay attention to the evolution of complex system. Santafe institute in the USA presented learning the complex adaptive system by agents, and Qianxuesen et al. proposed studying the open complex giant system by Metasynthesis, both of which have gradually become the focus of research. Life science has drawn the human genome map and the research on proteomics is expanding. The chaos theory and fractal theory involved with nonlinear science have made great achievements due to the use of computer, and have been widely applied to research of many subjects. Lots of large engineering programs, such as Mars exploration plan, large hydro project, residential environment renovation and so on, are changing from scenario plans to current tasks. On the one hand, information turns out to be more and more useful during the process. For example, controlling the

evolution of a system mainly relies on information but energy, and the running of modern society depends on information either, so does the protein synthesis and the implementation of large projects, although a clear understanding about information has not yet been attained up to now. On the other hand, the consumption of energy is growing. People expect resources are consumed as least as possible, and the control of the evolution of system is manipulated by a more economical mean, to improve economic efficiency. Therefore, people are more concerned about information, and are looking for methods to reduce errors and increase scientificity of making a decision. Information and information science have become the focal points. People want to promote production and raise efficiency by information. Moreover, the secrets of evolution of complex systems are supposed to be uncovered and some basic scientific problems are to be solved by information. The development of computer technology also makes an intensive study on the conception of information possible. The common features and laws of information could be found by people only through the processing with transfer, copy and storage of mass information. The real connotation and characteristics of information could be especially understood only after the controlling of large projects and the knowledge mining of data by information.

2. Making research on information from the view point of system science

As is known to all, different disciplines have different perspectives, focal points and research methods to make a study on the objective world. The theories and methods of system science could be used to study information. System science does researches on objective world from the view of relationship between whole and part, and has formed its own disciplinary characteristics.

System science is the science of models. Objects in objective world could be divided into several sorts of systems including simple systems, simple giant systems, complex adaptive systems and open complex giant systems in accordance with their complexity. Each sort of systems is studied by a kind of model of specific features, which applies particular mathematical methods to solve problems. Moreover, information is going to be discussed by a specific sort of models, whose exact definition in the model is to be discussed, and functions in the evolving process are to be explored in system science.

The research objects of system science are systems. Any object could be studied as a system. Once a system is set, the relations between the system and its environment and the rules of evolution under some certain conditions are needed to be analyzed. Information is taken as a system to learn in system science, and it is also learned from the view of control theory for its particularity. On account of the fact that information is mostly studied as a factor to control the evolution of systems, the characteristics of information can be comprehended through analyzing the features of evolution affected by information.

The system will be divided into several levels to discuss the relations between whole and part in system science, and different methods are adopted for analyzing different levels of system frequently. As some new properties of system would emerge from in-betweens of levels, the relations among levels are learned in system science. Besides, system science is also concerned about such problems like how emergence comes out and how to control it. At present system science mainly focuses on two kinds of objects, which are complex adaptive systems and open complex giant systems. Both the interactions among system components and interactions between systems and their environments are very complicated in the two kinds of systems. For such complex systems, people found that interactions of energy and matter among system components or between systems and their environments are not so significant; instead, the effect and control of information are quite important. The research of information has taken a crucial place in system science by far.

The evolution of complex systems, especially the evolution of complex adaptive systems and open complex giant systems is needed to study in system science. The subsystems in the model of complex adaptive systems are agents in majority, which should adapt to the environment and change their properties by learning. As a matter of fact, the process, in which the environment controls agents by information and coordinated global properties among agents are formed, is the control of information from the point of view of control theory. In the respect of computing methods, the information transmission within the system and between the system and its environment could be denoted by specific algorithms of computer program. The evolution behaviors of open complex giant systems composed of people are more necessary to be analyzed by information. The contacts among people in this kind of systems rely mainly on information, having not much connection with matter or energy (both play a role of information carriers only). Moreover, information mentioned here are basically symbolic messages, which are presented by languages

and words. The evolution of human society cannot be studied at all without languages and words.

