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ARTIFICIAL INTELLIGENCE AND INTELLIGENT INFORMATION PROCESSING

—— Future Perspective of Intelligent Systems ——

Shuji Doshita
Graduate School of Engineering
Kyoto University
Sakyo-ku, Kyoto, 606-01, Japan

Abstract

The concept of artificial intelligence was established in 1956 as an approach to give a machine an intelligence as human being has. During past 40 years, it has been focused to manipulate the formalized knowledge as in knowledge based system. The fruit of first generation AI will be the expert system. But, a next future vision of the second generation AI should be to realize an intelligent system to understand, solve and process the actual, unknown, complicated real-world problems by the integration with human intelligence. In this sense, it will be human-machine or natural-artificial intelligence rather than artificial intelligence. In this talk, the retrospection of the past history and the perspective of the future vision of AI research in the 21 century are presented from academic point of view.

人工知能と知能情報処理

（知的システムの将来像）

堂下 修司
京都大学大学院工学研究科
606-01京都市左京区吉田本町

人工知能というコンセプトは1956年頃に、人が持っている知的機能を機械に与えるための手法として提唱された。以来、約40年は、その研究は知識ベースシステムにおけるように、定式化された知識を機械の上で操作することに主点が置かれてきた。そのような人工知能の第一世代の果実は、エキスパートシステムであろう。しかし、第二世代の人工知能の、次なる将来像は、人間の知能との統合により、生きた、未知のかつ複雑な現実世界の問題を理解し、解き、処理するような知的なシステムを実現することであろう。この意味で、「人工知能」というより人間・機械知能ないしは自然・人工知能とも呼ぶべきものであろう。

ここでは、過去の歴史を振り返り、21世紀の人工知能のビジョンについて学術的側面から考えてみたい。

Knowledge processing is a very important aspect of intelligent information processing and a goal of Artificial Intelligence research. It is not enough to make an expert system by aggregating rules empirically, but also it is necessary to clarify;

(1) What is the essential concept expressed by the knowledge.
(2) How it represents the actual or real object to be solved.
(3) How to acquire the knowledge from actual problem.
(4) What is the essential mechanism of intelligence in acquirering the knowledge.

To cope with this problem, we need the comprehensive framework for total human-machine interactive systems from the standpoint of not only information science and computer science, but also system science, natural science, human science and social science.

Historically, information science has started its systematic approach by establishing the concept of information and control by C. Shannon and N. Wiener and the model of Turing machine as a theoretical an logical model of processing information formally. Von Neumann type computer architecture was devised as its engineering model, which has been used as a fundamental architecture of all the computer exclusively since 50 years. It was designed to realize the most effective mechanism as a "converter" of data in the definite world that is, the definitely represented data with a definitely described algorithm. However, it is not the best way to treat the other problems including informalness, uncertainty or incompleteness and sometimes errors. To solve actual existence problem we must overcome two difficulties; one is that no actual problem is not well structured in a definite way, and another is that there are considerable semantic gaps between actual problem and the described one. We analyze actual problem and form the information description that might be supposed to represent it as well as possible. Information is then converted to data, which are manipulated on the computer. But computer's function is only to convert the input data to output data without understanding the meanings that are conveyed by the information coded into the data. as shown in Fig. 1. Therefore, the output data had to be interpreted or recognized by human being to resume its meanings. For the computer to work as an intelligent information processing scheme, not as a mere data converter, structure of information itself and its meaning have to be represented on the computer and the mechanism to interpret or evaluate the information must also be implemented.

To do intelligent processing, we must clarify what is information. Although the term "Information" is used very widely in common, Its formal meanings must be re-argued from knowledge science and situation theory point of view as a clear concept. It is an ontology of concepts describing the beings, existences, phenomena, or events analyzed and recognized from the real world. This "real world" will include human, cultural, social, natural, physical and / or artificial world and its environments as Fig. 2. Each concept must have the name and the attributes such as property, structure, composition, function, operation, usage,

effectiveness etc., and also the mutual relation among them must be described making organized network as a whole system. In short, relationship is the essence of information, which is often called as "Infon" in situation theory. Knowledge is systematized information for some specific purpose. But not all of the aspect of the world are systematized as knowledge. It is only partial- or under-specification including so many uncertainty, ambiguity and non-deterministics. Knowledge system must make conversion and reasoning on such partially described relations. Therefore, straight-forward deductive reasoning is not applicable, but the sophisticated composite reasoning based on deduction, abduction and induction are essential to solve real world problems. The current computer, which has a rigid deterministic and sequential control with unorganized flat memory architecture is not suited for this purpose; that is, all the capability to make intelligent processing is burdened to the software. This is the reason that the software crisis is becoming a very crucial, intractable problem now a days.

