4.1 Systems Operation and *Propagation*

In today's information society, information is generated at such speed as high as we have never experienced before. Even though we cannot apparently send or receive *semantic content* of information like a package, it seems as if it is actively *transmitted* and *stored* using ICT, based on which our society is constructed and operated. Hence we call it "*information society*".

This dynamic situation, seeming contradictory at a glance, can be analyzed by separating it into two phases, micro and macro. The first *micro* phase is related to what has been stated in the previous chapters – *the operation of HACS*, or generation of communications. When seen from the viewpoint of a social HACS, if communications are continuously generated, we can assume "*(peudo-) transmission*" of some semantic contents. In addition to that, we can assume that the "*semantic structure* (semantic storage in the structure)" of the HACS is updated and correspondingly some information is generated.

The second macro phase comes into being as the accumulation of micro phases. A communication is a short term or instantaneous event, and an accumulation of which gradually changes the semantic structure and *syntagmatic program* of a HACS in the long run, where new concepts are added one after another. As such, the HACS *learns*. Furthermore a new HACS may be born together with the emergence of a new Erfolgs medium. Let us call these processes the "*evolution*" of the system. Owing to the learning and evolution, systematic and comprehensive semantic contents called values or ideologies are socially disseminating. Such transmission of semantic contents in macro phase is termed "*propagation*" in *fundamental informatics*.

The concept of propagation has some similarity to the "*transmission*" proposed by a philosopher Régis Debray which is historical conveyance of group ideologies. In the Debray's theory of media, transmission is defined as a diachronic concept, in comparison with communication which is a synchronic concept (cf. Régis Debray, *Manifestes Médiologiques*). Unless analyzing the both, we can never grasp the state of information society.

In this chapter we are going to mainly describe "propagation" in a *macro* phase. But before that, let us look back at and summarize the dynamics in a *micro* phase using an

example. Now think of a company which has several ten's of employees who are talking about the development of a new product. In each *psychic system* of the employees, *thinking communications* are continuously generated, as his/her own memory is activated by receiving other employees' stimulating remarks. *Life information* is being born at the time, which causes *signifying effects* in one's cerebral nerves through sensory organs. Correspondingly, the *semantic structure* (memory) stored in one's cerebral nerves as physical patterns is changing every moment. Here, needless to say that other employees' opinion is not copied to one's brain but interpreted based on one's memory. And the *life information* as an image will be converted into words, a sort of *social information*, and thinking communication will be generated in one's psychic system. Moreover, the opinion of an employee about a new product may undergo additional conversion to presentation documents, a sort of *mechanical information*, and may be given to other employees.

On the other hand, *discussional communications* about new product development are continuously generated in the company as a social system. The stuff materials of the communications are offered by the *semantic structure* related to the new product – various documents and files which have already been accumulated, and moreover, new statements and presentation documents by employees. Namely, from the viewpoint of this HACS, the psychic systems of the employees are seen as if *heteronomous systems* at a lower level, outputting useful social information for new product development. The production of discussional communications results from the signifying effects of social information newly born, which will update the *semantic structure* on the new product in the form of meeting minutes and so forth. In brief, it is the changes in semantic structures of psychic systems and of a higher level social system that constitute the micro phases of the semantic content transmission.

● **Supplements and Applications**

Let us note the *hierarchical relation* between structurally coupled *HACS*: a social system and psychic systems. It is the key to understand the "*propagation*", the macro phase of semantic content transmission.

Now we come back to the example of the company and its employees engaged in the development of a new product. The psychic systems (HACS) of the employees are operating autonomously in themselves – i.e., the employees can think whatever in their

minds, even though it may be unrelated to a new product. But when they say something unrelated to a new product, the statement can never become a material of discussional communication which is the component of the company system, a higher level HACS. This is because, *the syntagmatic medium* chooses only the statements logically connecting to new product development, and *the paradigmatic medium* judges the relation between the statement and existing documents of new product development. Naturally this does not directly affect the operation of the employee's psychic system. However, if that situation occurred repeatedly, the employee would gradually be alienated and excluded from the discussion.

Therefore to attend the discussion actively, an employee must make efforts to navigate one's own thinking process along with the theme of new product development, and to pull a useful idea out of one's own memory. That is nothing but the *constraint* or *restriction* which the higher level company system imposes on the lower level psychic systems. As a result, the brain content of an employee, or the semantic structure of one's psychic system will be, in the long run, occupied by the knowledge and arguments about new product development. Such a process brings about the *propagation* of semantic contents in a psychic system. For instance, a newcomer will be changing into a full-fledged worker owing to the propagation.

Generally speaking, this means that a higher level social system has *strong influence*, even indirectly, on the operation of lower level psychic systems structurally coupled with it. Here the social system may be seen as a sort of environment of psychic systems. Accordingly, the *life information* generated in person's cerebral nerves is under the influence of society – i.e., there is not only a flow *from life information to social information*, but also a feedback flow *from social information to life information*.

Conversely, the operation of a higher level social system is also *influenced* by the operations of the lower level psychic systems structurally coupled with it in the long run. It is true that a social system is closed in a sense that its component, a communication, is created recursively by the network of communications. However, the material of such a communication is nothing but *social information* that was output by lower level psychic systems. Hence, the social information generated in a social system has its origin in life information, which was created in a lower level psychic system, or more precisely, in a cerebral nerve system. Note that conversion into *mechanical information* is often inserted in such a macroscopic mutual interaction process between life

information and social information.

As such, we can see that the semantic structure of a social system (higher level system) undergoes gradual changes because of long-term and collective effects of psychic systems (lower level systems). For example, the content of a planning document of new product development is re-written frequently by adding the ideas of employees, while discussions continue at development meetings. The transformation of the semantic structure of a social system (i.e. propagation) is caused by such dynamics as this example.

What stated above generally applies to *any hierarchical relations* between HACS, not only to that between society and its members. In short, long-term transformation of HACS structure consists in propagation. The accumulation of the *information creation* and resulting *updates of semantic structure* bring about that. Here, the information creation is done by combining recursively the outputs of lower level HACS with the existing semantic structure.

