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The Law of "Information Conversion and Intelligence Creation" †

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Abstract: Intelligent information system, human information system in particular, should be able to successfully interact with its environment, via acquiring information concerning the problem in environment and solving the problem based on the information. The system should then possess such functions as information acquiring, transferring and processing, as well as information conversing to knowledge and intelligence for problem solving. All the functions have to be integrated into a process of "information conversion and intelligence creation". What will be presented in the paper is the law that governs the entirety of the process. The methodology, model, concepts, theories and principles that all support the law will be explained in brief.

Keywords: Informational Methodology, Ecological Model of information Process, Information Conversion, Intelligence Creation, Information Science

1. Introduction: methodology Issue in Information Studies

Owing to the methodology of "reductionism (divide and conquer)" being applied in information studies in the past, the information discipline has been broken up into a number of mutually isolated sub-disciplines, i.e., information research, knowledge research, and intelligence research. Further, the information research has been divided into syntactic, semantic, and pragmatic ones with the latter two ignored [1], the knowledge research into two fields (knowledge engineering [2] and knowledge discovery [3]), and the intelligence research into three fields (artificial neural networks [4~6], physical symbol systems [7~10], and senor-motor systems [11,12]), which have also been mutually separated as is conceptually expressed in Fig.1 below.

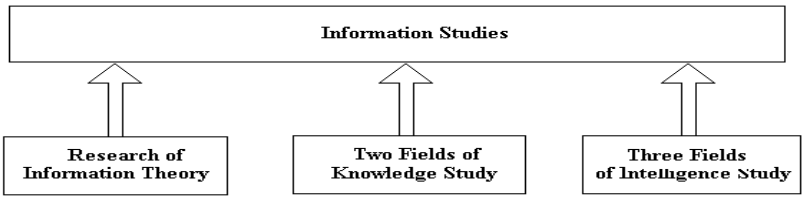

Fig. 1 "Divide and Conquer" and Information Studies

As is seen in Fig.1, within the discipline of information, there is no links among the fields of information, knowledge, and intelligence research. In reality, however, information, knowledge, and intelligence do form a sort of ecological process via the interaction between human subject and object. The contradiction between theoretical studies and the reality is evidently caused by the methodology of reductionism.

To remove the contradiction between theoretical studies and reality, the most crucial issue we should consider is to seek a new, and proper methodology for information studies, which should be able to reflect the links among information, knowledge, and intelligence so that the unified theory covering the entire information process can hopefully be established.

2, New Model, New Methodology, and New Results for Information Studies

The most influential model for information studies so far has been the one established by Shannon in 1948 that includes source for information generation, channel for information transmission, and sink for information receiving, associated with coding and decoding [1]. The major weakness of the model is its applicability mainly limited to the statistical communication and has thus severely lost the generalities of information process both in depth and width of the studies.

It is realized that the information process existed within the interaction between human subject and object in real world is most meaningful to human kinds and is thus the scope of information studies. It is a kind of ecological system able to make information grows into knowledge and then into intelligence. The model for information studies can be formulated as is shown in Fig.2 [13].

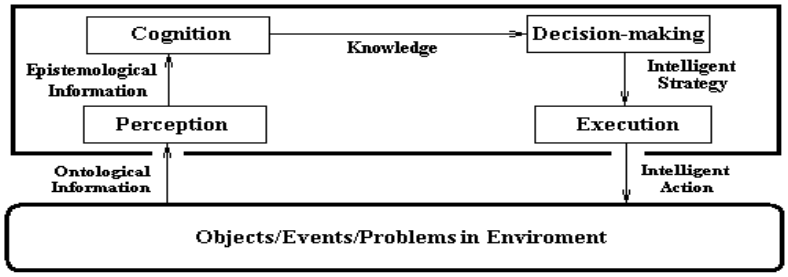

Fig.2 Ecological Model of Information Process for Information Studies

The lower part in Fig.2 represents the object/event/problem existed in environment, which exerts influence on human subject and thus should be carefully dealt with by humans. The upper part in Fig.2 stands for the human subject who possesses such kinds of typical functions as perception for information perceiving, cognition for knowledge producing from information, decision making for strategy creation based on knowledge and information, and execution for applying action to object according to the strategy.

More specifically, the ecological process of information through the interaction between human subject and object in the model includes the following elements and functions.

(1) Ontological Information (OI for short) presented by the object in environment.

(2) Epistemological Information (EI) conversed from OI via perception.

(3) Knowledge (K) conversed from EI via cognition.

(4) Intelligent strategy (IS) conversed from K and EI via decision-making.

