A Personal History of AI Research Activity

– Expert System, Knowledge Engineering and Ontological Engineering –

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Abstract:

Japan is located in the Far East and have a long history, which caused Japan a bit different from other countries in the world. I first describe what are typical characteristics of Japanese culture in the respect of academic activities as well as what changes the Japanese government is going to make. After this, I overview my personal research history to reveal what kinds of changes I needed to manage my research. Although the topics dealt with are related to Artificial Intelligence and Knowledge Engineering, I hope the paper delivers some suggestions about how to manage "Change".

Cultural difference

Before going into the main topic, let me introduce you Japanese culture, especially that of the academic society. One of the greatest virtues is ***Harmony*** of a group/society. It often has a higher priority than individual independence. This contrasts with Western culture very well. The fact that Japanese word "Wa", 和 which means harmony, is also used in the word meaning "peace" shows how much Japanese appreciate harmony. This mentality contributes to the well-organization of society, since when we have a conflict which might put the society into disorder, we can rely on the "keeping the harmony" principle to avoid the possible chaotic result.

Mobility is low in Japan. People prefer settlement in the same place for long time to moving around for finding better places to live. This also contrasts well with European. They say this is mainly because antecedents of Japanese are farmrs and those of European hunters. This results in that many of the researchers in Japanese universities had graduated the same university and stay there for their life-long term. Its good aspects include they form unique culture of their university by inheriting many from their precedents. But, its bad aspects include they tend to be conservative and, in the even worse cases, they are ignorant of what is happening outer world.

About 50 years ago, all Japanese people love Western, especially, American goods without any exception. This is mainly because many goods were imported from Western world and all of them are more modern and better than those made in Japan. But, situation has been changing during these

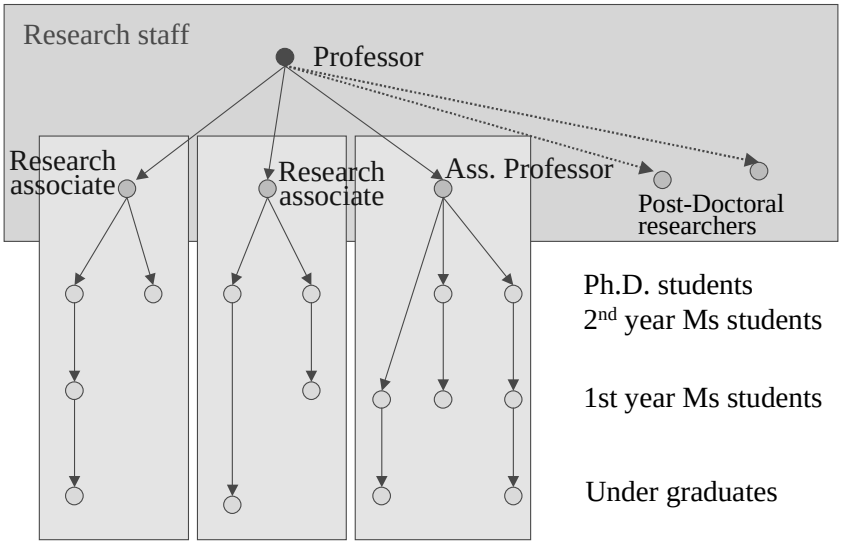

Fig. 1 Organization of a research unit.

20 years. As the Japanese goods have been getting better in their quality, appreciation of Japanese goods has become dominant and now it would be true that most of the Japanese think goods ***made in Japan*** are the best. The problem, however, is we still have an exception. That is, in the academic society, higher appreciation of **foreign ideas** than those invented by Japanese is seen often. It is apparently not a negligible situation. Many of the Japanese papers list mainly western papers in their reference with few Japanese. This hides Japanese research activities from Western researchers and disable for Japanese researchers to accumulate research results on top of those obtained by Japanese. We do need to invest maximum effort to overcome this unhealthy situation. We need a real ***change***.

Research activity at a University is another aspect of cultural difference. Researchers are not very independent of each other. Rather, we form a research unit that consists of four staff members:
One Professor., One Associate Professor and Two Research associates. All of them have tenure. So, their life is very stable, which enables them to pursue rather long-term goals. Salary of the research staff is paid by the government. A research unit usually has a few Ph. D. students, some master course students, say, 6-10 and 4 to 8 bachelor students. A professor does not have to pay any money for PhD students who are given scholarship from the government (amount is about $1.1K per month). These free professors from earning too much money to run his/her project too much.