4.2 The Constructed World

The mass media and the Internet each provide *an image of reality* for people. An image of reality is, so to speak, a pseudo-image of integrated world which is shared among people in society. Hence it has much to do with *propagation* of semantic contents. Nevertheless such an image of reality can for itself hardly be a sure basis of semantic structure or values of individual psychic systems. As stated before, diverse viewpoints and values coexist in contemporary society, and because of this fragmented situation general people cannot help having some hope for an image of reality, even though it may temporary and approximate one.

The mass communication or the Internet communication, each a component of *super social systems* as the highest level *HACS*, is a meta-communication – "the communication about communications". Therefore in order to consider it, we must pay attention to the communications in the lower level HACS, i.e., various social systems and psychic systems, and analyze how long-term semantic structures are formed in those systems. Obviously, an image of realty compels a sort of constraints or restrictions on them.

Later in this section, we are going to state the formation and transformation of semantic structures in personal psychic systems or social organization systems; how the conceptual structures are constructed there. First, let us make sure the premises of our arguments. Conventionally, it is widely believed that the construction of conceptual structure in the subject or individual is attained through the action called "*learning*" or "k*nowledge acquisition*". This action is nothing but, in brief, recognizing and memorizing the states of the given "*objective world*" correctly. Namely the possibility is assumed that people observe and describe the objective world as a bulk of universal "*knowledge*", the fragments of which constitute "*information* or *data*". And it is unconditionally believed that the subject or individual can add one's knowledge by exchanging such information or data with each other.

As stated repeatedly, such conventional way of thinking is totally denied in *fundamental informatics*. We can never reach the objective world, even if it may exist. We human beings are nothing but animals with incomplete sensory organs, and hence are living in each subjective world influenced by individual heredity, experience and cultural backgrounds.

In other words, each psychic system, or any HACS at large, *constructs one's own world* by interacting with its environment through its actions or operations. More concretely, it forms its semantic structure – especially conceptual structure. Note that the constructed world is no arbitrary solipsistic one, although the HACS is a closed system. This is because the viewpoint of a HACS has always the chance to be relativized by other HACS's viewpoints, and hence its actions and operations are adjusted all the time. That is the effect of "*second-order observation*" described below.

Based on each viewpoint a HACS is taking selective actions combined with information creation, which corresponds to *the observation and description* by the HACS. This is the action of interpreting the world by making subjective distinctions. Naturally the view is not absolute one and has its own blind spot. On the other hand, however, we know that it is possible for another HACS to observe and describe the world in a different way including the blind spot. And the mutual interaction of the two HACS gives chances for recursive action of *observing/describing one's own observation/description*.

Concerning this, let us take up the construction of a scientific concept. Against common sense, science is not something for knowing the state of objective world correctly. The

most precious feature of scientific concept construction is in its strict methodology to enhance the consistency of human selective actions and predictability of their results. A new theory must pass hard inspections about its logical correctness, evidence, the relation with existing concepts, etc. Nevertheless it can never attain absolute validity, and therefore new theories appear one after another. That is, even scientific conceptual structure cannot avoid a sort of relativity which is inherent to the world constructed by living things.

● **Supplements and Applications**

The way of thinking that we are living by adjusting multiple subjective worlds, not by recognizing the unique objective world, is termed "*constructivism*". The constructivism is a philosophical idea which basically supports *fundamental informatics*, and above all it is deeply related to the *propagation* of semantic contents and construction of concepts.

Here we are going to roughly trace the academic genealogy of fundamental informatics. Neglecting details, two theories appeared in the late 20th century can be regarded as its direct origin: *second-order cybernetics* and *autopoiesis theory*. Let us describe the former, as we already have explained the latter in detail.

The second-order cybernetics is the theory proposed by a physicist Heinz von Foerster in the early 1970s, who was a director of Biological Computer Laboratory (BCL) at the University of Illinois, USA. The basis of this theory is naturally *the first-order cybernetics*, which is often simply called "cyberbetics", proposed by Norbert Wiener in the middle of the 20th century. But it has a noteworthy feature that allows deep insight into the essential difference between the living thing and the machine, although the first-order cybernetics reduced living things to mechanical models.

It is often said that the first- and second-order cybernetics each examine "*an observed system*" and "*an observing system*", respectively. What is an observing system? – Here it apparently means a living thing, an autonomous system. As stated before, it is a system whose rules of operation and transformation are *internally* determined. The rules for a heteronomous system are, on the other hand, *externally* given. The theory of first-order cybernetics aims at giving operation rules in such a way that a system can adapt to environmental changes and maintain homeostasis, through the efforts of a human designer who is observing the system and its environment from the outside. Namely it

is nothing but a heteronomous system – an observed system – that can be analyzed in the first-order cybernetics. The system operation rules or input/output relations in the first-order cybernetics are completely determined in principle.

As for the living thing, on the contrary, the way it responds to environmental stimuli – the precise rule of system's operation and transformation – is generally unknown. More strictly speaking, a living thing is dynamically changing *the rule itself* (the way of action and selection itself). This is the reason why we cannot reproduce precisely the output of a living system, although we can do it for an ordinary machine system by giving past series of input. In order to examine such a living system, we must move our viewpoint to the inside of the system, and seek into the condition where *the system operation stabilizes*. A living system, while constantly *observing* the results of its action/ selection in an environment, tries to maintain its stable existence – this is nothing but the signifying effect of information. In other words, a living system *self-determines its operation rules* in the course of its recursive actions. The purpose of second-order cybernetics is to study such problems related to "observing systems".

An observing system is operationally closed, although an observed system is open. This suggests the theoretical relation between the second-order cybernetics and autopoiesis theory. In fact, von Foerster and Maturana used to frequently exchange their views in the 1960s. Both were challenging the difficult problem, the issue of cognition and action of living things, by the use of recursive models. A sociologist Luhmann tried to analyze the modern society through the same approach, and in his functionally differentiated society model the autonomous operation of a social system is seen as "observation" in itself.

The constructivism is an academic idea that has been developed under the influence of these researches. Such theories as the second-order cybernetics, autopoiesis, functionally differentiated society model, constructivism and so forth, are termed "*neocybernetics*" because they share more or less common approach. And fundamental informatics also belongs to it (cf. Clarke, B. and Hansen, M.B.N., Neocybernetic Emergence: Retuning the Post Human, *Cybernetics and Human Knowing*, vol.16, nos. 1-2, 2009, pp.83-99).

