■ *This article is the first report in the best of AI in Japan series. This series will focus not only on prominent accomplishments made in AI research and development but also on AI-related events in society. As the first in the forthcoming series, this opening article features a historical background and outlines the contemporary AI research activities in Japan. It then highlights some recent prominent results from industry. Finally, a future perspective is given.*

Toyoaki Nishida

The Best of AI in Japan — Prologue

The history of AI research in Japan goes back to the 1960s. At Kyoto University, Toshiyuki Sakai formed a research group that focused on media information processing (computer vision, speech processing, and natural language processing). The major members included Shuji Doshita (speech recognition), Makoto Nagao (natural language processing/computer vision), and Takeo Kanade (computer vision). At the Osaka Expo in 1970, Sakai's group presented the world's first face-recognition system.

Major AI research groups became more popular in Japan in the 1970s. The late Toshihiko Kurihara led a group at Kyushu University. The group's major contribution is a kana-kanji conversion system, which addressed the notoriously ill-formed problem of converting sequences of kana (or Japanese phonograms) into ordinary written Japanese sentences containing kanji (or Chinese ideograms), a difficult problem because of the many ambiguities that are hard to resolve even with semantic processing. This resulted in the Japanese Word Processor JW-10 that Toshiba made possible in 1979.

Knowledge information processing also became popular in the 1970s. The late Kokichi Tanaka led a knowledge information-processing group at Osaka University. Setsuo Ohsuga set up a logic-based knowledge information-processing research group at the University of Tokyo. Setsuo Arikawa established a research group at Kyushu University to harness numerous young researchers in algorithmic learning theory. A research group at NTT Labs worked on Lisp machines.

Although AI research was active in western Japan,

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around the 1970s it had still failed to gain the status of an established discipline in the east, even though the International Joint Conference on Artificial Intelligence (IJCAI) was held in Tokyo in 1979. AIUEO, an informal student community at the University of Tokyo, served as a basis for exchanging information and ideas about AI. Hideyuki Nakashima, Koichi Hori, and Hitoshi Matsubara, now senior AI researchers in Japan, "graduated" from AIUEO.

AI research in Japan rapidly expanded around 1985. In 1985, the Institute for New Generation Computer Technology (ICOT) was established to conduct research on fifth-generation computers. The late Kazuhiro Fuchi directed this project. The institute focused on a computational basis for knowledge information processing, which has resulted in hardware such as the parallel inference machine (PIM), programming languages such as the logic programming language KLIC, and applications based on the logic programming paradigm such as the legal reasoning system HELIC-II. The Japan Electronic Dictionary Research Institute (EDR) electronic dictionary project and the Real World Computing project were established after the fifth-generation computer project.

In 1986, Advanced Telecommunication Research Institute International (ATR) was founded and numerous advanced research projects have been conducted in the fields, among others, of brain science, robotics, and speech translation.

The Japanese Society for Artificial Intelligence (JSAI) was established in 1986, too. The major role of JSAI is to help the domestic AI community communicate with each other and with the international AI communities. It launched the Pacific Rim International Conference on Artificial Intelligence (PRICAI) and the International Conference on Algorithmic Learning Theory (ALT) in 1990. It served as the main body of the executive committee when the 15th International Joint Conference on Artificial Intelligence (IJCAI'97) was held in Nagoya. It cosponsored and raised funds for endorsing the finance of IJCAI'97. Setsuo Ohsuga, the second president of JSAI, chaired the national committee of IJCAI'97.

Figure 1 shows some statistics about JSAI. The number of members increased from 1986–1993 although it was in the middle of the "AI Winter." Definitely, the rapid increase in membership during the first several years is due to the founders' enthusiasm and the followers' appreciation of the group. It might also be because Japanese researchers depended more on funds coming from the government and large companies that had a rather long-term orientation, and because researchers thought AI had already established a firm discipline and hence deserved serious academic research, though the truth is not known.