(5) Intelligent action (IA) conversed from IS for dealing with the object.

(6) If there is an error between the state resulted from the action and the goal preset, the error should serve as a new kind of ontological information fed back to the input of the upper part of the model and the loop (1) – (6) will be restarted as an optimization for improving the quality of the strategy, reducing the error. The loop may need to run many times, each of which will produces a smaller error, till the satisfactory result is reached.

It is seen from Fig.2 that the ecological model for information process is more reasonable, and also more significant, than Shannon model is. This is because of the fact that the interaction between human subject and object in environment represents almost the entirety of the mutual relationship between humans and the outside world.

In viewing of the new model, the methodology applicable in information studies can well be termed as "ecology-ism". It meets the following views: the view of information but not the view of matter, the view of system but not the view of individuality, the view of ecology but not the view of statics, and the view of interaction between subject and object but not the view of isolation between them.

Clearly, "ecology-ism", the methodology applicable in information discipline, is radically different from "reductionism" which is the methodology suitable for classical physics.

Having applied the methodology of "ecology-ism" in information studies, a series of new results have been achieved (see Fig.3 below): a group of new concepts (ontological information and epistemological information, knowledge, and Intelligence), new theories (comprehensive information theory, theory of knowledge ecology, and theory of mechanism simulation of intelligence), and new principles (the three information conversion: 1#, 2#, and 3#). All of them have been integrated in information science in which the above contradiction was disappeared.

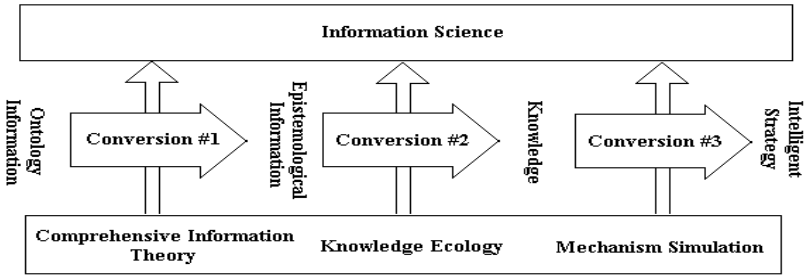

Fig.3 New Methodology and New Results in Information Science Studies

Most interestingly, **the Law of Information Conversion and Intelligence Creation** is emerged from the ecological process of information carried on within the interaction between the human subject and object in environment (See Fig.3).

In the following sections, each of the results, including the concepts, theories and principles supporting the law, will be explained. Due to the limit of the space, the explanations will be in brevity though. The detailed information can be found from the references [13, 17, 20-22].

3, Concepts Reformation Based on Ecology-ism

The concepts concerning ontological information, epistemological information, knowledge, and intelligence constitute an ecological chain of concept in information studies as seen in Fig.3.

3.1 Concepts Related to Information

Information is the most fundamental, and yet also the most confused, concept in information studies. It is therefore necessary to pay sufficient attentions here for clarifying the concepts and definitions of information based on "ecology-ism".

3.1.1 Existing Understandings for Information

There have been different understandings over the term of information in literature.

As typical examples, "Information is neither matter, nor energy" is one statement given by N. Wiener [14]. "Information is something that can be used to remove uncertainty" is another one adopted by C. Shannon [1]. "Information is the difference that makes difference" said by G. Bateson [15]. There are still many more but these three are most typical and influential.

Are all the understandings above equivalent? No. Which one of them is the best one? No comments. What is the relationship among them? No analysis. Is there any rule, or rules, to tell which one of the understandings should be used in which case? No such rule or rules so far.

Perhaps, only one thing has been quite clear that the confusions in understanding information existed in literature should be regarded as the major root for all confusions in information studies, because of the fact that concepts are really the foundation of a discipline.

3.1.2 Definitions of Information

Referring to Fig.2 and Fig.3 it is realized that there exist two kinds (instead of one kind) of information in reality: one is the ontological information and the other is the epistemological information. The former is the one produced by object in environment and is before the subject's percept while the latter is the product via the subject's percept from the former.

Definition 3.1.1 Ontological Information

Ontological information presented by any object is defined as "the states at which the object may stay and the pattern with which the states vary" ("states-pattern" in brief) [13].

The ontological information is so named because of the fact that this kind of information is determined uniquely by the object itself and has nothing to do with the subject.

Definition 3.1.2 Epistemological Information

Epistemological information that a subject possesses about any object is defined as the form, the meaning, and the utility of the "states-pattern" the subject perceived from the ontological information of the object, in which the form is named the syntactic information, the meaning the semantic information, and the utility the pragmatic information [13].

