Chapter 1. Information

1.1 What is Information?

Information is something that brings about *significance* to a human being, or in a wider sense to a living thing. Any living thing keeps taking some actions to live. When taking an action, it makes some choice for which a piece of information is utilized. In short, it is nothing but *information* that has some *signifying effect* for a living thing to survive.

Imagine a salesman walking around a town wants to have a cup of noodle at a lunch time. He can obtain guide-information from the Web through his cell-phone and visit a noodle restaurant near by. A human being, as in this example, often exploits information consciously to make a logical judgment, but it is usually not the case for other living things. A hungry dog intuitively runs up to the smell of food, and even a primitive creature like amoeba moves towards a high nutrition part in a solution. For most living things, *a choice and an action* are inseparable with each other, yielding information at the same time.

The first essential point here is that information is not pre-given as an objective entity in the environment. Rather, it appears together with the subjective action of a living thing. A dog walking besides its owner finds olfactory information in the environment to which the owner is insensitive. Such differences can also be found among human beings. For example, a wine-lover recognizes much more information than a non-drinker in the same glass of wine. Therefore information is intrinsically not a universal entity common to everybody but a *subjective entity* emerges on an individual basis. This is the first step in *fundamental informatics* (FI).

Nevertheless why do we have the common belief that there is pre-given, objective information, as we say "the search for the information in the web"? This is because we assume the quasi-objective world whose states can fully be described using pre-given concepts and corresponding signs. These descriptions are called a set of *knowledge*, the data elements of which are often regarded as information. It is obviously *language* that supports this kind of world view. As a matter of fact, the term *inter-subjectivity* indicates that each person's subjectivity itself is formed by the use of a language reflecting social commonness. Note that information brings about *significance* which represents, not only some value or importance, but also a semantic content expressed by a word. This reflects the assumption that the human living world can be described quasi-objectively through linguistic symbols.

We cannot, however, always rely on such an assumption. In fact, the saying that "the meaning of words depends on a context" expresses clearly the breakdown of this assumption. It is not unusual, generally speaking, that misunderstandings happen quite often through the fluctuations in interpreting words. Any argument inevitably becomes inaccurate unless we carefully examine this assumption.

The second essential point lies in that information is not a material. Rather, it is a *pattern* or *difference*. We can easily be assured of this, when considering we can send the same business message through e-mail or postal mail. Consequently, we cannot always apply scientific theories about material and energy to information-related problems.

Modern science is, like physics, mostly so-called material science which is based on the laws on cause and effect. We therefore tend to look into information through the material scientific approach. However, information and material are related to respective worlds/dimensions, and the material scientific approach often loses its validity in the study of information. An ecologist Gregory Bateson indicates the distinction between the two worlds, calling in his famous book *Mind and Nature* the former as *creatura* world and the latter as *pleroma* world.

Nevertheless it is sure that any pattern conveying information is embodied in some material. A postal mail and an e-mail representing the same business message are each a piece of paper and electric signals, respectively. The pattern formed on a material corresponds to the crossing section of the two worlds. A living thing leads its life in taking continuously actions each connected to some piece of information. Therefore we can define information as follows: *a pattern by which a living thing generates patterns.* This definition, however, refers mainly to the carrier of information. We must not forget that information can be found intrinsically in a different dimension than that for material.

● **Supplements and Applications**

Let us compare the above mentioned definition of information with the conventional definition. The Japanese term *jo-ho (information)* is said the abbreviation of *jyokyo hokoku(situation report)*, which is in the military vocabulary. But this definition is too narrow in the current information society, although some words like *information officer* and *information section* is still used in this military context. In the fifth edition *Kojien*, one of the most reliable dictionaries of the Japanese language, we can find two better definitions as follows: (1) a report of something happened (2) a piece of knowledge necessary to take actions or make judgments through some media. Here the definition (1) means that information let you know something that you have not known so far. We use the term information very often in this way in our daily life. Obviously this definition corresponds to the objective information which is based on the above mentioned *quasi-objective world* assumption. A piece of information, for instance, gives you the right answer to such question as "When did the Honnoji Incident occur?". But to such question as "What is the best French restaurant in Roppongi?", the answer depends on your personal taste. Further, you can never have a persuasive answer to such question as "Is the current government truly reliable?".

The definition (2), on the other hand, has wider implications. It is closer to our definition because it connects information with judgments and actions, even though it has still have something to do with the quasi-objective world as seen in the expression "a piece of knowledge through some media". We could say, however, that this definition does recognize a sort of subjectivity, since it regards information as something important for a subject who makes judgments and takes actions. Note here that the *subject* in this case means not living things in general but a human being. Namely information is defined to be utilized solely for the logical judgments of human being's conscious actions. Nevertheless we are living in the 21st century when the importance of ecological considerations increases day after day. We must argue information from the viewpoint of living lings in general as indicated by DNA genetic code.

Next let us look at more academic existing definitions. A typical one is what regards information as something related to *negentropy* (negative entropy). This definition, which is well known among scientists and especially among physicist, was born in the early 20th century together with the appearance of scientific thoughts on information. The concept of entropy, although originated in thermodynamics, can also be explained as a statistical concept in the kinetic theory of molecules. If we open the window of air-conditioned room, the room temperature will in time be the same as outdoors. This is because molecular movements are random in principle and therefore they tend to be uniform as time passes. The entropy of an isolated system, which corresponds to the degree of randomness, increases with time according to physical laws.

In communication engineering we may surely connect information to negentropy, based on the fact that we recognize the decrease in the degree of uncertainty (randomness) by receiving some information. However, this argument holds only for the transmission of signals (*mechanical information*). A receipt of information does not necessarily bring about the realization of any order, which is contrary to our belief. The concept of *order* is ambiguous in itself. The shelf of a discount shop, for example, looks disordered for a new costomer but is perfectly ordered for a shop master. In short, this definition employing negentropy concerns itself only to material scientific arguments, and therefore, is considered too limited.

Another famous definition of information has been proposed by Gregory Bateson. His definition "*a difference that makes a difference*" well describes the recursive property of information and its relation with cognition. As pattern recognition is the act of finding a difference in patterns, this definition is closely related to our already mentioned definition "*a pattern by which a living thing generates patterns*". But it should be noted that the definition by Bateson does not refer to living things. As a matter of fact, a machine with feedback mechanism can be equated with a living thing in Bateson's theory, which is totally different from *fundamental informatics*.