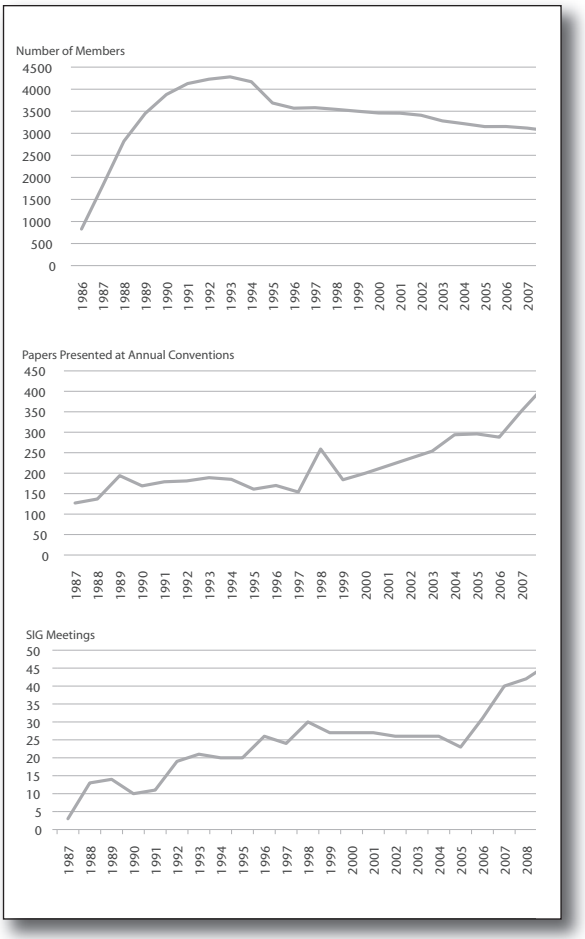

Figure 1. Some Statistics about JSAI.

On the other hand, the number of papers presented at an annual convention and at SIG meetings both are increasing. The Japanese AI community has become more participation oriented.

Contemporary AI Research in Japan

This year celebrates the 25th anniversary of JSAI, which now has around 3000 members. The major activities of JSAI in each fiscal year include journals (6 issues, 818 pages in total in fiscal year 2010), transactions (6 issues, 68 full papers, and 14 short papers—806 pages in total—in fiscal year 2010), an annual convention, and meetings hosted by special interest groups (4 regular, 13 topic oriented, and 1 project oriented).

The annual convention is the largest event. Just like most other academic societies in Japan, everybody can publish and present a paper without a competitive review so long as the paper does not have any particular problems, such as being marginally relevant to AI or deemed offensive to the

public or morals. Each paper is allocated 20 minutes for presentation and discussion. It is near the average of that in international conferences, and much longer than that in annual conventions of other academic societies in Japan, allowing participants to discuss the critical points of each paper. The quality of presentation relies on the morale of researchers and the editorial skills of program committee members. Researchers empirically know the quality of presentations and choose which session of the annual convention/special interest group to join. So far, it appears that the system has been supported by active researchers; in recent years, the annual conventions have attracted around 600 participants and more than 400 presentations. Participants are not only the authors but also constitute the audience, since sessions usually include a reasonable number of active discussants dedicated to the topic. In addition, JSAI has a special grant for a free reception so that the participants can enjoy informal discussions and foster friendship in a cultural atmosphere. Thus, JSAI's annual convention can be characterized as an annual festival to which many active members can contribute. In practice, according to my subjective judgment, the average quality of the papers is about the same as that for international workshops.

Although JSAI concentrates on promoting communications among domestic researchers, it has a couple of exceptions. The first is a series of international workshops. The first one was in 2001 in Matsue, Japan. Beginning again in 2009, the workshops are now called JSAI International Symposia on AI (isAI).[1] The selected papers have been published by Springer under the unified title of *New Frontiers in Artificial Intelligence*. The second is that the JSAI journal accepts papers written in English, which have been archived as Information and Media Technology (IMT) from J-STAGE[2] under the category of media processing and interaction.

We can now find several prominent groups of researchers in Japan. The RoboCup was founded by Hiroaki Kitano (Computer and Thought Award winner) and Minoru Asada and is now a worldwide event. Machine-learning research is also active in Japan. Hiroshi Motoda and Takashi Washio pioneered active mining. They invented, together with Akihiro Inokuchi, the famous AGM algorithm by extending Agrawal's a priori algorithm to graphs (Inokuchi, Washio, and Motoda 2000). A research group for multiagent systems founded by Hideyuki Nakashima, Toru Ishida, Eiichi Osawa, and Makoto Yokoo has made a significant contribution to the Autonomous Agents and Multiagent Systems (AAMAS) conference.

Besides the above main streams, some original research subjects include ontological engineering by Riichiro Mizoguchi, intelligent media by Katashi Nagao, acoustic stream analysis by Hiroshi G. Okuno, creative concept formation by Koichi Hori, skill science by Koichi Furukawa, social network mining by Yutaka Matsuo, and social intelligence design and conversational informatics by Toyoaki Nishida. Web intelligence, pioneered by Ning Zhong, and Complex Medical Engineering, by Jinglong Wu, originated in Japan.

Jewels from Japanese Industry

Some major ICT companies in Japan including NTT, NTT Data, IBM Japan, NEC, Hitachi, Fujitsu, Toshiba, Mitsubishi, Oki, Panasonic, Canon, Honda, Sony, Omron, and Fuji-Xerox have AI-related research groups and products. Japanese industries have invented innovative applications such as Toshiba's Japanese Word Processor, Sony's AIBO, and Honda's ASIMO.