Artificial intelligence has been aiming to cope with such a total system. But in the past, it was restricted to deal mainly with the symbolized world separated from the actual problem. Future vision of artificial intelligence must be established as an interactive system that manipulates the ontology of real world, accepting a raw information from real world, working upon real world and receiving the reaction from real world. The necessary approach for that purpose will be summarized as follows;

(1) Developing an intelligence science which integrates the artificial or machine intelligence and natural or human intelligence.
(2) To clarify the mechanism and found the methodology of the approach for cognitive learning process.
(3) To form comprehensive reasoning and inferring process on the ontology of knowledge, integrating deduction, abduction and induction mechanism in both analog and digital ways for open world problem.
(4) To construct mutual interaction system among multi-agents including human being and machine.
(5) To build intelligent media understanding and generating system that makes the dialogue possible for the communication among agents.
(6) To devise a new system architecture that is effective for memorizing, reasoning and exchanging the knowledge, other than current Von Neumann architecture.
(7) To apply these methodologies to actual real world open problems —— Real World Intelligence (RWI).

Each aspect of the above has been approached from separate standpoint, However, these must be closely coupled each other for realizing next generation artificial intelligence.

The first generation of artificial intelligence has been successful for definite, artificial world such as knowledge-based system on process control, manufacturing, transportation, business management etc. as shown in Fig. 3, the subject of the second generation of artificial intelligence in the 21st century, that is

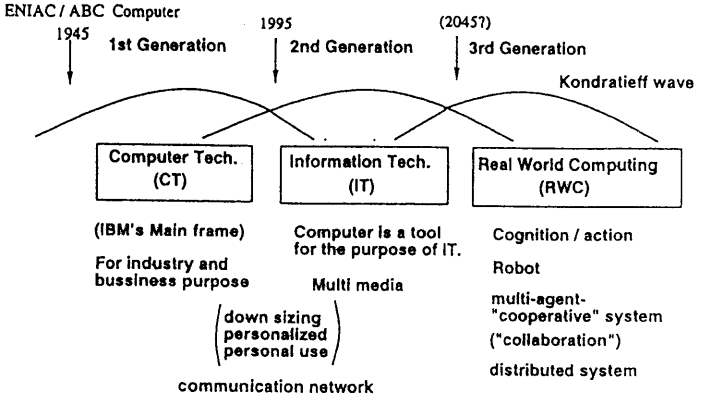
a new paradigm of A.I, is to deal with much more complicated, open ended, not-well-formed problems including artificial, natural and human activities, such as visual image understanding, speech and language understanding, dialogue understanding, active / mobile sensing and information acquisition, robotics etc., which are the bases of realizing the intelligent human computer interaction. The use of computer in the next generation must be interactive, active, dynamic one, whereas in the first generation it was rather one-sided, passive and static one.

The principal fruit of the first generation A. I. in past will be the knowledge base system, realized as the expert system. In the beginning of 1990s, many companies participated in the business and thousands of useful expert systems were developed mainly for industries or for artificial systems. At the same time, it has come clear that many essential problems are left unsolved for realizing of more intelligent system. Now, A. I. activities are stagnated or tranquilized. Thus, today A. I. research activities are basically to re-construct a new paradigm for the next generation A. I. technology. Our future vision is to realize intelligent human-machine interactive system which will collaborate by human-like media, way of thinking, behavior and attitude, as shown Fig. 4 and Fig. 5.

Generally speaking, the method of approach for information processing or information system depends largely on the way of thinking and cultural or social attitude of the people. Table 1 shows a result of comparison between Japan and U. S. A. in 1980's. Trend in Japan is somewhat different from those in U. S. A. We are putting stress rather on development or manufacturing than on fundamental research, and rather concrete areas than abstract areas. So the international collaboration is very important to overcome the difficulties that A.I. technology are facing for the future.

I expect that, after ten or twenty years, a new artificial intelligence, rather an intelligence science technology, will be blooming in Japan again, which is, based on the firm foundation, interactive and collaborative with human being and outer real world, intelligent, vivid, friendly, and then interested by every people, in daily life.