Note that the trinity of the three, i.e., the syntactic information, semantic information, and pragmatic information, is also named as the comprehensive information [13].

Different from the ontological information, epistemological/comprehensive information is determined not only by the object but also by the subject. It is clear that only by possessing the comprehensive information, could a subject have the complete information about the object.

It is reasonable to accept that (1) "the states at which an object may stay and the pattern with which the states vary, presented by an object" is "neither matter nor energy", (2) "the states at which an object

may stay and the pattern with which the states vary, presented by an object" is also the "something that can be used to remove uncertainty" in communication and (3) "the states at which an object may stay and the pattern with which the states vary, presented by an object" is just "the difference that makes difference" because what an object different from others is exactly its "states at which the object may stay and the pattern with which the states vary".

All the analyses given above indicates that the definition of ontological information 3.1.1 and the definition of epistemological information 3.1.2 can serve as the universal definitions of information, able to unify the statements given by Wiener, Shannon, Bateson, and others.

3.2 Resolving the Confused Concepts: "Data" and "Information"

Having explicated the definitions of information above, it is now possible and necessary to clarify some fundamentally confused concepts such as the concepts of 'data' and 'information' that have been puzzled many researchers in information discipline for quite long period of time and have also been the obstacles for achieving new progresses in information studies.

It is well known that voice, text, graph, picture and video are different kinds of analog signals. They respectively carry analog information and are thus called analog carriers for information. Similarly, data is also a kind of carrier of information. Different from the analog carriers, however, data, particularly the binary digital data, has the special features of "discrete in time domain and quantum in value domain" and has thus great advantages in signal/information processing and transmission in information systems.

Thanks to the advancement of digital technology, analog carriers/signals of information can easily be digitized into the digital form via the discretizing, quantizing and coding technology. As consequence, all kinds of carriers of information have digitized into digital form, the same form as digital data. Therefore, all kinds of carrier of information have got the same term, "data". In other words, different from the situation in the past, the terminology "data" today is referred to all kinds of carrier of information.

Referring back to the definitions of epistemological/comprehensive information, it is realized that data, as general term representing digital audio, digital text, digital graph, digital video, and real data, is just the syntactic (formal) component of epistemological/comprehensive information. Above all, the general term 'data' is not a concept independent from that of information, but in deed is a part of the concept of information, i.e., the syntactic information. That is to say, when people say "data", it should be meant as "syntactic information".

Furthermore, there is another confusing concept existed till now. When people talk about the term of "information", they often really mean "semantic information" because of the fact that semantic information is what people concern the most. However, what people can have in the literature of science and technology is only the "information in Shannon sense". Therefore, whether the term of "information" should be referred to the term of "information in Shannon sense, i.e., syntactic information", or should be referred to the term of "semantic information", there is no way out of the mess in many cases. This kind of chaos can be seen very frequently both in oral and written forms of discussion. This has been the most serious obstacle in making progresses in the studies of information discipline.

According to the new definitions of information stated in section 3.1.2, both the confused concepts of "data" and "information" may in most cases be described as that shown in Table 1.

Table 1 The Confusing Concepts of "Data" and "Information"

Confused Items	What People Say	What It may really Mean

Item 1	Data	Syntactic Information
Item 2	Information	Semantic Information

That is, because of the fact that we did not have the concepts of "syntactic information" and "semantic information" before, when one says "data", he may really mean "syntactic information" whereas when one says "information", he may really mean "semantic information", thus leading to great difficulties in information studies.

3.3 Concept of Knowledge Based on Ecology-ism

According to the new methodology, knowledge is grown from epistemological information and can further be grown into intelligence. Therefore, knowledge plays an important role of bridge linking information on one hand and intelligence on the other hand. This can be clearly seen from the ecological model of information process in Fig.2.

However, there is rather rare discussion on the definition of knowledge in scientific literature, even in the literatures concerning knowledge engineering and knowledge discovery. Therefore, it is wise to directly give our understanding on the definition of knowledge.

Definition 3.3.1 Knowledge

Knowledge that human subjects possess about a class of objects is defined as the "states that the objects may stay and the law with which the states vary", including their form, meaning, and utility that human subjects refined from the large amount of epistemological information samples of the class [17].

It is easy to see that the definition of knowledge is closely related to that of epistemological information. Comparing the definition of epistemological information 3.1.2 and that of knowledge 3.3.1, the difference between the two definitions just lies in that there is a word "pattern" related to epistemological information while there is a word "law" related to knowledge.