4.3 Personal Learning

Any living thing is considered to construct its own world and semantic structure through long-running survival actions. Among them, we must take note of the psychic system of a human individual. The problem accordingly concerns pedagogics or developmental psychology – i.e., there we must inquire into the mechanism of *semantic content propagation* brought by learning or knowledge acquisition. The academic theory corresponding to this issue in neocybernetical studies is called "*radical constructivism*", which was proposed by a cognitive psychologist Ernst von Glasersfeld where the word "radical" means the thorough pursuit of constructive way of thinking. In fact, the theory regards even mathematical knowledge – ordinarily considered "absolute truth" – as something constructed subjectively and empirically by an individual.

According to *fundamental informatics*, not only personal psychic systems but any *HACS* constructs one's own world. Hence, it is quite different in approaches from radical constructivism pedagogy. Moreover, it aims at analyzing informational phenomena in general, rather than children's learning. Nevertheless the argument of radical constructivism on how children construct their concepts is very important, when we consider the concept construction and meaning propagation of HACS, and it has a lot in common with fundamental informatics in a theoretical framework. Especially its argument on children's language learning is very thought-provoking.

How on earth do children learn their mother tongue? – The language is composed of a set of abstract symbols, and is learned a posteriori. Hence we can never understand any language without studying it. Why do some semantic images appear by uttering words?

This issue is explained by the language theory of radical constructivism based on "*empirical abstraction*" and "*reflective abstraction*", which was proposed by a psychologist Jean Piaget. For example, the figures of what expressed by the word "dog (doggie)" is quite diversified from Chihuahua to Great Dane. But because of empirical abstraction we can recognize the common feature among them, conceptualize and express them by the word "dog". Since a sort of conceptualization ability can be found in animals other than human beings, it may be an inborn feature of living things. However, even human beings need a certain amount of training to communicate with each other by using *symbols*. An infant calls a stuffed toy bear "Doggie", and will be corrected by his/her mother as "No, it's a teddy bear, isn't it". Then the infant comes across a dog while strolling and speaks to the dog "Hey, teddy bear" – causing people's laughter and mother's remark "No, that's a doggie". Through such experiences of trial and error,

children gradually become able to distinguish dogs from bears.

In addition, when the infant grows a little older, the mother may ask her child during a walk "Which do you like better, this doggie here or that doggie we saw a moment ago?". This time, the infant recalls the dog he/she saw a few minutes ago, and compare it with the dog in front of him/her. What the infant does is *recollection* or *reproduction* of his/her past experience. This is not a simple abstraction of something he/she is watching. Rather, it is the procedure to cut out a part from the memory stream of sensory impression, and put it intentionally into one's thinking. This procedure is nothing but "*reflection*", and the abstraction based on it is called "*reflective abstraction*". (In Piaget's vocabulary, the term "reflection" often means the manner of approaching something recursively.) If the infant makes an improper reply such as "I like a teddy bear than a doggie", he/she will probably be corrected and his/her trial and error ever continues.

Like that, what is important in language learning is not the precise "matching" with the objective world. Rather, it is "fitting (adapting)" to an individual's own subjective world. That is, the important thing is to attain *a stable condition of survival* in the empirical world constructed by a person him/herself.

Unlike the conventional solipsism or skepticism, the constructivism does not totally deny the existence of the objective world. It would like to look into the mechanism how each human individual, who can never recognize directly the objective world, manages to survive in it. Learning is nothing but the activity for that purpose.

● Supplements and Applications

With the spread of the Web and its search engine, schoolteachers and professors are worried about the prevalence of so-called "*copy&paste report*". It is now possible to immediately pick up the related statements about whatever questions from the Web by the use of a high performance search engine. Students can copy and paste them, making up reports quickly on their word processors.

Such copy&paste reports seem, at a glance, to describe a locally persuasive argument because they often make use of abundant data and technical terms. But when reading them carefully, we find many drawbacks: neglect of important assumptions, repetition of descriptions, insufficient analyses caused by mere listing of data, etc. Especially their

logics are sometimes inconsistent and their conclusions are often ambiguous, probably because they are composed of mechanical gatherings of *fragmental descriptions from various viewpoints*. Hence they are totally different from the reports elaborated by students based on their own thoughts.

Any student report should be rejected, if it is clearly judged to be a copy&paste report, as it may cause copyright infringement. Teachers or professors are making great efforts to find a copy&paste report, and even detection tools have been developed to help them. In fact, the possibility of detection is pretty large if a student has written a report by simply putting together the sentences from the Web, because classmates may write similar reports. Nevertheless some students may have a skill to pass through detection, by modifying or editing a part of web statements.

Yet the main point is not the judgment of passing /rejection, but that students can never obtain *knowledge of practical use*, however many copy&paste reports they may have written. Through the activities of empirical and reflective abstractions, a human being can master practical knowledge for one's survival. Based on such experiences, he/she can construct one's subjective world which is useful for problem solving. Writing a report should naturally be a part of it. But a student makes up a copy&paste report through only mechanical manipulation of ICT equipments, thus he/she could never enhance one's ability to solve practical problems about the report theme.

Despite that, why is a copy&paste report prevalent? It is naturally because students are more interested in "the act of submitting a high score report" itself, than in thinking about a report theme. It requires a lot of time and energy to compose a logically consistent meaningful argument. Rather, students find practical significance in submitting a passable report, efficiently written by making clever use of the Web through memorizing only related technical terms.

Here we can see a serious problem involving not only students but also educators. It is widely said that today we are living in knowledge society or information society. The "*knowledge*" there, based on popular thoughts, is regarded as something explaining the state of the objective world in a correct and scientific way with academic authority. And "*information*" is believed to be something like a piece of data composing knowledge, which therefore can be processed efficiently by a computer. This naturally leads to the idea that *studying* is nothing but effective retrieving and memorizing fragmented

knowledge, rather than developing one's own arguments. If educators, although superficially saying the respect for individuality, attach importance only to quick memorizing and processing of existing knowledge, they could hardly blame students for writing copy&paste reports making skillful use of a Web search engine.

Of course there are many educators who make efforts to enhance the students' ability of thinking, and try to bring out their own opinions. However, we can certainly find the recent tendency to attach too much importance to remembering existing knowledge. What is the reason for that? – Here we must take note of *another type of abstraction* which is neither empirical nor reflective abstraction. That is a new kind of "learning", different from individual learning for survival.