At last, we must comment on the question; " Is artificial intelligence effective or fruitful as a science? " or " Is artificial intelligence research a mere alchemy? ". Of course we can not realize perfect intelligence in explicit way as in the case of human intelligence. Artificial intelligence may not produce a fully intelligent industrial product. However, to clarify the methodology and principle of intelligence is very useful to give a more appropriate insight in realizing a more intelligent system. The way of thinking of artificial intelligence will also be an infrastructure or meta-methodology for every researcher in every field to learn as a general art.



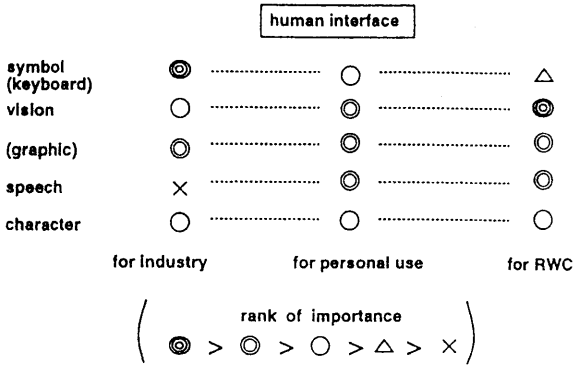


Fig. 3 From Computer Technology to Information Technology

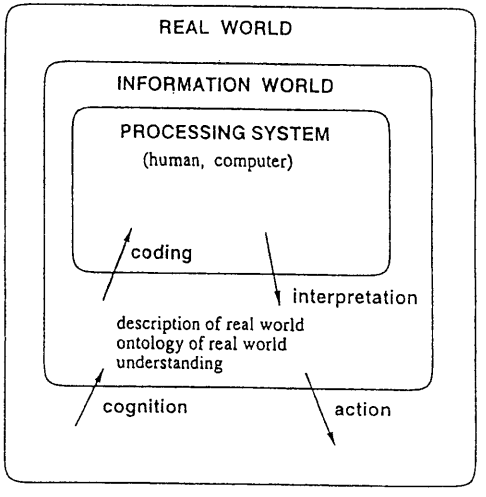


Fig. 1 Hierarchy of Information Processing

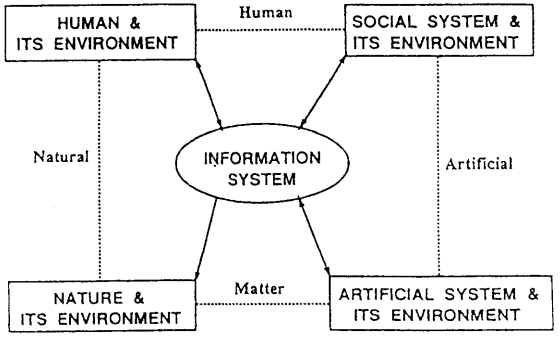


Fig. 2 COLLABORATIVE RELATIONS OF OBJECTS AND AGENTS IN INFORMATION SYSTEM

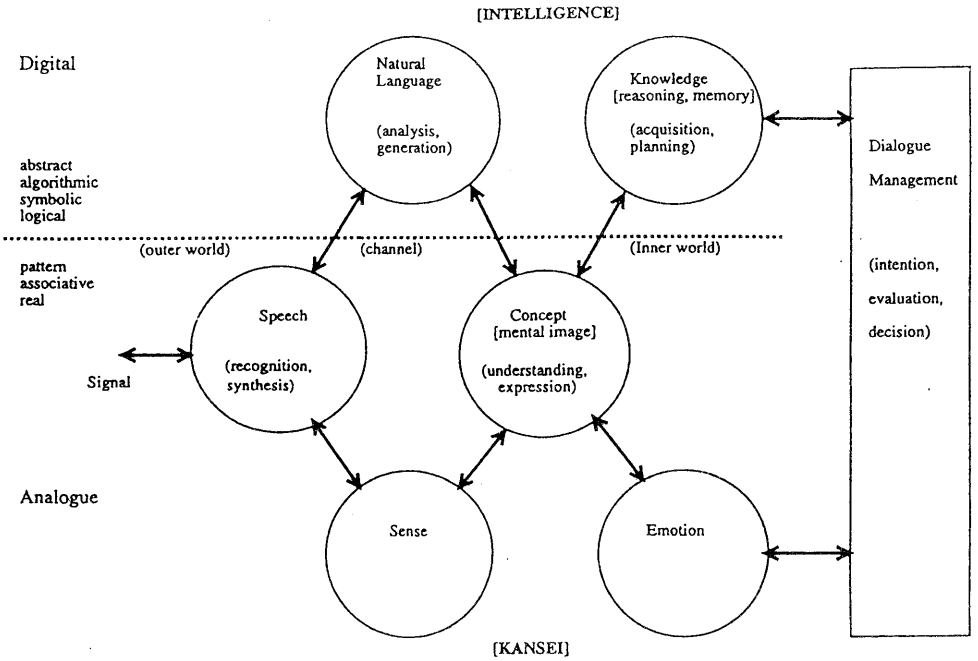


Fig. 4 Natural Dialogue System for Intelligent Human Computer Interaction Interface

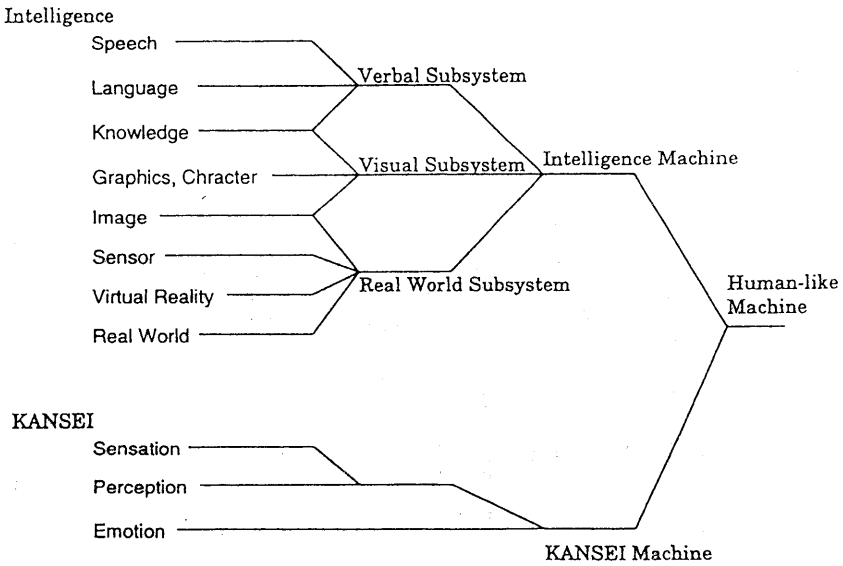


Fig. 5 Future Trend of Media Processing and Understanding
(From single media to multi-media, media fusion.