1.2 A Taxonomy of Information Studies

Fundamental informatics (FI) described here does not encompass completely the whole academic fields of information studies. Then where could we position FI? What are its objects? What does it aim to study?

Information studies can roughly be classified into four areas. The first one is *information engineering* or *information science*. As for information studies, the border between engineering and science is unclear, although the approaches of the two are often very different. In the past, the word "information studies" used to mean mostly this area, except for traditional library informatics. This area, which includes vast amount of knowledge on hardware and software having developed through the second half of the 20th century, is the academic basis of current Information and Communication Technology (ICT) industry. It is further divided into many subareas but most of which can be summarized in the name of *information processing studies* as they are closely related to the use of computers.

However, the rapid computerization of society has brought about the idea in educational circles that conventional information processing studies are too specific and therefore requires reconsideration. In the traditional education of information processing studies, programming skill is thought to be very important and various programming languages have been taught to students who take the course of information processing. Nevertheless there is a strong argument that programming skill is not necessary for those students who are unlikely to become ICT professionals. Therefore today, practical skills to manipulate software products (word-processor, spreadsheet, etc.) are widely taught in the name of information processing course. But they can hardly be called academic information studies, because these manipulation skills are lacking generality and valid only for a short time.

The second area is *applied information studies*. This is simply an aggregate of various bulk of knowledge for making good use of computer in many academic fields. Since when computers were put into practical use in the middle of the 20th century, they have actively been utilized not only in science and engineering fields but in the fields like economics and business administration as a tool of numeric calculation and simulation. With the prevalence of PC and the Web, computer application has rapidly been introduced to such fields as law, politics, history, literature, linguistics, philology, and other traditionally unrelated fields to ICT. The methodology of applied information studies is naturally the one inherent to the respective field, but it is interesting that the methodology itself can change accompanied with the use of a computer. Anyway this is not an integrated academic area but interdisciplinary area, which is composed of various techniques to use computers.

The third area is called *socio-information studies*. This is a comparatively new academic field established at the end of the 20th century with the appearance of genuine information society. It does not investigate the technology to realize an information society. Rather, it looks into an information society itself from the viewpoint of social science.

The information society here means the society where such media play important roles as computer and the Internet, rather than the conventional mass media such as newspapers, TV and the radio. Traditional media studies discuss the role of journalism and literacy of audience in the mass media society. It is not unusual that this approach is also employed for the analysis of a computer society. Moreover, new approaches recently appeared to analyze information society by using the methodologies of jurisprudence, economics, politics, sociology, psychology, pedagogy, literature, art studies, and other areas of study.

Fundamental informatics is nothing but the fourth area which constitutes the basis of other three areas. Information studies are often regarded as a set of practical knowledge, since they have been developed together with application of computers. Consequently, there have been few fundamental arguments what information or an informational phenomenon at all is. It is a pity that we have no philosophically unified view how to solve the diverse problems which have come into being by too rapid computerization of society.

The aim of FI is to offer the solid conceptual basis for above mentioned three areas, through obtaining theoretical perspective to cope with actual issues in information society. Its methodology has much to do with that of life philosophy, semiotics, sociology, and cognitive psychology. More precisely, FI should be located as a branch of *neocybernetics,* which is composed of autopoiesis theory, radical constructivism, functionally differentiated sociological theory, and other associated study fields.

● **Supplements and Applications**

We cannot say that up to the present we had no fundamentally conceptual arguments on information. In the field of information science noteworthy researches were carried out on the essence of information processing. A mathematician Alan Turing proposed in the middle of the 20^{th} century a well known model named *Universal Turing Machine*, which is an abstract model of reading/writing symbols on a tape. Any computer in use can theoretically be included in this model. A stored program computer, which is said to be designed by a mathematician John von Neumann, is nothing but an implementation of Universal Turing Machine. Many related interesting researches were carried out in the latter half of the 20^{th} century to examine the essential properties of information processing. Information processing here means mathematical logic operations, namely a set of symbol calculation based on Boolean algebra. We may surely position arguments including design principles of logical circuits or algorithmic correctness of a program to be bases of information processing. Note that, however, these arguments concern only mathematical logic theory. They are at most partially useful in the design of hardware or software. Namely they are located at completely different dimension from the problem dimension like how information society should be or how the current relation between a human being and a computer is.

Let us note here, however, that there has been an attempt to bridge the two. That is the attempt to equate human thinking with information processing by a computer. Obviously this is the way of thinking to regard a computer as a kind of *thinking machine*, where human thinking process is modeled as computer-based symbol manipulation. It is often called cognitive psychology and constitutes the theoretical base of artificial intelligence technology.

It is rather an old idea that a computer is not a simple calculating machine but a human-like thinking machine. Both Turing and von Neumann thought exactly in this way. We can see in its background the tradition of logicism which looks on precise human thinking as nothing but mechanical symbol manipulations. No matter how interesting the idea is, we can hardly accept this argument when we understand a human being as a kind of living things. Recent study of brain science indicates that human rational judgments are basically driven by emotion and passion, in other words, by bodily reactions. As we human beings have been evolved from primitive creatures like amoeba, we must admit that our logical judgments are rather superficial or partial in human thinking as a whole.

In short, the above mentioned theories concern solely the philosophical foundation of mechanical information processing. They have nothing to do with biological cognitive activities which support human-related information phenomena and the resulting social issues. The information society has plenty of problems that can hardly be solved by a mechanical approach.

On the other hand, socio-information studies aim at examining actual issues in information society. In fact, they have already contributed academically to the solution of various concrete problems. For example, some experts of information law discuss what legal responsibilities should be owed by the administrator of an electronic bulletin board, together with the offending user, to the victim whose honor was injured. These discussions have already been utilized to cope with actual cases. We can easily find a lot of such examples. One of them is a statistical analysis carried out by social psychology specialists, who studied the effect of cell-phone use among young people.

