

AI Research in the People's Republic of China

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1. Introduction

The field of Artificial Intelligence does not have a long history, being founded in the middle of this century. At that time the People's Republic of China was just being formed. The development of computer science education and research in China took place during the next few years. Research in the field of Artificial Intelligence in China started only at the end of the 1970s.

From the late 1980s, Artificial Intelligence became more popular in the computer scientists' society. In that period, the China Artificial Intelligence Federation was set up. This federation, with its headquarter at the Beijing Aeronautics and Aerospace University, is still active. In addition, there is the Artificial Intelligence and Pattern Recognition Chapter of the China Computer Federation, that has been publishing the quarterly *Pattern Recognition and Artificial Intelligence* since 1989. The Scientific and Technological Information Research Institute of China, P.O. Box 2104, Chongqing Branch, publishes the journal *Computer Science*, which has many AI-related articles.

Every two years the AI and Pattern recognition Chapter of the China Computer Federation organizes a national conference, attracting some 100 to 200 participants. The ninth one was held in 1994 in Chendu, Shichuan province. The China AI Federation has also held some conferences, but on an irregular basis.

To foster cooperation between Pacific Rim Nations, the Pacific-Asian Conference on Expert Systems was established. Its third conference will be held 16—19 May 1995 in Huangshan, China. The proceedings of this conference will be published in English, giving a much-needed entry point into Chinese AI work.

The goals of Chinese Artificial Intelligence scientists in the early period were as follows:

1. Understanding and catching up with new ideas, new concepts, new methods and new techniques in the world;
2. Training students and teachers so that there are more persons who can deal with this field. Courses in Artificial Intelligence were created in some universities and institutes;
3. Developing research programs focusing on foundational theory of AI;
4. Developing research programs which focus on applied research to bridge basic research with technical innovations and relevant applications;
5. Developing technology transfer programs between academia and industry and developing projects aimed at solving specific technical problems.

In this paper we give a survey of the development of Artificial Intelligence in China. Our discussion focuses on the main topics of AI in which Chinese scientists are currently engaged. These main topics are natural-language processing, knowledge engineering, computer vision and robotics, problem solving, speech and character recognition. In addition, we give a brief introduction to the field of AI applications not mentioned in the main topics.

2. Natural-Language Processing and Machine Translation

2.1. Language Understanding

Most of the research in this field is concentrated on creating syntactic and semantic analysis models for Chinese words and sentences. Increasing the effectiveness of man/machine interaction is also a significant research topic. Systems that are currently under development or in use in this area can process input paragraphs written in Chinese, analyze the sentences according to the rules of syntax and semantics, pick up the useful information and store that into a database. After that the system can answer some questions related to the input

paragraph. The system consists of Chinese words and grammar information base, automatic classifying word branch, Chinese word processing interface and Chinese sentence grammatic analysis system. A number of universities and institutes participated in this project; they are listed below.

1. Beijing University;
2. Nanjin University;
3. Tsinghua University;
4. Harbin Industry University (contact: Wang Keizhu);
5. No. 15 Institute of Electronic Industry Ministry;
6. Shenyang Automation Institute of Academia Sinica;
7. Shanxi University.

2.2. Machine Translation

In this field, apart from some foundational research, most of the work is devoted to finding ways so that machine translation systems can become pocket-size products. The main stream is making English-to-Chinese and Japanese-to-Chinese machine translation systems; this activity has resulted in commercial products (contact: Huang Changning, Tsinghua University).

Cooperation between research institutes and industry has brought the research results to the market. So we can find some English-Chinese and Japanese-Chinese quick translators in the market. The translation correctness of these products is satisfactory for commercial applications. In some systems rules were used to improve their translation correctness. These systems are called knowledge-based translation systems; such products are now being exported to east and south Asia.