A research unit is provided with several rooms clustering on the same floor. Full and associate professors have their own private room, each research associate stays in a room with students. One of the major duties of research associates is, thus, to keep a good human relation with students to enable smooth run of projects. The organization of a research unit is graphically shown in Fig.1 that shows a hierarchy headed by a professor. As you can guess from the hierarchical organization, research is conducted as a group activity with a hierarchically structured group in a tight

collaboration with the team members. This works very well for inheriting the results obtained by the senior/former students down to junior students and new comers. The major characteristics of Japanese culture, harmony is number one priority, also plays an important role as well as the fact that seniority is respected even when the difference is one or two years.

The research fund is equally given to all the research units and is amount to about USD60K per year automatically excluding expenses for light and fuel. Each unit usually hires a part-time secretary whose salary is $20K which is paid from the $60K, so money usable for research is about $40K per year. The amount looks very small at a first glance, but considering the fact that professors do not need to pay any salary of his/her staff or students, it is not very bad. Of course, we have other sources of research fund shown below.

Source of proposal-based funding

NSF-like system

Non-profit funding agency

National projects

as well as Collaboration with industries and donation from industries. Although reliable statistics about the average mount of external fund a research unit gets a year is not available, I think it is around $100K per year.

Another salient feature of Japanese academic culture is there has been no serious evaluation after funding. I suspect it is a surprise for Western people, but it is true. I could say we Japanese are weak at serious evaluation of peers' research results. I can point out some reasons for it. One of them is that it is socially not allowed to fail in any sense. Once he/she fails, it is very difficult to recover from it. This prevents from making a severe evaluation to rate a project at a low mark. This also fits well the ***softness*** of our culture. Note, however, that it does not mean we don't evaluate anything at all. Evaluation is done for long-term perspective implicitly.

As readers already know, any system and/or culture has both positive and negative sides. The following is a list of advantages and disadvantages of Japanese culture:**Advantages:**We could rely on the continuous funding, though the amount is minimal.

2. Not difficult to conduct a long-term research
3. Don't have to always write proposals
4. Four staff members and students are very collaborative to enable to have effective run of projects.
5. It is not hard for professors to persuade students to work under his/her plan of research.

DisadvantagesNot easy to form a project team dynamically because of the lack of personnel expense in the fund.

2. Boundary between units are high
3. Can't hire PhD students(students select research unit to join)
4. People tend to become less adaptive or flexible
5. Students are less independent and less creative.
6. If the professor is too active and powerful, the senior staff members feel less satisfaction.

As we have discussed Japanese culture thus far, it is fairly different from that of Western. This difference has made Japan a unique country and has partially contributed to the great success of industrialization. However, we have been discussing the necessity of “Change”.

Within this context, Japanese government has decided to change the national university system into so called ***Agency*** to introduce severe evaluation system and competition among them from 2003 or later. This decision has initiated a lot of discussion about all the shortcomings and advantages of the culture of our academic society mentioned above. Major changes include introduction of:

1. Limited term of employment to research associates
2. Performance-dependent distribution of the research fund from the government rather than the yearly fixed amount of funding($60K)
3. Strict and objective evaluation system for university, faculty, department and research unit as well as each researcher.

We understand this decision is in the line of so called ***Globalization*** of the academic system. It is true that it will provide us with a lot of benefits. At the same time, however, we should be careful NOT to lose the original advantages inherent in our culture. It will be critical to the success of globalization to devise a way that guarantees compatibility between our local culture and global standard.

Personal research history:

Research activities might have two driving principles: Investigation on what you believe is important and what people believe is important. The problem is the two are not always compatible with each other. If you mostly follow the former principle, then you might be isolated from the society that needs useful fruits. On the other hand, the latter principle might lead you to non-creative routine work. This is a trade-off problem. The position I have taken is the former. I some time have been in the majority of the research community and minority in another time. Majority/minority problem, however, is not my concern. I have followed my inner voice but I have been lucky, since what I wanted to do were within what the society needs. Fig. 2 shows the research topics I have studied thus far. I started my research life by parameter learning in statistical pattern recognition as my Ph.D. thesis.