Although they are effective for many cases, we dare say, each argument has been made on an individual basis. There is *no universal methodology* in socio-information studies. Generally speaking, their methodologies are simply handed over from existing disciplines such as jurisprudence, economics, politics, sociology, psychology, and pedagogy. This divergence has come from necessity, it is sure, but it would be rewarding to seek after common methodology based on philosophical considerations on information.

1.3 Conveyance and Storing of Information

From the viewpoint of commonsense, information is considered something we can convey. The definition in the *Kojien* as mentioned before has a nuance that information can be transmitted through some media. Note that the information storing is a mutation of information conveyance. This is because the former is nothing but transmitting information across *time gaps* by using memory devices, while the latter is transmitting it across *space gaps* by using telecommunication channels. Moreover, we store usually information temporarily at a sender/receiver when sending a message. Consequently it would be enough hereafter to discuss the conveyance of information.

To begin with, we must ask ourselves what on earth information conveyance exactly means. It is apparently impossible to hand over information as we do a package. When talking to people, we often find it difficult to convey accurately what we want to say. Sometimes serious misunderstandings could happen. Even if others look grasping the contents of our words, no one knows whether they truly do. Our ordinary communication experiences show us that we cannot necessarily convey our words' semantic contents.

Despite that, why could we relate the concept of information with the act of *conveyance*? Here we naturally recall *the information theory* proposed by telecommunication engineer Claude Shannon in the mid-20th century. This theory, although not concerned with information processing, is very well known as one of the fundamental theories about information and communications. When discussing information we always refer to Shannon's theory. Nevertheless, his theory in essence concerns solely *the conveyance of symbols (signs)*, and has nothing to do with the conveyance of semantic contents of information.

Shannon was engaged in the research of symbol coding as a telecommunication engineer in Bell Telephone Laboratories. In a telephone system sound symbols are transformed into and retransformed from electrical symbols (signal patterns). The best coding way is the one that achieves the highest performance, enabling to convey as many symbols as possible while avoiding noise disturbance. Shannon created an abstract model of symbol conveyance based on probabilistic theory, and proposed the mathematically optimum coding method. This model was obviously an extraordinary achievement in telecommunication engineering, but it had a drawback that it was easy to be misunderstood by general people. Namely it was apt to be interpreted as a general communication model which includes conveyance of semantic contents. We might say that the original communication model between transmission apparatuses was taken to be the model between human minds. This stretched interpretation has caused great theoretical confusion, although Shannon himself was aware that his theory has nothing to do with semantic communications.

One of the reasons of misunderstanding would be the abstractness of Shannon's model which is based on the probabilistic difference between information sender and its receiver. Let us take an example of a popular baseball match between the two universities Waseda and Keio. Here the sender is assumed to know the result of the match while the receiver does not. In the simplest case, the probability that one of the two universities won the match is either 1 or 0 at the sender while that is both 1/2 at the receiver. Once the information has been conveyed, the probability at the receiver becomes the same as that of the sender. In such a case we are inclined to think that the semantic content, the result of the match, has been successfully conveyed. Nevertheless we should discriminate this case from the transmission of digital symbols via electrical communication channels.

Note that probability is determined in an event space. As for symbol conveyance, the event space at the sender coincides perfectly with that at the receiver. Therefore we can successfully apply probabilistic theory to the analysis of communication. But as for semantic content conveyance, we know that the conceptual structures of the sender and the receiver corresponding to the event space are mostly different from each other. For example, the news of university match is likely to be ignored if the receiver is not at all interested in baseball.

Accordingly, we must assume the common conceptual concept at both the sender and receiver, in order to apply Shannon's model to the problem of semantic content conveyance. Sometimes we can approximately assume this way as, for example, answering a simple quiz about the location and time of a famous historical event. But these cases are rather uncommon. In general, we can never attain right argument if we directly regard the conveyance of symbols as transmission of semantic contents.

● Supplements and Applications

An extension of Shannon's model is often called *social communication model*, which has widely been employed in the field of communication studies of sociology and linguistics. It is assumed in this model that, by eliminating deliberately various noise factors, we can in principle convey semantic information contents from the sender to the receiver as if they were some packages. Let us call this *information package assumption* hereafter.

The information package assumption not only requires a common conceptual structure at the sender and the receiver, but it calls for the idea that we all human beings are living in *the common objective world*. The description of the states of this objective world is based on the common (universal) conceptual structure. Here a peace of information is regarded as something conveyed from those knowing a part of the description to others not knowing that.

There are certainly some cases in which we can make such an assumption. A typical example is a scientific measurement. Let us think of the measurement data representing the temperature at some time in a given city. The action to send the data to other cities, or store them for registration, looks certainly like handling of *information package*. But this is an exceptional case where the so-called objective world, which is based on scientific viewpoint, is widely shared by people.

Imagine that, just after making an inquiry, we receive a mail saying "Now I am thinking about your offer, so I will contact you one of these days". It would be a delicate issue to judge whether this is a positive or negative answer, which depends on generations and cultures. It might be better to assume that the next reply will never come.

Namely, we human beings usually live in subjective worlds which have different conceptual structures from each other. Hence, we cannot and should not make the above assumption in general. This leads us to the systems approach described in the following chapters.

Let us think of *the disclosure of information (freedom of information)* issue as an application problem related to information package assumption. With the spread of the internet, efforts are being made to disclose as much information as possible, enabling any information transparent for people in general. Especially those kinds of information are targeted which have been managed in major organizations with great social effect. Many people recently insist that major organizations like governments and leading enterprises must disclose completely what is going on inside and demonstrate they are obeying fair rules. For that purpose the internet is said to be a strong tool.

Malpractice in an important organization is not rare as shown by many instances of whistle blowing. To protect its exposure, information is often concealed. Therefore, the movement to seek after the disclosure of information can be thought reasonable. But we must not forget that it is not sufficient to open information to the public in a mechanical way. Even if, for example, all the minutes of official meetings in some organization are disclosed on the Web, we can hardly believe that it is *supervised by citizens* successfully. What can be open to the public is nothing but a series of symbols (*mechanical information*). The social communication model has brought about misunderstanding that the disclosure of information ensures sharing of semantic contents of information among people. It is not an easy task to see through the true intention of participant's remark. Often specialist and background knowledge are required. When sticking to the idea that everything should be made open, it may inactivate organizations because of prevalence of small fault findings with significant increases in paper work. Moreover it may make organizations, as a defensive action, turn official meetings into a mere shell and carry out substantial discussions in informal meetings. In order for public surveillance on the major organization activities, various approaches would be necessary such as setting up of a third-party organization composed of specialists, in addition to simple disclosure of information.