In the past, exploring rules of evolution of simple systems, or detecting relations among variables in a small minority, can be done by measuring and analyzing the recorded data from experiments. Nowadays, to deal with hundreds of thousands of variables, and to study the relations among them, which are no longer simple ones such as direct or inverse proportions, cannot be accomplished any more just relying on brain thinking or manual recording. These tasks must be finished by the approach of creating computer databases. Currently taking advantage of computer functions to dispose information is the method in research of many subjects. Subsequently several new subdisciplines, such as bioinformatics, medical informatics, engineering informatics and so on, turn up in succession, and specialized research contents are produced by recording, storing and classifying enormous factors which influence the evolution of systems. Someone called all these disciplines computer science, but experts in some particular branch called them so-and-so informatics of the branch. From the perspective of information science, computer which has all kinds of applications is used as a tool to study information, and information can be processed by many other means. Therefore, the correct statement should be that these subdisciplines fall into information technology, and the processing of information by various branches constitutes one trait of modern scientific research.

3. To understand information from the relationship among matter, energy and information

System science comprehends matter (mass), energy and information as a conceptual system of the trinity, and understands information through comparing the differences among them. Each of mass, energy and information (here refers to natural information of ontological level in inorganic circle, e.g. physical and chemical information; social information contained in languages and words, and relations among them will be discussed later) is an attribute of matter (or research objects), and is a kind of description of the objective world.

Mass means the magnitude of substances contained in an objective object, and it is a property of the object. The value of mass or specific gravity is usually brought to measure the quantity of substances contained in an object. Mass and inertia are

closely linked, so mass is also known as the measurement of inertia of objects. Actually, mass can be measured by two ways of inertia and gravity, which is respectively called inertial mass and gravitational mass, and the two kinds of mass are equal, i.e.

Inertial mass = Gravitational mass.

The study found that the mass of a system does not change arbitrarily. If substances of one system decrease, then substances of another system will increase inevitably, and the quantity of increasing and decreasing are equal, which is called “law of conservation of mass”.

Energy is a measure of the ability of system movement. People often make use of system movement, which refers to doing work, to serve for us. So energy is described as the power of doing work of system. Energy is also an attribute of system. As an attribute of matter, one of differences between energy and mass is that energy is the generic term of a type of physical quantities, including mechanical energy, thermal energy, electromagnetic energy, atomic energy and so on. In the field of physics, various forms of energy could convert from one to another, and the total amount of energy remains unchanged in the process, which is called “law of conservation and conversion of energy”. Furthermore, people extend the forms of energy to chemical energy, biological energy, brain power, potential, etc., and applied them to many fields. They consider all forms of energy comply with “law of conservation and conversion of energy”.

The proposition of the concept of energy not only made great progress for us to describe systems, but the concept has been applied to the analysis of system. The interactions among subsystems are the driving force of system evolution. A variety of forces are proposed for different systems. For instance, there are universal gravitation, electromagnetic force, strong force and weak force in physics, and the bond in chemistry such as ionic bond and covalent bond is a description of interaction forces between atoms when combining to a molecular. Besides, the notion of force is widely used in biologics and social science. All of these can be uniformly regarded as specific applications of the concept of energy.

Another application of the concept of energy is to make researches on control theory from the aspect of changing the objective world. Control theory is to input lesser energy to a system and make it output more energy which meets our demands

according to practical requirements. Control theory pays no much attention to the expected benefits of controlled systems for the little input of energy, but focus on how to make the output of system meet people's needs as much as possible. As it were, all the matter, energy and information can wield control on a system. In the early stages, relatively simple ways of matter control and energy control are adopted in common. For now, information control should be employed to make the evolution of system meet our complicated requirements better. This problem is going to be analyzed appropriately below.