As a matter of fact, information is something concerning with specific phenomenon that can tell about "what it is" while knowledge is concerned with the essence of the phenomena that can answer about "why it is so". Moreover, the essence must come from the phenomena.

3.4 Concept of Intelligence Based on Ecology-ism

Intelligence is the central concept in information studies. The purpose of seeking information in most cases in practice is to produce knowledge and intelligence that is needed for solving complex problems people facing.

However, there is a conceptual confusion between intelligence and wisdom in literature.

To the author's understanding, wisdom is a power much stronger than that of intelligence and can only be possessed by humans, not by machines. Generally speaking, human wisdom could have two abilities interacted: (1) ability to properly find and define problems, and (2) ability to understand and solve the problems defined. The former is to set up a framework for problem solving and needs many abstract factors to support such as clear objectives, sufficient knowledge, intuition ability, imagination ability, and inspiration ability and thus can be regarded as implicit intelligence. On the other hand, the latter is to solve the problems within the framework given by implicit intelligence and needs certain amount of information and knowledge and hence can be termed the explicit intelligence. Obviously, the implicit intelligence

would be difficult, if not impossible, to simulate technically whereas the explicit intelligence is possible to do so.

Artificial intelligence that we are talking about here is the discipline to understand and simulate the explicit intelligence of human wisdom, instead of implicit intelligence.

Definition 3.4.1 Intelligence

Intelligence, or more precisely explicit intelligence, is defined as the ability of understanding and solving the problems and embodies as intelligent strategy for solving problems [20].

Obviously, in order to produce the intelligence (intelligent strategy) needed for problem solving, one needs information, knowledge, goal, and the mechanism for conversing information to knowledge and then to intelligence under the guidance of the goal.

4, Theories Reestablishment in the Line of Ecology-ism

As seen in Fig.3, the Law of Information Conversion and Intelligence Creation is supported collectively by the theory of comprehensive information, the theory of knowledge, and the theory of intelligence. All the three categories of theory need to be reestablished.

4.1 The Theory of Information

Shannon theory titled with 'The Mathematical Theory of Communication' [1] has been the first theory of information in the world so far. It was established in 1948 for meeting the needs of communication research and has made great contributions to the development of communication technology and engineering.

4.1.1 The Limitations of Shannon Theory of Information rooted from Old Methodology

Due to the employment of the methodology of 'Divide-and-Conquer' Shannon theory of information has at least two kinds of limitations that make it can mainly be successfully applied in statistical communication field.

The first limitation is unable to deal with the content and value factors of information and only the form factor of information has been considered. Its second limitation is unable to handle the non-probabilistic information and only the probabilistic information is taken into account.

These limitations are no good for the basic requirements from the system view of information methodology. Shannon theory, without the content and value factors, cannot support the studies for the ecological information systems, intelligent systems in particular.

4.1.2 The Establishment of Comprehensive Theory of Information

For overcoming the limitations aforementioned, the 'Comprehensive Theory of Information' has been established in 1984 and summarized in the book "Principles of Information Sciences" published in 1988 and reprinted in the years of 1996, 2002, 2005, and 2013 [13].

The form, content, and value factors of information, which are respectively termed syntactic information, semantic information, and pragmatic information, are taken into account in the new theory. The describing parameters adopted are "certainty" for syntactic information, "logic truth" for semantic

information, and "utility" for pragmatic information and are thus correspondingly denoted by vectors C, T, and U.

Typically, for any given variable $X^t = (x_1, x_2, \ldots x_n)$, the comprehensive information will then be described by the matrix of parameters:

$$\begin{matrix} x_1 & x_2 & \ldots & x_n \\ c_1 & c_2 & \ldots & c_n \\ t_1 & t_2 & \ldots & t_n \\ u_1 & u_2 & \ldots & u_n \end{matrix} \qquad (4.1.1)$$

Where in (4.1.1) $\{x\}$ represents the set of states at which the object may stay while $\{c\}$, $\{t\}$, and $\{u\}$ represent the pattern with which the states vary. Note that the parameter certainty c may either be the probability p if x is random variable or be the membership μ if x is fuzzy variable; while the parameters t and u are memberships because the logic truth and utility here are fuzzy in nature.

Based on the representations for information shown in matrix (4,1,1), the measurements for syntactic, semantic, and pragmatic information can be established by using the probability theory and fuzzy set theory [16]. For more detail, please see the reference [13].

Thus, syntactic, semantic, and pragmatic information, either probabilistic or non-probabilistic, are uniformly defined, described and measured. It is easy to prove that Shannon theory is a kind of statistically syntactic information theory, a special case of comprehensive theory of information when $c_i = p_i$ with t_i and u_i are ignored for all i in eq. (4.1.1).