3. Knowledge Engineering

Knowledge Engineering in China has emerged from the laboratory into the commercial reality of corporate applications. In this field, Artificial Intelligence technology, more specifically expert systems, have been applied to a diverse set of industry, agriculture and medical society in China. Research interests focus on knowledge representation models, reasoning strategy, machine learning and knowledge refinement, and cooperation in multi-agent systems. Expert systems of different

scales were developed widely in the society. Systems are in production use and under development in the areas of diagnostics, design, finance, scheduling, and a variety of other areas. There are many such systems, and here we can only give a brief introduction to the most notable of these applications.

- *Jilin University, the Mathematics Institute and the Computing Institute of Academia Sinica* (contact: Liu Dayou) implemented an oil and gas resources evaluation (OGRE) expert system. This system was developed to find crude oil and gas according to the geological prospecting data. The OGRE system consists of five subsystems: geological analogy system, crude oil generation condition evaluation system, reservoir bed evaluation system, oil and gas movable evaluation system and local area multiplex evaluation system. Recently, the OGRE system has been used in oil prospecting in the sea.
- *The Hefei Intelligent Institute of Academia Sinica and Agriculture Academia Sinica* (contact: Xiong Fan-Lun) developed expert systems for improving the application of fertilizer in farm work, predicting insects pest and selecting the fine varieties.
- *The Institute of Automation of Academia Sinica* (contact: Shi Chunyi) developed an IC circuit graphic explanation expert system and a Device Fault Diagnostic Expert System.

In the medical field, a heart and brain blood vessel diseases diagnosis expert system was implemented by the Computing Institute of Academia Sinica. A pediatrics diagnosis system, and some Chinese medicine diagnosis expert systems were implemented in a cooperative effort of hospitals and Xi'an Jiaotong universities.

Some other systems worth mentioning are:

1. Ground water discovering system, Nanjin University;
2. Transportation scheduling system, Tsinghua University;
3. Weather predicting expert system, Jilin University;
4. Economic Information Predicting System, Zhonghuan Software Co.

All of the systems mentioned are used in their respective field.

In addition to the development of specific expert system applications in China, some institutes and universities have developed several generalized expert system application development tools. These tools were used in the development of some practical applied expert systems. Important ones are:

1. No. 32 Institute of Electronic Industry Ministry, Beijing Aeronautics and Aerospace University, and others developed a rule-based decision making expert system Environment (contact: He Chen-Wu). The function of this tool is similar to that of OPS5.
2. Jilin University has led the development of the explanation and diagnosis oriented problem solving tools system (contact: Liu Dayou). This system is aimed to be a multi-expert cooperation tool and solve conflicts in multi-agent reasoning.
3. The integrated and generic expert system development Environment (IGESDE) was designed and developed by the Mathematics Institute of Academia Sinica (contact: Lu Ruqian), Zhejiang University, and others. This system has four kinds of inference methods: generic reasoning, scheduling reasoning, deductive reasoning and approximate reasoning. The knowledge base consists of a rule base, a frame library, a data base, a subroutine library, a sample library and an interface library. IGESDE was used in the development of some applied expert system.

Although many expert system and expert system development tools were not mentioned above, the listed ones give an indication of the scope of the work done in the People's Republic of China.

4. Computer Vision and Robotics

Several institutes and universities in China are engaged in computer vision and robotics. As a robot moves through an environment, it should be able to draw on knowledge about the environment. Such knowledge is not always directly represented in a useful form, nor is it always detailed or correct. Perception can correct and augment the world model, allowing the creation of a local environment model which is more useful for planning and navigation. Computational and storage

constraints force the specification of the environmental model to be local and time-dependent. In this field the research interest focused on investing methods for world model and environment model representation, the features to be used for object recognition, the strategies to be used for matching object descriptions and segmented data. Some groups focus on the next generation of machine vision, which seems still to have a long way to go. Many research groups work on sensor-based robot systems and image processing systems. We mention some of them.