4.4 Organizational Learning

Today it is virtually impossible for a person to live in a society by constructing one's own world only through *empirical and reflective abstraction*. Certainly children are constructing basic concepts for everyday life through personal experiences, while using words and executing feedbacks. However, as growing older, what they learn in a junior high school, high school and university are mostly more abstract concepts. Note that these concepts have been constructed by "*social abstraction*" – i.e., constructed not in an individual dimension but in a social-organizational dimension. In other words, here, learning is carried out in a social organization *HACS*, rather than in an individual HACS who is only allowed or even required to memorize the concepts obtained by social abstraction.

For instance, an individual does not learn such concepts through personal trial and error as those related to science, foreign language, law, economics and so forth. In most cases, an individual passively learn them by heart, and simply *add* them to one's own semantic structure. The diverse concepts in the present *knowledge society* make up *knowledge-base*, which nobody living today can be ignorant of.

The difference between the two ways of concept-learning would become clear, if we compare the learning methods of *mother tongue* and *foreign languages*. When studying mother tongue, children construct their own concepts, as stated before, by the feedback and adjustment of the results of their actual usage of words. The problem is whether or not they can achieve successful communications for survival, rather than the

transmission of strict meaning of words. On the other hand, such an actual trial and error is unlikely to happen, when beginners study a foreign language. Instead, they try to translate foreign words into those of their mother tongue – i.e., beginners try to understand and memorize the foreign words by connecting them to corresponding concepts of their mother tongue. Since the concept of a foreign language is naturally not coincident with that of their mother tongue, the understanding of beginners is often incomplete and causing errors.

It goes without saying that the learners of mother tongue and foreign language are the same in respect of making frequent errors. But the important difference is that the conceptual structure itself of the social organization, to which the learner belongs, may be *changed* or *updated* with the word usage of the learner in the case of mother tongue studying. On the contrary, that never happens in the case of foreign language studying. Baby talk sounds cute, and adult members in the family often make conversations using children's incomplete expressions. In addition, it is not unusual that school boys and girls use a sort of slang in a class room, or that the employees of a company use strange jargon understandable only among them. In the case of foreign language study, on the other hand, the error of a beginner is simply objectively indicated as *a mistake*. Those who attend the construction of conceptual structure of a language are basically limited to its native speakers, and non-native beginners are allowed only to passively memorize existing vocabulary and grammar.

The same thing can be said not only about the knowledge of foreign language. Rather, it can also be said about any *expert knowledge* – science, technology, law, economics, etc. For non-professional general people, the concepts constructed by professionals' social abstraction are *authoritative knowledge* which should not be modified.

The situation is naturally different for professionals of that field. They are always making efforts to *update* or *modify* the existing expert knowledge through academic research work. Even if a professional proposes a new argument, it could not become an influential expert knowledge in society, unless it is admitted to be correct in an expert group through mutual evaluations. The new argument is considered not a personal concept belonging to the individual professional, but *an organizational knowledge* produced by professionals' social abstraction.

Today any professional field is increasingly fractionalized, and huge amount of papers

and documents of a field are made public day by day. Namely for an individual, almost all parts of knowledge-base are out of one's specialty. As a result, people are inclined to fragmentally believe in the most of knowledge and information offered by the mass media or the Internet.

● Supplements and Applications

In order to attain flexible *propagation* of semantic contents, ideally, it is desirable that *organizational learning* and *personal learning* are tightly connected, where both have an influence on each other. That sort of relation can actually be found in a comparatively small size social organization and its members. For such a case, the social organization system (HACS) is positioned at higher level than psychic systems (HACS) of its members which are always under the *constraint/restriction* by the social organization system. Naturally the conceptual (semantic) structure of the social organization has strong influence on its members' conceptual (semantic) structures. On the other hand, however, the communication of the social organization is being generated from the material based on the remarks of its members (outputs of psychic systems), and at the same time *the conceptual structure* of the social organization is being *updated*. Hence there can theoretically be the influence of each member's conceptual structure on that of the organization in the long run.

But actually, unlike ancient segmentationally differentiated society, we can hardly find such a relation in the present society. The more the professional fractionalization proceeds and the greater *the knowledge-base* with expert intelligence grows, the harder for an individual to critically understand the world through one's own experience, as one has ever more things to memorize by rote.

Here we can find *the trap of the so-called knowledge society*. While blaming students for their copy&paste reports, we are inclined to seek after clever ways of saving energy to interpret and memorize information, with the tremendous increase in *mechanical information* related to professional knowledge. The prevalence of cheap how-to books such as "Mastering something in three days" is a typical example.

We have several serious problems in such a fragmented society of today. Most of the present social issues – an environmental issue, aging society issue, etc. — are connected to diverse academic fields and impossible to be solved by narrow special approach.

Moreover, we must not forget that even prevailing expert knowledge cannot avoid errors. Doubtful fallacy or incorrectness is hard to be tested by general people who are not professionals.

This can happen even in the case of foreign language learning. We often find, in an exam-oriented English textbook, obsolete expressions unused anymore in English speaking countries. Apart from studying classic literary works, that kind of knowledge is useless for practical conversation with English speaking people.

It is not uncommon in the fields of science and technology that *obsolete knowledge* is circulating. Especially, when such a knowledge statement gets mixed in Web search results, it enlarges misunderstanding among people. We must be careful because a search engine usually determines *the listing order* not by the content of knowledge statement but by its access count.

What should we do to prevent people from being crushed under tremendous amount of professional knowledge, and enable them to solve various problems in present knowledge society? Generally speaking, it is considered useful to incorporate interactive *feedback circuits* into each learning process of social organizations and individuals. The *collective intelligence* introduced in Chapter 3.7 "Bi-directional media" can be employed for the feedback. Like an on-line encyclopedia Wikipedia, the mechanism enabling general people to exchange their views and correct mistakes is expected to be the way to overcome the people's passive attitude of memorizing professional knowledge by rote.

Despite that, there remain lots of tasks to make collective intelligence truly effective. We cannot always assume *the optimistic view* which collective intelligence depends upon – the view of human nature as fundamentally good. The binary code of the Internet system is "*stimulative / non-stimulative*", and the syntagmatic program is "*reputation*". The participation of nonprofessionals, if combined with sensational demagoguery, may cause the prevalence of ignorant fake knowledge among people. This risk is especially serious for the knowledge of political or economical issues where sharply divided opinions are found, rather than knowledge of science and technology issues. For the future we should still work on how to make the most of collective intelligence.