1.4 The Amount of Information

One of the problems of information society is said to be *the information deluge*. There is too much information in the Web and we can easily imagine that we are drowned in a flood of it. But first we must ask ourselves how to measure *the amount of information*.

The simplest amount is a file size which everybody is familiar with. As for image data and text data, it can be calculated by the number of pixels or characters, respectively. A Japanese character is usually expressed by 16 bit symbols (a series of 16 binary symbols). In this case, a book of 200 pages has a file size of at most 1,920,000 bits, where each page is composed of 15 lines and each line has 40 characters. In most cases a text file is reduced in size by paragraph lines. For an image file, the size is often much smaller than the total number of pixels owing to data compression.

These represent, however, merely *the amount of symbols* which has nothing to do with *the amount of information content*. When people say "This book is thick but has little information", they implicitly compare two kinds of information measure. A thick book of many pages naturally includes a lot of symbols, but it may have scarce information content if the reader is familiar with or uninterested in what is written in it. Here the amount of information content represents *the amount of significance for the reader*, which depends on one's subjective judgment and has no objectivity. Moreover, the reader oneself can hardly calculate the accurate amount. Strictly speaking, there is *no* objective value for the amount of information content.

Despite that, why do people often refer to the amount of information content? They have supposedly been misled by the social communication model already mentioned. As a matter of fact, it sometimes happens that we obtain insignificant results after searching for information on the Web and acquiring great amount of symbols. In a case like this, the term *the amount of information* often causes logical confusion.

We must remember, however, that the amount of information can strictly be defined in the Shannon's communication model which is the base of the social communication model. The amount is defined as follows.

When a symbol has successfully been conveyed through a communication channel, the amount of information obtained at the receiver is given as $-\log p$, where p represents the probability that the symbol is transmitted. We can count the information amount by the unit of *bit*, as we take the base of logarithm function for 2. Assume, for example, we convey two kinds of symbols "a" and "b" through the channel. In case the transmission probabilities for both "a" and "b" are 1/2, the amount of information the receiver obtains is always $-\log (1/2)$, namely 1 bit. But in case the transmission probabilities for "a" and "b" are 1/4 and 3/4 respectively, the amount of information of transmitting "a" is

–log(1/4), namely 2 bits.

This definition of the amount of information –log$p$ is derived from the *additivity* of information. It means that we can obtain the same amount of information whether receiving it little by little or all at once. For example, just imagine that we convey 4 kinds of symbols { a, b, c, d }. Let us divide them into two groups X={ a, b} and Y={c, d}. When a symbol has been transmitted, the information amount indicating "the symbol belongs to X or Y" plus the amount indicating "the symbol is the first symbol or the second symbol" should be equal to the amount indicating "which of the four symbols has been transmitted". It is well-known that logarithm functions satisfy this relation. Anyway we should not forget that we can calculate the amount of information only for symbol conveyance. As for the semantic contents that the symbols represent, we can never define the amount of information at all.

● Supplements and Applications

Usually a character is represented by binary symbols in a computer. Theoretically speaking, then, what kind of binary symbol allocation could achieve the best performance? Let us think of a text written by n kinds of characters { a_1, a_2, …, a_n } which we want to send via communication cannel. When representing the probability of character "a_i" appears in the text as $p(i)$, its information amount can be given as –log$p(i)$. Therefore the optimum binary symbol for this character "a_i" should have the length of –log$p(i)$ bits. Likewise we can allocate variable length binary symbols to each character from the viewpoint of theoretical efficiency. Intuitively, it is desirable to give a short binary symbol for a character appearing very often, and long binary symbol for a character appearing rarely. For a Japanese text, we could build up a binary symbol system in the way that hiragana (Japanese phonetic alphabet) and kanji (Chinese character) each have short and long binary symbols respectively, since the former appears much more frequently than the latter.

Although these variable length symbol systems are expected to achieve high efficiency, actually they are not widely used. We use mostly a fixed length binary symbol system like JIS code, where every Japanese character, including hiragana and kanji, is represented by fixed length 16 bit symbol. Apparently this is because the computer processing of fixed length symbols are much easier than that of variable length symbols.

Note that *the average amount of information* carried by a symbol when we receive a text composed of n kinds of characters can be given as follows:

$$-\{ p(1)\log p(1) + p(2)\log p(2) + \ldots\ldots + p(n)\log p(n) \}$$

This is sometimes called "Shannon's entropy" which represents the probabilistic property of the text as an information source. In actual communications, however, $p(i)$ s are generally not known unless statistically analyzed. Therefore the argument above is interesting only from a theoretical viewpoint.

As an application issue, let us comment on an electronic book (e-book) which has been drawing great attention recently. The possibility to read a book on the screen of PC has long been foreseen, but it is not until the advent of tablet-type portable terminals that many people begin to read a book on a display by downloading a book from the Web. A portable terminal for this special use can contain as many as 1,500 English books in a light compact case. This exactly is a good example that demonstrates the merits of portable terminals as compared with paper books by showing the amount of information of digitized symbols.

Since books are bulky and heavy, we sometimes cannot help disposing of them due to storage space shortage. Obviously it is good news for people reading widely that a lot of books can be stored in a small portable case. This is especially true for the researchers of the humanities who range extensively over the literature. Moreover, they can analyze a text by the use of word retrieval function on an e-book. There are some portable terminals offering functions of taking notes and extracting a part of a text, which is surely useful for paper writing.

Despite that, we should not forget that the reading experience through a portable terminal can never be the same as that through a conventional paper book. We can hardly predict how the reading experience will change with the prevalence of an e-book. It would be very likely that pretty many people cannot feel satisfied with e-books, especially for the generation of people who grew up reading paper books. It is hard for them to fully understand and memorize the book, no matter how long they watch the display.