Information is one of attributes of system. Many attributes of system can be viewed as information intuitionally. Some experts even said that "the state variables of system are information" or "the state of motion and its changes in things are information", which are of some sense. All the features of system compositions and the numerical proportions, relative locations, connecting ways among them, and the shape, structure, functions of system, etc., can be regarded as information. Mass is a physical quantity of describing the magnitude of substances contained in a system and energy is of many forms, but information includes much more contents. Information is the general item of a large class of quantities, and it even includes mass and energy, so they could be regarded as information. Allowing for the understanding of system and the actual process of cognition, we emphasize that constant state variables in the process of transmission can be viewed as information, because those changed state variables in transmission cannot be replicated, and then cannot help us to recognize the system.

The meanings and functions of information are different when confronting different objective objects in various disciplines. In physics, mass and energy play more important roles in analyzing the motion of system, besides, some variables depicting system states have their own names, and their properties and functions have been well known, so there is no need to introduce the concept of information (Taking information as a basic and uniform concept, the analysis of information problems of physical objects is also needed). But in biology, especially in the analysis of the process of protein replication and organism formation, the concept of information is particularly required to introduce to explain the evolving process. Therefore, information is studied by various subjects respectively, and the corresponding informatics comes into being, which provides abundant materials for the unification of the concept of information. However, the knowledge and definition of information of different disciplines have not reached a consensus, and a common understanding is still needed to put forward at present, so as to promote the development of various

subject informatics.

To describe and understand systems, the research on complex systems is not concerned about the number of subsystems in the system, but the relations among them. It regards the structure and function of system as important, and values the control of system and the way of setting up coordinated mechanisms within the system from the view of establishment and management of system. “Information” should be well understood for achieving the purpose. All the structure and function of system, and the relations among them are information of ontology. Now the control of system is not a simple control of energy, but the control of information. For example, considering controlled variables it has changed from the sound intensity control to the tone control. For the controlled system, it does not take the conversion and conservation of energy into account, but focuses on the recognition, copy and preservation of controlled variables, and makes the system evolve with the structure and function given by controlled variables. Thus the control theory for complex systems is nominated as information control theory for the time being, which is different from traditional control theory and needed to rebuild. We believe the founding of information control theory could gain enlightenment from the self-organization control.

4. The research of information science should be strengthened in modern science

Mass, energy and information are three state variables of system, and all of them play a great part to help us to know and understand the system. However, they contain very abstract and rich contents, especially for information. With the deepening of science research and the increasing of complexity of research objects, the function of information is becoming more and more important. If the 20th century is an era of energy, then the 21st century is an era of information. The research on information and information science is ought to be strengthened in modern science.

As the contents of information are broad, the common laws which information complies by are required to be studied when information of a particular subject is being investigated, and the fundamental and theoretical research will promote the understanding of information in each subject. But we still think it should give priority to the development of informatics of disciplines at current. From the perspective of

system science, subject (or field) informatics is a technology discipline to promote the development of information science. Informatics of a particular subject, for example, bioinformatics, geographical informatics, human informatics, chemical informatics and geological informatics, confronts concrete research objects, of which information connotation is relatively narrow, and easy to be discussed. Moreover, there is sort of similarity when do the analysis on complicated research objects in terms of research achievements of various disciplines, and it makes for summing up some basic problems of information in the future. However, the study of theoretical information puts the accent on integrating all the information, which needs to classify them and discuss the common characters of information in each system. We deem it impossible to accomplish this task recently for specific information of each system has not been learned clearly.

Now many experts in various discipline fields are engaged in information processing and data mining, and these technical works do not belong to the fundamental study of information. Their works are very important, not referring to the importance of pragmatic like technical or economic aspects, but to the importance in theoretical informatics. To understand the concept of information intensively, we cannot solely rely on philosophy speculations, but should more depend on the conclusion of basic properties of information by each discipline in the process of dealing with specific information. That is what we are doing presently and some articles have been published to communicate with others.