4.5 Machine Learning

Can an information processing machine such as computers really learn something? – In principle, an information processing machine is a *heteronomous* system, which is *open* and operated under the rules provided by human beings. Hence it can neither learn autonomously nor construct its own world. The learning in its true meaning is a privilege of a *closed* system, or more precisely, an *autopoietic* system.

Despite that, the so-called *learning machine* has been studied for several tens of years. For example, an optical character reader which is a pattern recognition computer system has already been widely used. In addition, there is even an information processing machine that some engineers advocate having *autonomy*. What does the autonomy mean there?

As a matter of fact, we already stated that a human psychic system (lower level HACS) is seen as if it were a heteronomous system from the viewpoint of a social system (higher level HACS). With the rapid development of ICT, human beings are going to have more opportunities to cooperate with computers than ever before. Hence, let us here think about what it means for *a machine to learn*, while reflecting on the essential difference between autonomous and heteronomous systems.

In the case of a heteronomous system, as stated in Chapter 2.8, its output (action) is completely determined by *the past series of input*. Note that the operation rule has been given by human beings. For a simple machine *without memory*, its output can be computed by the present input solely. Even for a machine with memory, its output can be computed by the present input and its internal state, which is determined by past series of input. In the case of an autonomous system, on the other hand, its output (action) depends not only on the past series of input but *on the way the system has processed past inputs (i.e., on the past operations)*. In other words, the rule of operation itself changes according to the former processing (operations) and its results.

The important issue is the way the operation rules change. For autonomous systems like living things, the rules are internally determined and not only the rules themselves but the way of changing rules is unknown. Therefore strictly speaking, we cannot but conjecture the next response from a living thing even to the same stimulus. Namely, an autonomous system is closed and its output *cannot* be foreseen. This is the reason why we cannot completely predict the other people's states of mind.

For a heteronomous system whose operation rules are given externally, on the other hand, we *can* completely predict the next output from the past input series. But what will happen if the rules comprise "*the rule to change rules besides the initial rule*"? Given such a meta-rule – the rule to change operation rules based on past processing (operations) and their results – the prediction of next output is pretty difficult even though theoretically possible. *A learning machine* is exactly that kind of system. It has its *rule of changing rules*, which is a more abstract rule, along with an initial rule. (A feedback machine of the first-order cybernetics can be considered a simple example.) Because the output of a learning machine varies depending on input series, the prediction of next output becomes not easy. When input changes greatly, and the rule of changing rules is complex enough with high-level abstractness, the output prediction becomes *virtually impossible*.

Such a complex learning machine may give us an impression as if it were operating in a real autonomous way. Of course it is originally a heteronomous machine, because human beings give its operation rule, no matter how complex it may be. But we often consider it as *a kind of pseudo-autonomous system*, since it keeps changing the way of operating recursively according to its own operation results.

The learning machine, which has the flexibility to adjust the way of acting corresponding to the environmental situation, is an attractive system that can be very useful. Moreover, through the research on it, we might be able to investigate into how the operation rules of living things – especially that of human psychic systems – are like, and how they are being changed.

● **Supplements and Applications**

There are at present many projects to develop a so-called *autonomous robot* which has the learning function. So far most of practical learning machines have been simply a sort of adaptive machines which can select a desirable operation rule from a group of prepared rules when detecting some changes in an environment. Today however, the research on higher learning facilities is being carried out as stated in Chapter 2.8. What is especially interesting is the development of an experimental robot with *pseudo-autonomy*, which enables to change its operation rule *almost internally* through making conversational interactions with its surroundings (cf. Frédéric Kaplan, *Les*

machines apprivoisées).

For example, imagine an experiment as follows. First the experimenter shows a red ball to a robot with microphone and speaker, and asks "What is this?". If the robot answers "Tomato", then the experimenter responds "No" and gives it no reward. After repeated trial and error, the robot will gain a reward when it returns the right answer "ball" for the first time. Through such "*experiences of nomination*" the robot gradually obtains the ability to recognize a ball. This may seem somewhat similar to the pattern recognition of an optical character reader. But the robot does not have any initial definition of the attributes of a ball (round, red, etc.). Rather, it starts from total ignorance, and connects little by little the sound symbol and visual image based on *the conversation with the experimenter*. This is the same result-reward type of training for animals. It is only the rule "Try to gain a reward" that a human being gives the robot from the outside. Therefore it looks like that the robot has created the concept of ball internally, if it has succeeded in recognizing various visual images of a ball.

In addition to such voice recognition, it is possible to train a robot to *take action* following the order of an experimenter through the same result-reward type training. For example, imagine a robot which has wheels, a motor, and a magic hand. When being given an instruction "Bring me a ball", the robot begins to look around the room, finds a ball, and finally brings it to the experimenter. It is noteworthy that we may expect a kind of intimate relation between the experimenter and such *an educatable robot*.

More interesting experiment would be the effort to make many robots to invent and develop their own vocabulary through the experience of *conversation in a robot society*. Such an experiment termed "Talking head" was carried out during 1999-2000, where about 3,000 robots in Tokyo and several European cities were connected by the Internet and did *the act of nomination* with each other. After a few months, the robots became using almost *ten words in common* correctly, some of which were not human words.

The research and development of such an experimental robot brings about fantasies on a scientific basis. In addition, we may think about more practical use of it. For example, we can easily imagine a robot team working in an area of radioactive contamination where human beings cannot enter, adapting flexibly to the situation.

Despite that, the reinforcement of (pseudo-)autonomy of a robot is undesirable for

practical purpose, although it might be interesting from theoretical viewpoints. The greatest merit of a machine is obviously its predictability – we can foresee the action of a machine because of its strict *repeatability*. If we cannot predict the action of the next instant, the machine may become a troublesome existence because it is out of our control. More concretely, such a robot can attack human beings in an unexpected situation. The nightmare of science fiction will appear if we imprudently pursue too much the autonomy of robots.

It is a great issue what kind of *pseudo-autonomy* we should develop for a robot of practical use. For a robot working at a dangerous place, such a design might be desirable that its basic actions are remote-controlled by human beings while it can cope with unexpected risks in an autonomous way.