Book reading is a kind of bodily experience involving eye and finger movements. A precious book is composed not only of simple rows of text symbols. Rather, it consists of various elements such as binding, lay-out, finger-touch and the personal notes written on the corner of a page. We will miss essential points if we note only the amount of information symbols when discussing our reading experience. The merits and demerits of an e-book ought to be analyzed from diverse angles, including the multimedia functions of an e-book.

1.5 A Body and *Life Information*

The information concept in *fundamental informatics* is captured by three categories – *life information*, *social information* and *mechanical information*. Note that these three are not exclusive with each other. According to ordinary thoughts, people are inclined to interpret them as DNA genetic information, mass media information and computer-generated digital information, respectively. But this interpretation is completely wrong. Any information is basically life information, and a part of which is transformed into social information. Further, a part of social information is transformed into mechanical information. In the course of these transformations, the original properties are kept intact as much as possible. Therefore conceptually the following relation holds.

life information $\supseteq$ social information $\supseteq$ mechanical information

Namely life information is *the widest definition of information*. We described at the beginning of this text that information is something that brings about *significance* to a living thing. This is nothing but the definition of life information. That is, life information is thought to be the most essential information in a radical sense. In modern information society, ICT has a great influence on our ordinary life and information is often seen from a mechanical viewpoint. Nevertheless the concept of information without considering the activities of living things can never become truly reliable.

What is, then, the *significance* for a living thing? It is not what has been given beforehand. A living thing continues to recognize and choose food, enemy, opposite sex etc. in order to survive. Through this try-and-error process, something significant can be determined post factum. In brief, significance or value is formed when a living thing has made some choice with a good result. For example, eating something nourishing has significance or meaning for the living thing, which may cause changes in its cerebral nerve cells and in its manners of actions. This corresponds to the physical semantic structure of the living thing. Based on the semantic structure, the living thing can continue its feeding behavior. Naturally such formation of significance or meaning is done not only individually but also genetically. A part of semantic structure is inherited from generation to generation. In sum, significance or meaning is produced recursively through the chain of try-and-error activities of a living thing, where *life information* plays an important role.

One of the important points is that a living thing does not take in any life information from the outer world through sensory organs. Of course a living thing is always exposed to various stimuli of the outer world. It has contact stimuli through taking actions, and even if it keeps still, it undergoes stimuli of light, wind, etc. We should remember, however, that they are not information in themselves but triggers for the emergence of information. Eventually, information emerges inside of a living thing.

A good example of a concrete image of life information would be a pattern appears in cerebral nerves. In each living thing, the pattern caused by identical stimulus may take different form. That is, a living thing does not introduce pre-given information into its body, but it produces life information recursively based on its own semantic structure. At the same time, the produced information modifies its own semantic structure itself. Therefore we might say that the changed part of a semantic structure corresponds to the emerged "information". In this recursive chain, outer stimuli are not always necessary and life information can emerge recursively inside of a living thing. This is understandable as we think of our dream or illusion. As a matter of fact, life information is truly "a pattern by which a living thing generates patterns".

Life information can be found in any living thing. And naturally a human body is considered full of these information, but most of which are left unrecognized. After a meal, for instance, there appear a lot of life information in digestive organs, but they are usually not recognized by a person concerned. Such unrecognized life information is called *raw information* which is neither observed nor described.

The fact that we are not conscious of the greater part of human life information never fail to remind us the importance of *tacit knowledge*, a type of knowledge hardly described explicitly. It is this type of knowledge that supports physical skills of sports.

We cannot overestimate the importance of raw information for our survival.

● **Supplements and Applications**

Human thinking used to be considered mainly carried on the human brain, and particularly on one's cerebral neocortex. It is the assumption that rational reasoning like deduction, induction and inference plays the essential part of human thinking. In the late 20th century, this assumption encouraged the research of artificial intelligence, and many researchers made efforts to build up a human mind model using computer-based inference engines.

But today, the development of brain science has shown that human thinking is basically composed of *emotion* or *feeling*, in addition to rational reasoning. To put it plainly, the primary drive is often irrational emotion or feeling such as being somehow scary or unable to endure something, and then rational reasoning is employed in order to effectively control one's actions to satisfy the basic drive. This assumption is quite persuading. A human being is, as is often said, an emotional existence, and it is not unusual that we take an irrational action based on a detailed elaborate plan.

Where, then, do emotions or feelings come from? We must pay attention to the whole body including internal organs and muscles. Let us think, for instance, whether we get goose flesh because we are scared, or we become scared because we have goose flesh. Although common sense tells us the former is right, so-called James - Lange theory insists that the latter is more likely, which is today widely supported by many researchers. That is, first occur bodily reactions and then feelings come about by monitoring the reactions in the brain. A neuroscientist Antonio Damasio argues in his famous book *Decartes' Error* that emotions, or bodily reactions, are *experienced by the brain*, resulting in the emergence of feelings. Not only dogs or cats but even animals without well-developed cerebra, can express their emotions such as anger or terror through bodily actions, which are obviously very important reactions for their survival. Considering biological evolution, it would be quite natural to regard emotional bodily actions to be more essential than rational reasoning. Life information is greatly related to such emotions. For example, when we feel nausea, there appear patterns of life information.

Then how does human rational reasoning come about? Human mind, or consciousness makes up the image of one's *self*, by continuously monitoring the states of one's body which has life information. The self, who is based naturally on one's physical body, is also a social being. In brief, we might say that rational reasoning becomes indispensable to keep *logical consistencies* of the self as a member of a society.

Here we find interesting application issue. How is it possible to have *a different personality* in virtual space, if the self is based on one's physical body? When a user communicates with others in an on-line game or electronic bulletin board, he/she can play a totally different character from the real one. In virtual space, a serious middle-aged clerk man can turn into a playful young girl, or a reserved calm lady can behave like a selfish macho dictator. The internet is not only a place to express freely one's own opinion as a citizen but it provides people with occasions to act freely as *a virtual self*, completely liberated from ordinary real self. There is an opinion that this is one of the greatest charm points of virtual space.

Turning into another character from time to time may be a good change of air. But becoming a different self everyday for many hours introduces a sort of ambiguity in one's own self-image. There is a risk that it brings about dissociative identity disorder. The causes and symptoms of this disease are too complex to be analyzed in a simple way. But the appearance of plural personalities on one single body is considered due to simulation abilities of human brains.