4.2 The Theory of Knowledge

There have been two kinds of research in the field of knowledge till the present time. One is the Knowledge Engineering established by Feigenbaum [2] in the 70th of last century for dealing with the expert systems. The other is the Data Mining and Knowledge Discovery started from the 90th of last century for extracting knowledge from certain databases [3]. However, there have been no links between these two.

4.2.1 The Limitations of the Knowledge Research Rooted from the Old Methodology

Also due to the prevalence of the methodology of 'Divide-and-Conquer', there has been no systematic, and unified, theory of knowledge existed so far.

As one can see, the research of Knowledge Engineering is concerned only with the needs from certain expert system designs whereas the research of Knowledge Discovery is dealt merely with a few specific databases. They both stand separately.

There is little effort made for basic research on general theory of knowledge. What is the definition of knowledge? What is the relationship between knowledge and information and between knowledge and intelligence? No solution for such fundamental questions. As a result, the current status of knowledge theory cannot provide effective support to the law of information conversion and intelligence creation.

4.2.2 The Discovery of Ecological Features for Knowledge

For improving the situation in the research of knowledge theory stated above, we have made efforts in the study of knowledge theory during the 90th of last century. A paper titled with 'A Framework of Knowledge Theory' was published in the Journal of China Engineering Science in the year of 2000 [8].

In addition to the discussions on basic definition of knowledge, classification of knowledge, and the measurements for classes of knowledge, a new scientific issue, the ecological issue for knowledge, has been reported in the paper. The discoveries on two categories of ecological chain for knowledge were described.

The first discovery is the internal chain of knowledge ecology: the empirical knowledge (which is in the under-matured state) is growing up to be the regular knowledge (which is in the normal-matured state) and then further growing up to be the commonsense knowledge (which is in the over-matured state) via certain operations respectively. It can be seen in next section, the internal chain of knowledge ecology provides the solid foundation for integrating the three schools of artificial intelligence research existed currently.

The second discovery is the external chain of knowledge ecology: the epistemological information can be growing up to be knowledge and further growing up to be intelligence. The most valuable, and also most interesting, thing for this discovery is that the external chain of knowledge ecology reveals the real secret of the mechanism of intelligence growth.

The two discoveries do demonstrate that the results of knowledge theory study have provided with really essential contributions to the study of intelligence theory. Without such contributions from knowledge theory research the mechanism of intelligence growth and the unification of the three AI theories would be impossible.

4.3 The Theory of Artificial Intelligence

There have been three major schools of artificial intelligence research. One is the artificial neural network research based on structural simulation of human brain [4-6] and initiated from 1943, which has been termed "structural approach, or approach 1". The second is the physical symbol system research based on functional simulation of human brain [7-10] and started from 1956, which is named "functional approach, or approach 2". The third school is the sensor-motor system research based on behavioral simulation of intelligent beings [11,12] and beginning roughly from 1990, that is called "behavioral approach, or approach 3".

4.3.1 Limitations of Artificial Intelligence Research Rooted from Old Methodology

Again, due to the employment of the methodology of 'Divide-and-Conquer', all the three schools have been isolated from each other and unable to merge into an integrated theory of artificial intelligence research.

Many researchers are not satisfied with the situation of isolation in AI. Recently, attentions have been paid to the establishment of the unified theory of artificial intelligence [18, 19]. However, the progresses for unification of AI have been far from success.

4.3.2 The Discovery and Establishment of Mechanism for Intelligence Creation

As is mentioned above, the root for the mutual isolation among the three schools of artificial intelligence research can be sought to the fact that all the three research schools employed the methodology of 'Divide-and-Conquer', that is, dividing the intelligent system into three respects: structure, function, and behavior.

Recalling the external chain of knowledge ecology, it has been clearly indicated that the mechanism of intelligence growth is the "information–knowledge-intelligence conversion". More precisely, it is such a series of conversion – (*a*) from ontological information to comprehensive information, (*b*) from comprehensive information to knowledge, and (*c*) from epistemological information and knowledge to intelligence.

As consequence, the new approach to intelligence simulation based on the mechanism of intelligence growth, that is the information-knowledge-intelligence conversion, has eventually been successfully established [20], that can be termed "mechanism approach, or approach 4".

4.3.3 Unification of AI Approaches within Mechanism Approach

Based on the mechanism approach to AI, we have achieved another result important to artificial intelligence theory.