4.6 Evolution of Systems

Values, ideas, scientific and technological knowledge etc. are *propagated* and shared among people through the learning of *HACS* of individuals and/or social organizations whose semantic (conceptual) structures are being molded little by little. But the *propagation* takes the form of not only such a gradual change but also a rapid and drastic change like a chemical phase transition. That corresponds to *the birth of new HACS*. In brief, a new Erforgs medium comes into being, through which communications are navigated to a new direction, and a closed area is going to appear in communication space. As a result, a fresh HACS is born that brings about a peculiar semantic (conceptual) structure. A new world image or values are being formed and established in such a way. Moreover, the sequential birth of HACS in various geographical areas, which have the same Erfolgs medium as the HACS originally emerged in a particular geographical area, often causes the wavelike propagation of the similar values.

Let us consider as typical examples the Erfolgs media proposed by Luhmann such as power, money, truth, love and so forth. In a pre-modern society, especially in a medieval Christian society, the God was absolute authority on which every communication is finally dependent. Everything – politics, commercial trade, academic research, and mutual love – was based on sacred words of God, whose logic used to give the meaning of the world. That was exactly the universal integrated conceptual structure shared by people at that time.

But after the Reformation of the 16th century and the resulting religious war had caused serious cracks in Christianity, European political power could not rely on divine authority any longer. Now it must recursively construct political meaning and concepts on the basis of its own logic. Thus *the modern age* has arrived, when people carry out laws on pure legal logic, take commercial activities on only economic logic, do research and development on solely academic logic, love each other on their own logic of sentiment. Such a state of European society began to spread out to *most* of the countries on the earth. Namely, the HACS of a functionally differentiated society have come into being in almost every country. The structural products of them include a parliamentary system, enterprise and market, school and academic society, modern art, etc.

The Japan after the Meiji Restoration is no exception. Let us take a short look at a "*newspaper*" as an example of a birth of new HACS. For a while after the Meiji Restoration, a newspaper was regarded as an educational tool for *people enlightenment*. But with the arrival of the Freedom and People's Rights Movement as well as political parties, it became *a party organ bulletin* to be used to advocate a party's opinions and discuss various political issues. Such a newspaper was called "*the oh-simbun [major newspaper]*" which had a blanket format and written in literary style. Together with that, a more popular newspaper called "*the ko-shimbun [minor journal]*" appeared which had a tabloid format and written in colloquial style, to take up familiar issues, happenings and entertainments in an ordinary life.

And it was in the 1890s-1900s that *the commercial newspaper for general people* finally arrived, which integrated these two types of newspaper. The rapid increase of circulation has contributed a lot to that, which was brought about by highly elevated national consciousness through the two wars, the Sino-Japanese War and Russo-Japanese War, accompanied with mass printing technology by the introduction of a rotary press machine. The economic independence enabled the newspaper to take preferable distance from political power. In this way, the "mass communication" came into being based on original news gathering, which covers interesting happenings (reports), pleases people (entertainment), and discusses political, social and economical problems (journalism). Here the *newspaper HACS* was born whose Erfolgs medium is "current topics", binary code is "popular/unpopular", and syntagmatic program is "circulation". As a result, common *image of reality* has come to be shared among general people.

● Supplements and Applications

Let us consider the Internet from the viewpoint of information *propagation*. Like a mass media system, an Internet system is also the *HACS* as a *super social system* situated at higher level than ordinary social systems, and gives restrictions to them. Nevertheless we cannot yet regard it as a mature medium. This is of course a demerit of the Internet system but is also its merit at the same time. What is necessary for the Internet system to become able to provide new images of reality that give other persuasive views than the conventional images proposed the by mass media?

As stated in Chapter 3.8, the Internet is defined as a HACS with the Erfolgs medium of "themes", binary code of "stimulative/non-stimulative", and syntagmatic program of "reputation (the amount of access or links)". Its characteristics are *fluidity*, *fractionalization* and *anonymity*. The internet, as a bi-directional medium with unspecified message senders and receivers, generates communications recursively in small or middle size groups each of whose members come together or take apart freely. However, there are some *social networking services* (*SNS*) having almost fixed members, in which people generally participate in their real names. Moreover, it is not uncommon that millions of people are attracted to a common theme causing a big wave of opinion. We can often find such a phenomenon when some unusual social events happen.

Let us note the following example. What kind of voices was heard in the Internet just after the accident of Fukushima nuclear power plant caused by the earthquake on March 11th 2011, which made people afraid of radioactive contamination? Naturally the mass media reported every day the message of the government, the supervisory authorities and the electric power company. In addition, they reported the state analyses and advices of experts in nuclear engineering and radiation medicine. But general people were not satisfied indicating that the *information disclosure* is not sufficient. They strongly doubted that the people concerned were intentionally *concealing* the great risk of total ruin of Tokyo Metropolitan area, or the fact that serious scale of radioactive contamination had already happened. Accordingly, the Internet space was once filled with such critical opinions. The presupposition of these Internet communications was that the information of the mass media is seriously distorted by the people concerned who try to escape from taking their responsibilities, and therefore the information from disinterested general people is much more reliable.

Nevertheless most of general people were at a loss because they could not judge which information is believable. The speakers in the Internet seem well-informed, but some of them are anonymous and unlikely to take responsibilities for their speech. As a matter of fact, there are swindlers who try to sell quack medicine pretending to be effective for radiation protection. The influence of the Internet communication has little to do with its scientific accuracy. Rather, the influence grows recursively and enormously if it is stimulating and get reputation. There is a risk that an amateur speech of a celebrity on the Net causes groundless fear, resulting in a fatal panic.

Hence the mere disclosure of information cannot, although important it may be, solve the problem. General people have no professional knowledge of the validity of methods for measuring radiation and its risk. So they cannot but get puzzled how to act, even when shown a large amount of data. Then what is lacking?

People's doubt comes from the fact that, in brief, the professionals concerning to nuclear reactor – those of the electric power company, supervisory authorities and even related scholars – all look to be *companions*. It seems that they share interests and the source of their information is almost the same. Therefore what is needed is a professional *second opinion* which consists of calm arguments based on plural viewpoints and information sources. That is, the open discussions and critical exchanges of views reflecting constructive opinions and ideas could solve the problem.