In ordinary thinking, human brains monitor one's emotions which are bodily reactions, resulting in the emergence of feelings. And in order to rationalize these feelings, logical reasoning is employed. However, human beings can bypass a part of this process, and simulate emotions (bodily actions) in one's brain by the use of language. Sympathy with others also appears in this way. Nevertheless we must not forget that it is nothing but a simulation.

1.6 A Symbol and *Social Information*

Life information does not circulate in human society in its original pattern. Human mind or consciousness observes the life information, and describes the way it is by using symbols such as words or visual images. Through this process life information is transformed into *social information*. Actually any information utilized in human society is social information. Therefore we can say this is the information in a narrow sense.

Let us take up a simple case that we feel something abnormal in our stomach. There appears life information, yet it still remains raw information. It is not until we consult a doctor and put "I have nausea and stomachache" that the life information becomes social information. After a diagnosis, the doctor will describe the state of the patient using medical terms.

In addition to such an example of social information transformed from human life information, we can have social information from other living things. If a human being observes and describes the life information related to other animals, it can be social information. A typical example is an ethological research report on chimpanzees written by an ecologist. As having been described based on human concepts, it must be different from the world view of chimpanzees themselves. This indicates the limitation of human thinking of observing other living things.

In brief, social information consists of symbols (especially words) and of their meaning, or semantic contents. Here the relation between these two is quite delicate and complex. First, life information itself is once-and-for-all existence peculiar to an individual body, but social information expressed in symbols is social and communal existence which has abstractness shared in its community. Being expressed in Japanese, social information reflects Japanese conceptual structure, and hence it would be understood only in Japanese society (Japanese linguistic community). For example, if we put "nauseating feeling" in two languages – e.g. in Japanese and English -- the semantic contents would be subtly different from each other. As is well known, a linguist Ferdinand de Saussure denied universal concepts and indicated that the way of coupling between *signifiant* and *signifié* is different from language to language.

Second, the meaning of symbols can be interpreted in many ways even in the same linguistic community. The degree of freedom in interpretation is in general pretty large. When listening to the word "dog", some imagine a cute toy dog like a poodle, others do a fierce dog like a Doberman. Moreover, the interpretation in our mind may dynamically change as time goes on. A philosopher Charles Sanders Peirce thought that such a dynamic process constitutes human thinking.

In short, the relation between symbols and their meaning is relative and not fixed. A code system, giving the correspondence, could be floating. (Note that, however, a code system defining the relation between symbols is fixed, such as ASCII.) Strictly speaking, *the meaning of words is dependent on the way they are used*, as suggested by Ludwig Wittgenstein.

Despite that, when we talk about "information sending/receiving", we often assume implicitly that the relation between symbols and meaning (semantic contents) is clearly determined. This comes from the basic assumption mentioned in Section 1.1 that the states of the world in which we are living can be described quasi-objectively using symbols and the description constitutes *world knowledge*. Even if we do not completely hold this assumption, we are inclined to think that, at least in many practical cases, a speaker and a listener share a certain conceptual structure and they can give and receive element data of knowledge in the name of information transmission. It is just like giving a correct answer in a TV quiz show.

Here we must ask ourselves how should be an *information society* like. In the worst case, it may become an inflexible society where everything is treated as a quiz that has simple correct answer. We must pay great attention to avoid such a shallow world view.

● **Supplements and Applications**

One of the most important problems in the Internet age is the problem of language. Owing to the Internet, international communication has greatly become handy. Formerly it used to take a week or more for a letter to reach a destination, but nowadays e-mail enables us to communicate abroad almost at once, thus makes efficient to carry out international business or academic collaborations. Moreover, there appeared even such service as offering international telephone calling without charge.

These developments in ICT have much to do with recent economic globalization. Many people say that the enterprise previously doing its business mainly in the domestic market must go out and take part in international business in the global market. And it is the importance of English, or American English, as a Lingua Franca (international communication language) that is frequently advocated.

No doubt that the United States has played the leading role in the development of the Net culture, as shown by web pages in English which takes the largest number in all languages. The ability to handle English in the Net space surely enables us to communicate with many people abroad. From now on, the ability will be sought after even more and more by those want to get involved in international activities.

In spite of that, if the whole net space of the 21st century is occupied by English texts, it will in the long run bring about great loss in cultural diversity. There are several thousands of languages on earth, each of which has long cultural tradition. As Saussure stated, conceptual structure of each language is different and this diversity is the mother of originality. Let us take some examples. Although many people are fond of hamburgers supplied by American chain store, they would also be disappointed if they cannot enjoy the cuisines of various countries. Japanese comics and animated cartoons have world wide popularity, which is said to be closely related with Japanese cultural tradition.

Fortunately, the Net space nowadays is not necessarily a space of English. As a matter of fact, we used to have strict limitations in the kinds of character to handle in the Net space, but that situation has greatly improved. Particularly important is the creation of the universal common character code system, the typical of which is well-known Unicode. In Unicode, any character in any national language text is designed to be allocated to a world-wide common binary code, to make it easy to be processed in computers. Before the arrival of Unicode, the same Chinese character in a Japanese text, Chinese text and Korean text were expressed in different ways within computer memories. Unicode has solved this inefficiency. At the beginning, Unicode was proposed by American ICT private companies, hence there were critical opinions in countries using Chinese characters. But afterwards the public as well as private institutions in those countries took part in building up Unicode. Through such international collaborations, it has become an international standard and authorized by ISO. Today we can express any text in almost any official language in the world by the use of Unicode.

In sum, we are now able to exchange various texts written in any language internationally through the Internet, supplied with appropriate fonts and software. There are already web pages in many languages, which show that the Net space is becoming more and more multi-lingual. A lot of non-native Japanese people are said to be eager to read Japanese web pages by studying Japanese, because they want to know more about Japanese comics and animations.

What is important is to discriminate the circulation of linguistic symbols from that of semantic contents. It is true that the Internet has greatly promoted global communications, but we must take care not to be too much English dependent. If the semantic contents circulating in the Net space overemphasize American culture, the 21st civilization will be too standardized and monotonous. There are some 7 billion people in the world, of which only 5 or 6 percent are native English speakers. In the age of globalization, the value of diverse local cultures increases.