That is, we have four approaches to AI research. Approach 1 is the artificial neural networks based on structure simulation and empirical knowledge. Approach 2 is the physical symbol systems based on function simulation and regular knowledge. Approach 3 is the sensor-motor systems based on behavior simulation and commonsense knowledge. Approach 4 is the universal intelligent system based on mechanism simulation and universal knowledge. It is discovered that the approaches 1, 2, and 3 are the three harmonious components of the Approach 4 according to the internal chain of knowledge ecology. This leads to a unified theory of artificial intelligence as seen in Table 2 [21].

Table 2: Unification of the Approaches to AI

Approach 4	**Information**	**Knowledge**	**Strategy**	**Examples**
Mode A of Approach 4	Information	Empirical	Empirical	Approach 1
Mode B of Approach 4	Information	Regular	Regular	Approach 2
Mode C of Approach 4	Information	Commonsense	Commonsense	Approach 3
Mode D of Approach 4	Information	Innate	Innate	

As is seen from Table 2, the approach 1, artificial neural network, is the example of mode A of approach 4 with empirical knowledge; the approach 2, physical symbol system, is the example of mode B of approach 4 with regular knowledge; and the approach 3, sensor-motor system, is the example of the mode C of approach 4 with commonsense knowledge.

In other words, the approach 4, mechanism approach to AI, is the universal approach that harmoniously unifies the three approaches to AI. This result ends up the mutually separated relationship among the three AI approaches in history.

5, Principles Exploration: The Information Conversions

Having had the three classes of fundamental concept and the three categories of basic theory as the mainstays of the law, what we have to do the next is to find the conversion principles for effectively linking

the comprehensive information theory, knowledge theory, and intelligence theory and for eventually implementing entirety of the law.

5.1 First Conversion: from Ontological Information to Epistemological Information

It is clear by looking back to the ecological model for information studies in Fig.2 that the first class of information conversion should be the one that is able to converse the ontological information to epistemological information, or equivalently comprehensive information.

It is particularly important to explain the principle of the first class of information conversion because of the facts that some ones do not realize the concepts of ontological and epistemological information existed and some others do not know how epistemological information can really be conversed from ontological information. In other words, many researchers do not understand that ontological information and epistemological information/comprehensive information do exist in reality. They thus do not know that ontological and epistemological information constitute the first part of ecology of information process.

The principle of first information conversion can be shown in Fig.4 [21, 22].

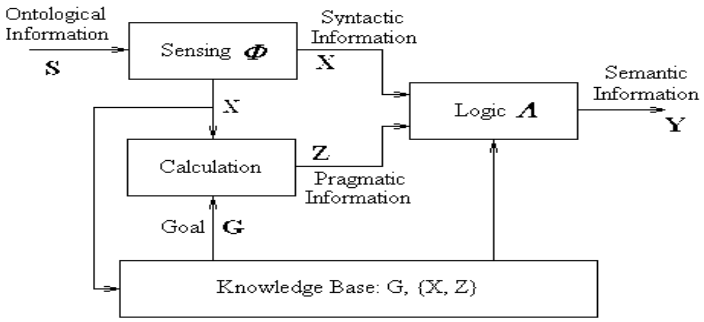

Fig.4 Principle of First Information Conversion

As is seen in Fig.4 that the syntactic information *X* can directly be acquired directly from the ontological information *S* by using sensing system. This can be expressed as a map function in mathematics:

$$\Phi: S \rightarrow X \qquad (5.1.1)$$

The pragmatic information *Z* can then be obtained as the correlation calculated between *X* (the syntactic information achieved already) and *G* (the subject's goal).

$$Z = \text{Cor.}(X, G) \qquad (5.1.2)$$

Finally, the semantic information *Y* can well be defined in semantic space by the joint determination of the syntactic information *X* and pragmatic information *Z* associated:

$$Y = \mathbf{\lambda}\{X, Z\} \qquad (5.1.3)$$

This process of (5.1.3) can also be explained as what in Fig.5 in which X is given in the domain of syntactic information and Z is given in the domain of pragmatic information and then the corresponding

scope of Y can then be uniquely defined in the space of semantic information by the joint of X and Z. The symbol**λ**in (5.1.3) is an operator of mapping and naming.