Like the above example, what is essential for the sound evolution of the Internet HACS is not the simple assembly or addition of many people's opinions. Rather, we need to bring forth *diverse on-line communities* (HACS) involving professionals, where we can exchange and deepen our views.

4.7 Digital Divide

The arrival of the Internet as a new *super social system* in addition to the mass media is considered basically preferable. General people are provided with a new *image of reality* from another viewpoint, hence we can expect *multifaceted complex propagation* of semantic contents rather than conventional one-sided *propagation*.

Here we must notice, however, an obstacle termed "*digital divide*". What makes trouble

is the possibilities that some people may suffer a disadvantage when taking social/ economic actions or receiving various services, because of the limits of their abilities to manipulate ICT devices and access the Internet. Such people are left behind in an information society. The decisive gap between the people, who can and cannot have the image of reality provided by the Internet, may cause the breakdown of national consciousness and various social functions because of communication cuttings.

Considering the circumstances mentioned above, we mean by the word digital divide a phenomenon that brings about *diverse discontinuities or gaps* in a society with the rapid spread of digital ICT like the Internet. It is one of the purposes of *fundamental informatics* to make up a theoretical basis to discuss and solve such a problem.

Note that, however, the word digital divide is often used in a little different meaning. This word has come to be widely used since the beginning of the 2000s, and it is mainly employed in the meaning that *the ability and/or frequency of accessing digital information in the Internet etc. differ greatly among social classes (groups), resulting in noteworthy enlargement of economical/social gaps among such classes*. Disadvantageous classes are featured by low income, low education, rural habitants, female and so forth. Sometimes the issue is discussed not in terms of national gaps but of international gaps between advanced and developing countries. Consequently, the policies on overcoming digital divide are sought after in the hope of improving the access abilities of disadvantageous class people.

Nobody denies the importance of such policies and their enforcement. However, we should notice that there is a too simple assumption that the improvement of people's ability to access digital information immediately leads to the increase of knowledge, to the growth of economy, and finally to people's happiness. If the free access to the Internet means nothing but the greater opportunities to obtain huge amount of *mechanical information*, it may cost excessive interpretation energy and hence even prevent original activities. Human beings tend to be seized by the sense of powerlessness facing with tremendous amount of professional knowledge. That may result in the increase of copy&paste reports and the decline of human thinking ability. In addition, a tendency may appear that people limit their interests to the details of entertainment works; i.e., they try to keep their identities by communicating only with the enthusiasts of the same topic. There are young people being involved in an on-line game as deeply as they look ruined persons. They are also the victims of digital divide,

aren't they?

Namely we could say that, for the purpose of solving difficult problems of modern society through the active use of the Internet, only the policy on improving the net-access ability of particular social class is insufficient. We must seek after a new evolution of social *HACS* to eliminate digital divide.

Another point needs to be indicated is that the people of poor net-access ability are not necessarily those of low income, low education, rural habitants, and/or female. Rather, there are many people of poor net-access ability among those of high income, high education, urban habitants, and/or male. Elderly or middle-aged people of management have such tendency. We must not forget the fact that net-access is not restricted to business use through personal computers. The net-access through high-function cell-phones is very popular especially in Japan. Today, many Japanese women, old or young, are enjoying their consumer lives in cities or the countryside. Hence, digital divide has to be discussed from another viewpoint.

● **Supplements and Applications**

Why are there so many elderly or middle-aged men, working as a manager in a major company, who are not very good at making use of ICT including access to the Internet? – They have generally enough logical ability as well as high income and education. One of the main reasons is that they are too busy to learn manipulation technique of ICT devices. Moreover, they are lacking in the motivation to master it, because most of their work concerns general or complex judgment such as human relation management; i.e., their subordinates take charge of formulated standard work. The preparation of more or less formal documents based on net-access (if necessary) is the work to be done by their secretaries or subordinates. Therefore they are not at all worried even without so-called ICT literacy.

Naturally such elderly or middle-aged managers would become powerless at once, if their subordinates leave away. But should we blame such managers, or people without ICT literacy in general, because they cannot fit the information society?

One of the apparent problems is that at present there is no human interface standardization for not only the Internet but also for various ICT devices and

application software products. The main ICT manufacturer can change quite freely the human interface for manipulating devices or software products such as an operating system, net browser, mailing software, word processor, spread sheet, etc. This may be preferable in the respect that a user can make selection from wide variety of products with diverse interfaces. But in fact, it causes the undesirable situation that an oligopolistic manufacturer is allowed to determine arbitrarily a *de facto standard interface* based on its own market strategy. In order to attain good sales of a new product with new functions, input/output interfaces are changed all the time, forcing users to learn a new interface constantly. This is one of the causes of *digital divide* because of its troublesomeness particularly for elderly or middle-aged users.

If ICT literacy is as important in an information society as foreign language or calculation, it should be taught in public educational facilities. But in such an organization, people are reluctant to teach manipulation know-how in the name of "Information Processing" etc. – because it was designed by a private company based on its marketing strategy irrelevant to any inspection by academic authorities. Consequently, what is important is considered *the standardization of human interfaces of ICT*. User groups and intellectuals should cooperate with manufacturers to design a good standard interface, and disseminate it through public education to make people confidently manipulate ICT.

Another issue more essential is that there is a serious misunderstanding about how to make good use of ICT – especially computers. It is a common belief that the purpose of ICT is the improvement of *production efficiency*. Namely we believe unconditionally we can reduce production cost by replacing the work used to be done by human beings with computer operation as much as possible, which make us win a price competition. We find this way of thinking not only in manufacturing industries but also in various service departments of public and private. Thus, conventional human services at a window disappear and professional clerks are fired. Instead, general people must help themselves to have service by manipulating a special computer terminal, a personal computer or cell-phone. Typically they must *converse* with a web system in front of a screen.

Such a computerization may temporarily (locally) achieve production cost cut through the reduction in the workforce. However, in the long run, it is likely to cause *inefficiency* on a total social scale, because it compels many people to waste great time and energy.

As stated in Chap.2.2, a computer can never make real-time *conversation* with a human being. It is a *stubborn and inflexible* automatic machine that cannot do anything but the logical processing programmed by a designer in advance. A kind professional clerk at a window may try to understand the meaning of a user's complex question. But in the case of a computer service, a user is forced to adapt oneself 100 percent to the machine logic.