Statistical pattern recognition
Clustering and non-parametric data analysis
Speech recognition/understanding
Expert systems
Deep knowledge and knowledge compilation
Intelligent tutoring systems(ITS)
Knowledge Engineering
Task ontology

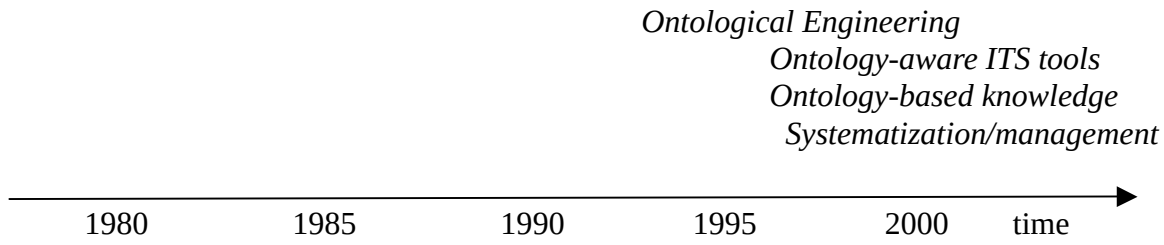

Fig. 2 History of my research topics.

Let me explain the change of topics shown in Fig. 2. During I was a Ph.D. student, I was interested in not only patter recognition but also Artificial Intelligence(AI).

(1) The first change was caused when I became a research associate of a research lab headed by a professor whose specialty is speech research. It was a natural extension of my work. Actually, it was a simple instantiation of my general interest in pattern recognition with the speech domain. Speech understanding is a combination of speech recognition and AI. I can conceptualize this change as "***natural adaptation***".

(2) The second change happened in the so-called AI boom. I have to confess the change was partly caused by stimulus from outside, that is, expert system boom. When I learned the idea of knowledge base(KB) I found it was what I wanted to do in AI field. Since then, all of my decisions on research topic were voluntary. Once I jumped in KB research, I started fundamental research about KB rather than the simple rule base technology. My topic was deep knowledge and knowledge compilation of deep knowledge to generate shallow knowledge. By deep knowledge, I mean first principles, knowledge of structure of artifacts, and so on. By shallow knowledge, I mean rules directly applicable to problem solving. The topic is essential to understanding of what is knowledge to expert system research. But, it is not major research, since most of the KB research activities were concerning rule base building and knowledge acquisition from domain experts. I am sure the topic is the origin of my current work on ontological engineering. This change can be conceptualized as ***influence by outer world.***

(3) I had a lot of interest in inference techniques including learning(inductive inference) as well as KB research. I learned Shapiro's MIS: Model Inference System that builds a prolog program from a set of facts when I was a member of a technical committee of the 5^{th} generation computer project. It is viewed as a semi-automatic prolog program generator or prolog program debugger. Although it is theoretically beautiful, it does not scale up as is always the case in AI systems. Very fortunately, however, I suddenly had an idea of its application to learner modeling in Intelligent tutoring systems(ITS). In ITS, facts correspond to learner's behavior(answers to the questions) and the prolog program to the learner model explaining learner's behavior. Because the size of the program is not large in ITS cases, it does not have to scale up. Furthermore, facts that MIS requires during its model building process nicely correspond to quizzes posed to the learner. I found perfect match between MIS and a learner modeling framework ITS needs. I made a substantial extension of MIS to make it a perfect framework of

learner modeling(Introduction of 4-valued logic and non-monotonic reasoning). The idea enables me to make a considerable contribution to ITS community. Although it is not a change but creation of a new topic, I can conceptualize it as ***meeting and creating a new idea***.

(4) At the same time of the initiation of ITS research, I wanted to deepen my KB research and extended it to the research on a general knowledge-based system environment that is the core topic of knowledge engineering. This is conceptualized as ***natural extension***.

(5) Within the knowledge engineering framework, I coined the term "task ontology" which is used worldwide in the KB community nowadays. After I started the research on task ontology, I became confident that ontology is what I have looked for as a deeper topic of knowledge engineering. Thus, I committed myself strongly to ontological engineering that I declared in the IJCAI95 panel session and initiated in Japan. An ontology is a system of concepts underlying in the target world. This change is conceptualized as ***further deepening*** of the research and ***firm commitment to a philosophy of research methodology.*** This needs some explanation. AI research is divided into two major types: *form-oriented* research and *content-oriented* research. The former includes logic, formal reasoning, knowledge representation, planning, etc. and the latter expert system, knowledge engineering, machine translation, etc. Needless to say, the former has dominated AI research. My big concern has been the fact that form-oriented research is too weak to solve real world problems and that content-oriented research is too ad hoc. Since 1995, I have promoted **content-oriented research** aiming at making it more respectable by introducing solid foundation on which we can accumulate research results. Ontological engineering is what I need to realize my goal, that is, to establish content-oriented research.