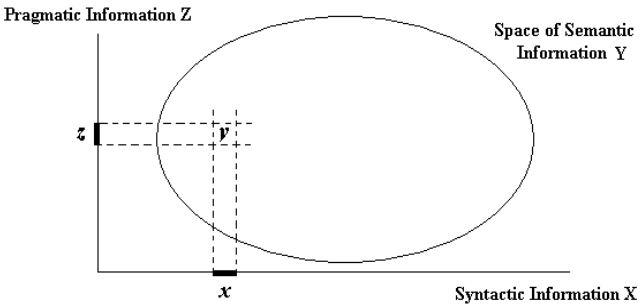

Fig 5. Semantic information Defining

As consequence, the ontological information *S* at the input of Fig.4 has been conversed into the three components of the comprehensive information -- syntactic information *X*, semantic information *Y*, and pragmatic information *Z* -- at the output in Fig.4.

It is very interesting to note that the first class of information conversion expressed in Fig.4, Fig.5 and Eq. (5.1.3) clearly reveals the definition, the meaning, and the generative approach of semantic information and Y can serve as the representative of X and Z. This is why people are concerned with the semantic information the most.

This result is also of high significance as there have been heavy clouds confused around the concept of semantic information. Because of the confusion, very few people could say exactly what the semantic information is in the past.

It is worth of pointing out that the syntactic information, typically the Shannon information, can meet mainly the needs of communication calculation while semantic information, as the legal representative of both syntactic and pragmatic information, can support the needs of content processing and meaning inference in such areas as computing and intelligence studies.

Therefore, the epistemological/comprehensive information theory, the trinity of syntactic, semantic, and pragmatic theory of information, can serve as the integrative theory of information, forming the foundation of knowledge and intelligence.

5.2 Second Conversion: from Epistemological Information to Knowledge

According to the external chain of knowledge ecology discussed above, the principle of the second information conversion, which is also called the principle of knowledge generation, can be implemented through the following scheme in Fig.6, performing the function of generating knowledge from epistemological/comprehensive information through induction.

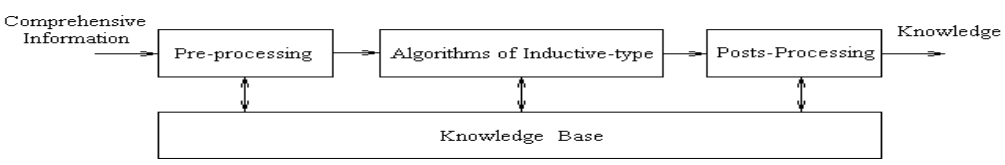

Fig.6 Principle of Second Information Conversion

As is seen from Fig.6, the input of the scheme is the comprehensive information whereas the output of the scheme is the knowledge newly produced. The knowledge base, as a fundamental element of the scheme at the bottom in Fig.6, will provide support to the unit of inductive-type algorithms by giving 'the scope of the knowledge interested' and 'the knowledge already had' so that the unit of inductive-type algorithm can work properly. At the same time, the knowledge base will give supports also to the units of pre-processing and post-processing.

The crucial operation that will be performed in the scheme of second information conversion is the inductive-type algorithms. This is understandable because of the fact that information is phenomenon in nature whereas knowledge is essence in nature and that essence can only be abstracted from phenomena via induction. As the inductive-type algorithms, it may have such kinds of forms as standard mathematical inductive algorithm, statistical inductive algorithm, analogical algorithm, and associative algorithm, and so on.

It is worth of pointing out here that the quality of the results derived from inductive-type algorithms depends on the quality and scale of the sample set used for induction. Generally, the better the quality and the larger the scale of sample set is, the better the quality the results will have. Furthermore, there would also be the interesting phenomenon of 'emergence' existed in inductive process expressing the turning point beyond which the high quality of the result will be come out.

As is well known, inductive algorithm cannot give the guarantee to always having the right results. Therefore, evaluation process of the inductive results is necessary. If it is valid under certain criteria, the result is regarded as new knowledge and is fed into the knowledge base. Otherwise, it will be fed back to the inductive process for reprocessing. These functions are performed via the unit of post-processing.

On the other hand, the unit of pre-processing is arranged for monitoring whether the scope of the comprehensive information at the input of the scheme is suitable for the needs of the system: feeding in the good ones and filtering out others. This kind of function can well be performed by the technique of pattern classification.

5.3 Third Conversion: from Knowledge to Intelligent Strategy

The function for the third information conversion to perform is to produce the intelligent strategy so that the subject will be able to interact with the stimulus that is given by the object in real world via ontological information. The intelligent strategy will be produced on the bases of (1) the comprehensive information, which is the subject's reflection of the ontological information, (2) the subject's goal preset for problem solving, and (3) the knowledge already possessed, which represents the subject's understanding toward the entire problem concerned.

The strategy is called intelligent because the execution of which should be able to achieve the double win – on one hand, the result of interaction should reach the subject's goal (the subject's requirements), and on the other hand, the result of interaction should maintain the knowledge constraints (the object's requirements).