We cannot realize *the fast input of mechanical information* to a human mind. The internal world and conceptual structure of a human being are being built by taking a long time. Therefore, it seems apparent that an impetuous computerization for cost cuts is likely to cause service quality degradation and the serious digital divide.

4.8 A Man-Machine Complex System

It is sure that the information society of the 21st century is going to develop based on ICT, particularly on the Internet. There, human beings and electro-mechanical ICT are so tightly integrated that they yield a sort of *man-machine complex* system. With the speed-up of ICT development, the physical and cultural environment around us is changing more rapidly than ever. In such a situation, how can we construct an information society free from digital divide?

What is indispensable for making a desirable relation between human beings and information processing machines is an analysis and deep insight based on fundamental concepts such as information, media, communication and so forth. Through the *HACS* model, as stated before, information phenomena in various fields from an individual to society are understood on the basis of *dynamic relations among hierarchical closed systems*. Thus, we can clearly examine the essential features, common or different, of the mechanical processing and living operation.

The HACS model is a general purpose multi-hierarchical model, but in this text we have focused on the systems of three ranks – super social system, social system, and human psychic system. Through the dynamics of these three rank systems, thoughts and values are propagated. The Internet and various ICT each play roles in the *propagation* process. Hence, we would commit over simplification, if we regard ICT or the Internet only as handy tools. They have strong influence enough to change the semantic structure of each individual, and even lead us to the radical reformation of an

information society.

Although the potential of ICT or the Internet is great, they also have traps. We ought not, above all, to replace too many human activities with ICT processing, producing too much *mechanical information*. That may not only result in ineffective social activities, but also damage human *creativity* and *adaptability* to environments. As already stated, mechanical information (a symbol) is nothing more than a sort of stimulus for a human mind. A human being tries to interpret it recursively and create *life information* and even *social information*, which requires considerable amount of energy. Accordingly, when a great number of stimuli comes at one time, a human being either totally refuses to receive them, or becomes a blind follower of mechanical logic by limiting one's free thinking. Namely, a human being voluntarily changes into a (pseudo-) information processor, and even becomes *a spare part* of "*a social mega-machine*".

The psychic system of an individual in a social mega-machine is operating under strong restriction by a social organization system at higher level. We can hardly expect the *feedback operation* (converse effect) from a psychic system to the semantic structure of a social organization system. This is because the upper level social organization is in operation based on strict computer logic, and its semantic structure is not at all flexible. Since human beings behave like machine parts following an instruction manual, such a information society may look highly efficient. But to tell the truth, it is very *fragile and dangerous*. Although a living thing has originally a creative potential to adapt to environmental changes, a human being gradually loses the potential while he/she is doing nothing but rapidly process a large amount of mechanical information in a social mega-machine.

We must overcome such a dark impression of a man-machine complex system. How could we find a new image of it which can, conversely, promote the creativity or thinking ability of a human being? It may naturally be desirable to build a social organization by substituting a machine processing for a part of human activity – especially unskilled labor. Nevertheless, in that process, we should pay close attention to avoid the over-rigidity of the operation of a social organization. An application of a suitable learning machine may be helpful for it.

In brief, a systematic consideration is indispensable which realizes *flexible semantic propagation* based on life information, in order to maintain and develop an information

society in an ever changing environment.

● **Supplements and Applications**

We have not yet found the clear image of a desirable *man-machine complex system* in the future. It is to be sought after through research and development. What is important is not only becoming skillful in manipulating ICT and the Internet, but also noticing the existence of *a social mega-machine* and making a critical examination of it.

Let us take a short look at the history. Frankly speaking, the 20th century was an age when logic was regarded as an ultimate ground of academic activities. Namely it was believed that we can obtain reliable knowledge by putting together, while following formal rules, logical propositions expressed using clear linguistic symbols. Here subjective judgment or feelings are strictly excluded. This way of thinking was eagerly pursued by the researchers of logicism philosophy and foundations of mathematics such as Gottlob Frege, Bertrand Russell, Ludwig Wittgenstein and so forth.

The theoretical founders of a computer, Alan Turing and John von Neumann, were also experts of foundations of mathematics. Therefore there is no doubt that a computer is *a logic machine*. That is, the computer was thought not simply a calculating machine but an ideal machine that could realize *human accurate thinking*.

Consequently, it was quite natural that the classic study of artificial intelligence of the late 20th century was aimed at developing *an inference engine*, which mechanically links and processes various logical propositions. That is an embodiment of the idea that we can solve a problem by automatic deduction from knowledge propositions, which are stored in a computer memory and describes accurately the state of the objective world. The Japanese fifth generation computer system was also a high-performance inference machine, that has given us the dream of a robot like *Astro Boy* in the 1980s. Let us call, not only such an artificial machine but generally an expensive large-size mainframe computer executing logical processing self-sufficiently, the "*Type I Computer*" from now.

After the 1980s, a *personal computer* that has a high-performance human interface as well as an inexpensive mass-produced micro-processor has wrested supremacy over the ICT market from a mainframe computer. We call this the "*Type II Computer*", which includes a cell-phone and a tablet-type portable terminal.

The main feature of the Type II Computer is that it executes logical processing by *interacting with* a human being. In addition, it enables people to contact others who are distant from them in terms of time or space; i.e., it helps the *conversation* between/among human beings through ICT as seen in the Internet.

From the viewpoint of *fundamental informatics*, the shift from the Type I to the Type II (from a mainframe to a personal computer) is considered very preferable. We can expect to solve only problems in very limited areas, by such an approach as uncritically assumes the objective world and formally/mechanically links logical propositions describing the world's state. Since the Type II Computer processing includes *semantic interpretation based on living human beings* as well as *mechanical information* processing, it is more flexible and is able to cope with problems in wider areas.

Despite that, even in the application of the Type II Computer, we have not yet sufficiently investigated how semantic structures are formed in a human mind or a social organization. As a result, there appears an over-expectation for the Internet accompanied by the tendency toward the *social mega-machine*.

The 21st century is the age when the workings of *the brain* or *body* which are thought to be making the basis of logical thinking attract considerable attention. What is sought for is the *enforced living activity* which has a close connection with machines. *Neocybernetics* is considered to provide an academic clue to study such a new concept. So let us call the kind of computer the "*Type III Computer*", which is expected to realize an innovative man-machine complex system. Then, what kind of computer is that? – It is exactly the question that this text raises in conclusion.