The experts of universe informatics proposed that the universe is constituted by information initially, and discussed some very attractive issues like the information of cosmic origination and the transformation among information, energy and matter, etc. With different opinions, we hold that the big bang theory of cosmic evolution is theoretically self-consistent although, and there are some supporting examples in practice, it is still a hypothesis which hasn't obtained a universal admission in scientific community, based on this, it is certainly difficult to get unanimous research results by discussing above fundamental problems. The prospective exploration could be done by a minority of people, and most researchers, especially the young people, should not exert too much effort in it. More experts of different spheres, such as natural science, humanities, social science and philosophy, etc. are supposed to go into the issues of information in their own field, and solve problems about the definition, properties, characteristics and research methods of information in the field. At the same time, they should pay more attention to communicating with others and

drawing on experiences of making new achievements in other regions to accelerate the research in their domains. This academic conference is exactly held on the purpose. The road to success likely lies in establishing connections among various disciplines, and unifying the conception eventually, and then theoretical informatics could be founded.

5. To pay special attention to the difference between natural information and "language and word" information

Information is the concept widely used in various disciplines, and it is been talking about by lots of people nevertheless the contents are not the same. People often make no difference between information and information carrier, and also understand the similar concepts, such as information, messages, data, knowledge and so on, without distinction, which sometimes need not to distinguish indeed. We would like to make a point that connotations of the concept of information of different subjects merely in the field of natural science are different, and cognitions of information in various disciplines are different as well. For instance, the states of matter are information in physics, the composition and structure of chemicals are information discussed by chemists, genetic codes, the number of chromosome and genetic maps are biological information concerned by biologists, all of which have not attained an agreement so far. However, the in-depth research on information in specific subject is required urgently for production practices, and continuous development of information processing technology is in need, in order to adapt to needs of the development of disciplines. Now it is failed to provide sufficient achievements in each subject to summarize and conclude, so there is no way to put forward a generally accepted concept of information by all subject experts, as well as an evolution rule followed by all kinds of "information".

The distinction between two categories of information is especially wanted when unifying and standardizing information. One is the information of system itself, or call information reflected by system, which is an expression of intrinsic characteristics of system. Another is information reflected mostly in languages and words, which usually has been correspondingly transferred according to some certain rules (known as language and word information). The information of system itself is ordinarily a description of system properties, as we said before, "state variables of system are

information", which exactly refers to information of such category. In many subjects, some properties of system without using the concept of information have been well studied. In physics, the frequency of sound, the shape and color of object and so on fall into this column, all of which have been learned thoroughly in physics without using the concept of information, and this is why quite a few physicists refused to acknowledge information science. Nevertheless, for language and word information, we no longer care about the voice frequency of languages or the shape of words, but focus on the content of them. For instance, although shapes of "3", "III", "三", "three" are different, the main information is the same, which stands for the number of "3". It should be mentioned that people gained the information by learning. Having created the uniform rule known and recognized by all people, and having stipulated for the representation of them, the four characters stand for the same meaning now. The premise of people's thinking and communication lies in a common conveyor of thought for them, that is to say, the information included in languages and words is the same. Children learn the understanding of information at first to know what information some certain sound or image carriers present (load). The translation of foreign languages is to establish correlations among different expressions of the same information in effect. A case in the point is when such information as "Yin and Yang" and "Qi Gong" cannot be expressed in foreign languages, we could definite the same pronunciations as Chinese as their information carrier.

The research of noeticscience should be paid particular attention in the study of language and word information. Now some research on information is an exploration to thinking virtually, which comes down to noeticscience conceptions such as concept, reasoning, logical thinking and imagery thinking, etc. The subject of thinking is the brain, and the object is information, but noeticscience and information science are not alike. The automatic migration of research achievements of information, even of language and word information, to noeticscience is not appropriate, that would cause confusion. Similarly the achievements of noeticscience should not be viewed as the knowledge of information. For subject informatics, making a study on thinking information as well as on the connection between information and thinking, and carrying on researches respectively on the thinking subject (the brain), the thinking object (information) and the thinking process (interrelations) from a new perspective on the basis of noeticscience research of the past to analyze distinctions and associations among them, not only can promote the development of noeticscience, but also will be a trend of the research of theoretical informatics.

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