(6) After the commitment, I extended the idea of ontology and ontology-based system building to ITS, intelligent design and knowledge management. These extensions have been done with a lot of successful intermediate results. These are mainly thanks to my previous research experience that is totally compliant with ontological engineering and the powerful nature of ontological engineering. This is conceptualized as ***principled extension***.

I have described several turning points in my research activities mainly from academic perspectives. All changes/extensions of research topics were made just from academic aspects. I did not have to consider any other factors such as funding or students for the topics. Students first choose a research unit to join and then we propose them who choose my lab what we want to investigate and ask them to choose one for each. So, we never had such a case that we had to stop the research due to the lack of funding.

I have conducted my research as shown in the Fig. 2 with enough amount of fund to date which came mainly from NSF-like funding agency and industries which were interested in my work. I have been open to industries and had a lot of collaborative work with them. Without the interaction with them, I could not have attained the current achievements.

Reference(only in the year of 1999)

Meta-Functions of Artifacts, Yoshinobu Kitamura and Riichiro Mizoguchi: Proc. of The Thirteenth International Workshop on Qualitative Reasoning QR-99, (1999), 136-145.

An Ontological Analysis of Fault Process and Category of Faults, Yoshinobu Kitamura and Riichiro Mizoguchi: Proc. of Tenth International Workshop on Principles of Diagnosis DX-99, (1999), 118-128.

Learning Goal Ontology Supported by Learning Theories for Opportunistic Group Formation, Thepchai Supnithi, Akiko Inaba, Mitsuru Ikeda, Jun'ichi Toyoda and Riichiro Mizoguchi: Proc. of Artificial Intelligence in Education AI-ED'99, (1999), 67-74.

An Ontology-Aware Authoring Tool - Functional structure and guidance generation -, Lai Jin, Weiqin Chen, Yusuke Hayashi, Mitsuru Ikeda, Riichiro Mizoguchi, Yoshiyuki Takaoka and Mamoru Ohta: Proc. of Artificial Intelligence in Education AI-ED'99 (1999), 85-92.

Ontological Engineering of Instruction: A Perspective, Jacqueline Bourdeau and Riichiro Mizoguchi, Proc. of Artificial Intelligence in Education AI-ED'99, (1999), 620-622.

Ontology more than a Shared Vocabulary, Mitsuru Ikeda, Yusuke Hayashi, Lai Jin, Weiqin Chen, Jacqueline Bourdeau, Kazuhisa Seta and Riichiro Mizoguchi: AEID99 Workshop on Ontologies for Intelligent Educational Systems, (1999), 1-10.

An Ontology-Based Human Friendly Message Generation in a Multiagent Human Media System for Oil Refinery Plant Operation, Riichiro Mizoguchi, Toshinobu Sano and Yoshinobu Kitamura: Proc. of the IEEE SMC99, IEEE Systems, Man and Cybernetics Society, (1999), V-648-65.

Human Media Interface System for the Next Generation Plant Operation, Riichiro Mizoguchi, Akio Gofuku, Yoshitsugu Matsuura Yoshihiko Sakashita and Mikio Tokunaga: Proc. of the IEEE SMC99, IEEE Systems, Man and Cybernetics Society, (1999), V-630-635.

A Methodology of Collaborative Synthesis by Artificial Intelligence, Riichiro Mizoguchi, Yoshinobu Kitamura, Eiji Arai, Masahiko Onosato, Koji Kawakami, and Tadataka Konishi: 2nd International Workshop on Strategic Knowledge and Concept Formation, (1999), 221-232.

Towards Redesign based on Ontologies of Functional Concepts and Redesign Strategies, Yoshinobu Kitamura and Riichiro Mizoguchi: 2nd International Workshop on Strategic Knowledge and Concept Formation, (1999) 181-192.

A Multiple View Authoring Tool for Modeling Training Materials, Yusuke Hayashi, Lai Jin, Mitsuru Ikeda, Riichiro Mizoguchi, Yoshiyuki Takaoka and Mamoru Ohta: Proc. of 7th International Conference on Computers in Education: ICCE99, (1999), 187-190.

Communication Content Ontology for Learner Model Agent in Multi-agent Architecture, Weiqin Chen and Riichiro Mizoguchi, Proc. of the 7th International Conference on Computers in Education: ICCE99, (1999), 95-102.

Technical Knowledge Dissemination in Industries - Foundation and Practice, Mamoru Ohta, Masahiko Ueda, Yoshiyuki Takaoka Mitsuru Ikeda and Riichiro Mizoguchi: Proc. of the 7th International Conference on Computers in Education: ICCE99, (1999), Vol.2, 285-290.