1.7 ICT and *Mechanical Information*

Social information is considered to be exchanged through face to face conversations. There semantic contents are conveyed together with symbols like voices and gestures. Among animals this is virtually the only way of communication. But in the case of human beings, efforts are made to realize *semantic content conveyance across the time and space* by transmission of symbols alone, which are processed in a way detached from the semantic contents.

Actually these efforts might often fail, as was stated earlier. Nevertheless they are expected to succeed with the assumption that we live in the common objective world and social information is a part of knowledge which describes how the world is like. This is because the conceptual structures ought to be the same for the information sender and the receiver, even beyond time and space gap, and therefore symbol transmission ensures the conveyance of semantic contents. This apparently plausible assumption introduces *mechanical information*, which is *the narrowest definition of information*. In brief, mechanical information is composed simply of symbols themselves.

When talking about mechanical information, we are apt to think of binary digital symbols to be processed in a computer. But they are only parts of it. The birth of mechanical information dates back to primitive rocket signals of ancient times. A set of characters which were born several thousand years ago can be regarded as a typical example of mechanical information. People tried to convey and store the meaning of what was said by writing characters on some material, either directly by ideograms or indirectly by phonograms. In old days characters were written on clay, bone, wood, papyrus, sheepskin, etc. And the appearance of paper scrolls and books enabled us to carry written texts easily and store them in libraries.

It would be better here to recall the role of an ancient scribe or a copyist. Like a messenger in an army, a scribe need not interpret or understand the meaning of a text. What was expected him was only to copy characters as precisely as possible. That is, in the work of a scribe, the semantic contents of characters are concealed and made latent.

This basic feature, concealment of semantic contents of social information, was afterwards succeeded to various analogue ICT: typography, photography, record, movie, telegraphy, telephone, radio, TV, etc. In a sense, they simply expanded and automated the processes, which had partly been done by scribes or copyists, in order to attain highly efficient mass reproduction. And the digital ICT using computers and the Internet is considered an advanced form of this technological improvement. When PCs or server computers process an e-mail, they regard it as simple binary data hence the meaning of the mail is kept latent. In short, ICT is no more than a tool to improve efficiency and to decrease the cost necessary for the conveyance and/or storing of symbols.

Mechanical information consists of symbols which made *temporally independent of their semantic contents* through some media, to convey social information to far away across the time and space. Needless to say, the original purpose of mechanical information is to convey the semantic contents of social information from a sender to a receiver as accurately as possible. Therefore there exists life information at the basis of any mechanical information. Nevertheless, why do we have the impression that mechanical information is detached from life information or life activities in the information society full of mechanical information?

One of the reasons is a sort of social stabilization effect in our modern information society, which tries to keep semantic contents expressed by symbols unchanged across time and space, in order for mechanical information to work well. Originally, a living thing responds to various outer stimuli from an ever-changing environment, and its interpretation of symbols often changes dynamically. Consequently, when symbols (mechanical information) are transmitted across vast distances of time and space, the semantic contents are apt to shift greatly from the original. Preventing this shift is the mission of the organizations or institutions in an information society, where the interpretation of symbols is usually done respecting rules and conventions. Namely the social information in this case is made *quasi-mechanical information*.

● Supplements and Applications

The ability to easily copy, store and distribute *an enormous amount of mechanical information* by the use of ICT is obviously the great feature of our modern information society. The memory cost per bit has extraordinarily decreased for last several decades, and wide-band optical fiber channels have prevailed to enable the transmission of a high-volume file like moving picture. As a result, we have now *the information flood problem*.

When thinking about the causes of this problem, we should not forget the new trend of software, in addition to changes in hardware. The World Wide Web (the Web) has spread to the whole world since the mid-1990s, but at first web pages were mostly operated by government and companies because creating and maintaining web pages used to require pretty work. But after the late 2000s, new handy services such as blogs and *social networking service* (*SNS*) began to be introduced, making ordinary people to express their personal views freely on web pages. This naturally contributed the increase in the mechanical information in the Net.

In the past, the way to distribute great amount of mechanical information was confined to the mass media, which required considerable cost. Therefore it was such limited people that could make their view in public as a politician, bureaucrat, academician, journalist, commentator, etc. But nowadays general people can express their opinions in the Net and exchange views without much cost. This is considered in principle very preferable in a democratic society in which diversity should be respected.

Nevertheless we must pay attention to a trap hidden there. In so-called information flood, what is surely abundant is only mechanical information – many symbols. As to diverse semantic contents, we are often in short of enough circulation. For example, there are possibilities that deviated opinions with prejudice are copied in huge quantities and distributed widely in the Net, and valuable opinions of minorities are totally ignored. Since anonymous remarks are often allowed in the Net, one person can distribute his/her opinion extensively in the name of many different persons. If we want to make use of the Internet for political activities, we must first create a system or rules to prevent such risks and ensure fairness.

We may cope with these issues by appropriate means. But in general, an excessive increase in mechanical information causes another critical problem. That is, we human beings are likely to lose our thinking ability when facing with too much amount of mechanical information. Eventually, we may narrow our perspective and sometimes even stop thinking.

A symbol is a stimulus for a mind (consciousness). Considerable amount of *energy and time* are necessary in order to interpret stimuli for oneself and to produce life information in the way to modify one's own semantic structure. If too much stimuli come at one time, our mind cannot cope with them in an appropriate manner. As a result, we are inclined to stop grasping the semantic contents of symbols deeply based on our body. Rather, we tend to interpret everything in a shallow and formal way, to attain *efficient processing* of symbols. Let us remember the common saying that ancient people read a few difficult classics intensely while modern people read hundreds of cheep how-to books extensively.

Another problem of information flood is that we are inclined to *confine our interest and become near-sighted*. It is the tendency to reduce the fields of symbol interpretation as much as possible, putting many fields completely out of concern. This is related to the narrow attitude to be agitated easily by simple slogans and totally reject different opinions.

We know that these tendencies have already become the feature of modern people's thinking. They might be regarded as a natural response when human beings have been thrown into the flood of mechanical information. What is important is to recognize that we are in such an unprecedented situation.