Text Analysis and Knowledge Mining (TAKMI), developed by IBM Research Tokyo, is a text-mining tool that integrates information extraction from text, text mining, and index generation for mining (Takeuchi et al. 2009). TAKMI has been beta-tested by customers since around 1990 and has turned into a product called IBM Content Analytics, widely used in the business domain. IBM Content Analytics is deemed one of the most successful pieces of software made up by AI technologies. It won the best JSAI journal paper award in 2009 and received the most innovative product award from JSAI.

The Laddering Dialog Engine jointly developed by Oki and Recruit[3] implements the laddering method of eliciting the user's hidden need or desire through dialogue. It combines natural language processing and a domain ontology to analyze the users' emotions, satisfaction, and trust. The interpretation is used to provide information to the user.

The speech-translation technology for mobile devices created by NEC (Okumura 2008) is a compact real-time machine-translation engine on smartphones that can respond within one second after the completion of input. NEC has created a large-vocabulary, speaker-independent, continuous speech-recognition engine using a dimension reduction of acoustic models based on the minimum description length (MDL) principle and an efficient distance calculation algorithm. It also introduced techniques for loading lexical rules and compressing the representations of intermediate results, while using a lexicon-driven parallel translation engine to cope with expressions peculiar to the spoken language.

The face-recognition technology created by NEC has achieved the highest recognition performance among the participating organizations, with the highest identification rate of 95 percent from 1.8 million people and the lowest verification rate of 0.3 percent.[4] The NEC team used the GLVQ algorithm to achieve the subsuming support vector machine (SVM) performance.

Some Future Perspectives

Definitely, the most critical great challenge is to make a substantial contribution to the recovery from the Great East Japan Earthquake. AI technologies should be integrated to help people work together by sharing information and knowledge. The problem is roughly classified into two subproblems: restoration from the tsunami and terminating the nuclear disaster. The former is a long-term project, ranging from the reconstruction of the living environment to mental care. The approach should be economical enough to be sustainable. The technology needs to be assistive and embedded into the society so that everybody can

Figure 2. Singing Humanoid Robot HRP-4C by AIST.

Demonstrated at CEATEC JAPAN.

Figure 3. HRP-4C Singing and Dancing with Professional Dancers.

Demonstrated at DC-EXPO2010.

benefit from it. In contrast, the technology for the latter should be effective to rather emergent problems that become evident from time to time, such as safe and secure termination of malfunctioning nuclear plants, or identification and removal of radioactive materials from the living environment, to name some. Although there are many challenges for AI technologies, the biggest challenge might be to make their contribution predictive, clear-cut, and accountable, because people have lost their patience with failure even in the long run.

Another great challenge that the Japanese researchers are addressing is strong AI. A practical milestone toward that direction is building an embodied musical intelligence. Masataka Goto, Shuuji Kajita, et al. aim at building a "pop dancer" robot that can autonomously sing and dance. Building a dancing singer robot is quite challenging, for one needs to address not only technical issues such as synthesizing natural singing voices or facial/body movements with human-like expressions, but also artistic issues such as producing emotional and aesthetic representations to entertain people. Goto and colleagues have already developed some key technologies such as VocaListener (Goto et al. 2010), which generates natural singing voices by imitating human singing. They have also developed a facial expression and body movement generator. Figure 2 illustrates how a humanoid robot sings a song.

There are many interesting remaining challenges, such as aesthetic communication for a "pop dancer" robot to sing and dance with other agents. Last year, Goto and colleagues demonstrated how such a "pop dancer" robot might sing and dance with human dancers (figure 3). Although the demonstration was made by a manually choreographed humanoid robot, it clearly suggests future directions. This might be considered a promising successor of Japanese anime and serve as a strong attractor to accelerate joint research among academia, industry, and artists. It will not only provide interesting research opportunities but also help us think about the ultimate goal of AI more concretely than before.

Notes

1. See www.ai-gakkai.or.jp/jsai-isai/2011/index.html.

2. See www.jstage.jst.go.jp/browse/imt.

3. See OKI and Recruit Selected for Japan's Government Project with their Laddering Search Service for the Second Consecutive Year, www.oki.com/en/press/2008/07/z08060e.html.

4. See NEC's Face Recognition Technology and Its Applications at www.nec.co.jp/techrep/en/journal/g10/n03/ 100306.html.

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Toyoaki Nishida is a professor at the Department of Intelligence Science and Technology, Graduate School of Informatics, Kyoto University. He received B.E., M.E., and doctor of engineering degrees from Kyoto University in 1977, 1979, and 1984, respectively. His research centers on artificial intelligence and human computer interaction. He founded a workshop series on social intelligence design and, in 2003, opened up a new field of research called conversational informatics. Currently, he leads several projects related to social intelligence design and conversational informatics. He is president of JSAI, an associate editor of *AI & Society,* an area editor of *New Generation Computing,* and an associate member of the Science Council of Japan.