For meeting all the criteria described above, the principle of third information conversion could be implemented by the scheme shown in Fig.7.

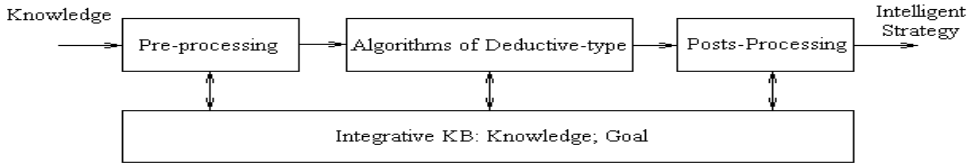

Fig.7 The third Class of Information Conversion

As can be seen from Fig.7, different from the situation in second information conversion, the major algorithm performed in third information conversion is the deductive type. The function of deduction is to converse the knowledge, as well as epistemological information, to the intelligent strategy under the guidance of the subject's goal.

In any cases, the evaluation for the quality of the intelligent strategy so produced is necessary. If it is qualified in meeting the criteria described above, the intelligent strategy can be accepted and be fed to the next unit for conversing to intelligent action to be executed. Otherwise, it will be fed back to the deduction unit for reproducing. These functions are performed through the unit of post-processing.

6, Summaries and Conclusions

Referring back to the ecological model for information studies shown in Fig.2 and Fig.3, and comparing with other works for information studies known already, one can see that a number of new results have been presented in the paper:

(1) New scientific views on information are emphasized, that is the view of information, the view of system, the view of ecology, and the view of interaction between subject and object.

(2) New methodology applicable to information studies, that is the "ecology-ism", instead of "reductionism", has been refined based on the new scientific views.

(3) New model for information studies, as the embodiment of the new scientific views and the new methodology, is presented as expressed in Fig.2.

(4) New concepts needed in information studies have been created that is the ontological and epistemological information, knowledge ecology, and mechanism of intelligence growth.

(5) New concept of comprehensive information, specially the semantic information, is clearly created, which are different from the concept of information in Shannon information theory.

(6) New theories in information studies are established, i.e., the comprehensive information theory, the theory of knowledge ecology, and the intelligence theory of mechanism simulation.

(7) New Principles of information conversion in information studies are discovered, i.e., the conversion of ontological information to comprehensive one, the conversion of comprehensive information to knowledge, and the conversion of knowledge to intelligence.

(8) The law of information conversion and intelligence creation is finally emerged from the interaction between human subject and object, which is the integration of all the results above.

The great role that the law of information conversion and creation plays in problem solving within the framework of information studies can generally be explained in Fig.8 below.

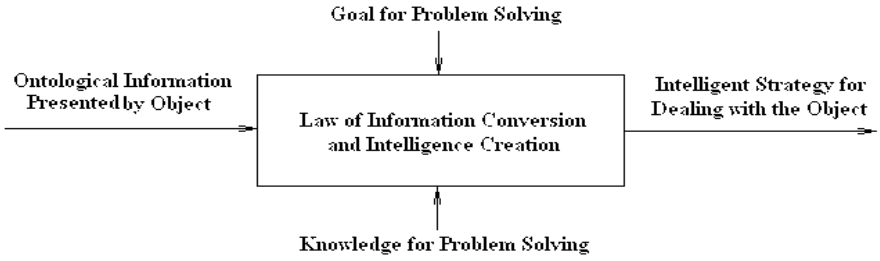

Fig.8 General Model for problem Solving in information studies

As is shown in the model in Fig.8, whenever a subject is facing an object of any kind in principle, he will receive the ontological information presented by the object in reality as input. And then by applying the law of information conversion and intelligence creation, supported by right knowledge and guided by his goal, he will be able to achieve the intelligent strategy for solving the problem with 'double win' criterion.

The law of information conversion and intelligence creation clearly reveals the secret of how the intelligent strategy can successfully be created for humans when the subject faces the stimulus from object in the outside word. This result is really meaningful for the understanding of the human intelligence. The law of information conversion and intelligence creation also gives the inspiration on how the intelligent strategy can successfully be created for machine. This is also meaningful for understanding the information science and the universal artificial intelligence.

More significantly, if combining the law of information conversion and intelligence creation in information science with the law of energy conversion and conservation in physics, human kinds will be greatly benefited from the both laws: the latter tells how to observe the sustainability in the nature and society while the former tells how to solve the problems for improving the living standards and maintaining sustainability in the nature and society. They are complementary, and also fundamental, laws.

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