1.8 Digital and Analogue

Modern information society is called *digital society*, as shown by the digitization of TV broadcast. But we often hear people say "The digital is cold though useful, so I like better the warm analogue". What on earth is the digital? How is it different from the analogue?

The word digital originally comes from *digit*, or *finger*. Because we count number with folding our fingers, a digit has become to mean a *figure (numeral)*. Therefore a digital symbol is nothing but the kind of mechanical information which employs figures to represent something. For example, the character “A” is represented in ASCII code by 8 bit binary symbol “01000001”. Digital ICT means the ICT that manipulates digital symbols. The representative of digital ICT is naturally a digital computer where binary digits 0/1 are manipulated. There were analogue computers in the past, but they are not in use any more.

On the other hand, the word analogue means *analogous* or *similar* in shape. Originally information is related to a pattern. An analogue symbol is the kind of mechanical information which employs analogous (similar) patterns to represent something. For example, the carve in a L/P record represents the vibration pattern of sound, and the photographic negative shows the reduced image of a subject. What manipulates analogue symbols is called analogue ICT, in which not only photograph but telephone, radio, and TV used to be included. There sound and/or light patterns were transformed into analogous electrical patterns.

Since a piece of information is originally a pattern, it is easy for us to understand an analogue symbol intuitively. In addition to that, the sensory organs of human beings (living things) are so formed to recognize patterns. Consequently, even digital ICT often manipulates analogue patterns at human interfaces, by transforming internal digital symbols into corresponding analogue patterns. Let us remember the e-mail processing where characters, represented by 8 or 16 bit digital codes in computer memory, are represented by character font patterns on the display screen.

Then why is digital ICT widely used? Most important reason is that distortion and/or shear in patterns are easy to be born in analogue symbols because of noise. Although the purpose of mechanical information is to transmit symbols across distances of time and space, it cannot help more or less undergoing pattern distortion in the course of transmission. The color of an old photo fades and the sound of an old L/P record becomes noisy.

On the other hand, digital symbols are in general robust and hard to be influenced by noise, because they can be treated as numerical values. Even if errors occur in the transmission, they can mostly be detected and recovered. In short, the transmission accuracy and efficiency of digital symbols are expected to be much better than those of analogue symbols from a communication engineering viewpoint.

There are quite a few examples. An old hand-written manuscript becomes little by little unreadable as time goes on. On the other hand, a file created by a word processor can be retained almost for ever without quality degradation. As for TV, digital broadcast service is surely clearer than analogue one, because the former is easier to control the amount of mechanical information sent to audience. It would be obvious that the digital symbols can bring us *higher-definition graphical images* than analogue symbols can, if comparing the images of DVD with those of VHS video. Note that, however, a digital information file may run the risk of becoming *totally unreadable* because of subtle difference in logical processing, which is peculiar to digital processing of mechanical information. For instance, it is not uncommon that the image registered by a recent DVD recorder cannot be played back by an old DVD recorder produced a few years ago. In that sense, VHS video might be considered to have *higher mobility*.

● Supplements and Applications

Analogue symbols and digital symbols can be transformed reciprocally. Usually we first change an analogue pattern into digital symbols, in order to transmit, process, and store them efficiently. And after that, we change them again into an analogous pattern to make it understandable for us. There are two ways to digitize analogue symbols. The first way is to give each different pattern *a code number* as an identifier. For example, several tens of thousands of Japanese characters (*kanji* and *hiragana*) are used in Japanese texts. So we can employ a 16 bit code system which can identify 65,536 different patterns each corresponding to Japanese characters.

The second digitizing way uses *sampling* technology. This is a technology to express a pattern by time-space mesh data, where each mesh element shows luminosity or intensity of the pattern in numeral values. In the case of monochrome photograph, for example, an image is expressed by a series of pixel data: 2-dimensional mesh data the element of which corresponds to the degree of darkness.

Here, the fineness of mesh, or sampling interval, determines the accuracy how close the digital data are to the original analogue patterns. The so-called sampling theorem tells us that we can attain complete digitization if we do sampling as frequent as two times or more of the maximum frequency level of the original pattern. Roughly speaking, sampling of enough fineness ensures us the data transformation from analogue to digital (AD) or from digital to analogue (DA) without any distortion.

Let us take a look at music sampling for a CD. The sampling frequency of CD is 44,110 Hz, because the audible range of a human being is said from 20 to 20,000 Hz. Naturally in many music numbers there are sound components with inaudible high frequency, but by ignoring them we can enjoy complete regeneration of music number through playing a CD. Note that, however, some music lovers insist that a human being can feel the sound outside the audible range at some part of a body.

Digital symbols are mostly generated by transforming *continuous* analogue patterns to *discrete* numerical values. These features clarify the merits as well as demerits of analogue or digital symbols. Any pattern is impressed on some material. As classical mechanics shows, the material world is basically continuous except for the atomic world. This continuity causes the demerit of analogue symbols: distortion of a pattern when transmitted across time and space. Nevertheless, its merit is also caused by the continuity. Imagine that we are driving on a curved road. Even if the first wheel position is not right enough, we can gradually adjust the wheel position so as to turn the curve smoothly. There are a lot of such examples. We can still be moved by an old noisy L/P record, and we understand the content of our worn-out favorite book. In short, analogue ICT has a kind of robustness which allows us analogical interpretation neglecting slight differences. Therefore it gives us a “warm” impression.

On the other hand, the reason why digital ICT gives us a ”cold” impression is that it is nothing but integrated logic which is separated from the material world, and is intolerant to inaccuracy. When we make use of a web service, we get embarrassed because a small key-in error often causes a total rejection of input operations. Difference of only one bit might result in totally different operations in digital ICT.

This feature of digital ICT is strongly related to the security problem, especially that of computer virus. Digital ICT in general shows robustness in noisy environment, because it can detect noise and remove it by logical processing. But this merit is, to put it the other way around, also a demerit that it easily becomes the victim of subversive activities by malicious logical processing. Even slight modification of a kernel program can bring about a totally fatal operations or destructions of files. In this sense, we could regard digital ICT as something *fragile*.