From telecom media to deep understanding, value-added media)

Table 1. Comparison of Japanese Activity vs U. S. A. activity in Information and Communication Technology

	Research		Development		Manufacturing	
Total Eveluation	<	↘	−	→	○	↗
Software	<	↓	−	↘	+	→
Software Eng.	<	↘	−	↗	>	↑
OS	<	↓	<	↓	+	→
Application Software	<	↓	−	↘		
Language	<	↓	−	↘	>	→
Database System	<	↓	<	↘	<	↓
A. I.	<	↘	−	→	−	→
Processing of Japanese	○	→	>	↑	>	↑
Speech	○	→	+	↗	+	↗
Machine Translation	○	→	○	↑	−	↗
Expert System	<	↓	<	↓	<	↓
Language, Tool, Processor	<	↘	−	→	−	→
Natural Language Understanding	<	↓	<	↓	<	↓
Architecture	<	↘	○	↗	+	↗
Parallel Processor	<	↘	−	↑		
Super Computer (Hardware)			○	↗	−	↗
Super Computer (Software)	<	↓	○	↗	+	↗
Workstation			<	↓	<	↓
Clone			+	↗	>	↑
Communication						
(Hardware side)	<	↘	○	→	+	↗
(Software side)	<	↘	−	→	<	↗
LAN	<	↗	−	→	○	→
Hardware	○	→	○	→	○	↗
Protocol, Software	<	→	−	→	<	↗
Faximile, OA	<	→	+	→	+	↗

Taken from abstract of the lecture of David H. Brandin (Journal of IPSJ, Vol.26, No. 5, 1985)

Current Status of Japan	Future Status of Japan
< : far behind	↓ : more lagging
− : behind	↘ : lagging
○ : comparable	→ : unchanged
+ : advanced	↗ : leading
> : much advanced	↑ : more leading