1. Dynamic image analysis and tracing system research includes several topics: Hough algorithm research, tracing system research (pre-processing, parallel processing and high-speed signal processing) and methods for locating moving objects. The research group consists primarily of the Institute of Automation of Academia Sinica, Tsinghua University and Zhejiang University.
2. Advances in sensor technology have provided "3-D cameras" that accurately measure distance at each picture element. Research in range image understanding is aimed at reconstructing high level geometric descriptions of objects from dense range images of a scene. Some applied image processing technologies are put to use in practical applications. (Contact: Xuan Guoyong, Tongji University, Shanghai 200092.)
3. The printed wiring board checking system is an automatic optical inspecting device. It can detect wire faults in circuit boards. The Institute of Automation of Academia Sinica, No. 15 Institute of Electronic Industry Ministry, No. 32 Institute of Electronic Industry Ministry, Tongji University and Shanghai Jiaotong University are engaged in this research. (Contact: Xuan Guoyong, as above.)
4. The material grain distinguishing system was used in oil pipe checking, baling quality checking and welding seam inspecting in industry. This system was developed by Xi'an Jiaotong University and Shanghai Jiaotong University. (Contact: Liang Deaun, Xi'an Jiaotong University.)
5. The high speed image analysis system was developed as an application of machine vision. It was used in the vehicle license plate distinction

system. Xi'an Jiaotong University, Tongji University, 789 Factory and Middle China Science and Technology University are engaged in this work.

Robot kinematics, dynamics and control are all significant fields in robotics. Advances in robot control are required in order to eliminate special-purpose tooling and over-reliance on absolute position accuracy in current generation programmable assembly cells. Telerobotic systems also form a research topic in this field. The typical telerobotic system in use today simply reflects the human operator and provides the operator with some kind of sensory feed-back. The research groups in this field try to find the appropriate mix of human intelligence, Artificial Intelligence, sensory capability and robotic capability to perform remote manipulation tasks. Some groups devote their attention to new approaches to achieving active control; others focus on designing a new practical robot which can be widely used in the industry. Arc surface moving inspection telerobotic systems, underwater monitoring robotic systems and welding robots are used in hard and dangerous environments. Tsinghua University, Harbin Industry University, The Institute of Automation of Academia Sinica, and Shanghai Industry University are engaged in research on robotic systems.

5. Speech Recognition and Handwriting Recognition

Cognitive simulation models based on AI concepts and techniques can be applied to practical problems in daily life. In this field, speech understanding and handwriting recognition are important subareas of pattern recognition science in China. Most of the research deals with Chinese speech recognition and Chinese handwritten character recognition.

5.1. Speech Recognition

In speech recognition, research is focused on recognition theory and methods, cognitive modeling and algorithm optimization. The applications in this field can be divided into two groups. One is large vocabulary speech recognition tuned to individual speakers; the other is middle-scale vocabu-

lary speaker-independent speech recognition. The applied system was developed in a telephone office; it can "understand" speech and help the operator to find the phone number. The Institute of Acoustics of Academia Sinica, Tsinghua University, The Institute of Automation of Academia Sinica and Harbin Industry University are engaged in these topics. To support this research, a Chinese speech sound database was created by the Academia Sinica, that can also be used in speech sound generation systems.

5.2. Handwriting Recognition

In Chinese handwritten character recognition, the research groups try to find a method which can recognize Chinese characters as quickly and reliably as possible. Many methods are used in the handwriting recognition system and most of them still have some shortcomings that need improvement. Typical methods are the skeleton extracting method, the unit partition technology, semantic and pattern combination method, and the template matching technology and fuzzy attributes recognition method. Active research groups are located at Harbin Industry University, Xi'an Electronic Science and Technology University and 789 Factory.

6. Fundamental Research

This research field does not need expensive devices and therefore attracted the attention of many universities. Several related research topics are being pursued: problem modeling and automated heuristic generation; theorem proving; developing techniques for reducing search in planning problems through mechanical abstraction of problem solving spaces and goal augmentation; development of methods for learning control rules for subgoals ordering; new methods and their implementations in uncertain reasoning and non-monotonic reasoning. Jilin University, Xi'an Jiaotong University, Harbin Industry University, East China Normal University, Beijing Industry College, Middle China Science and Technology University and Congqin University are engaged in this area.

In addition to the topics which we introduced above, there are several other active areas being pursued in China: research on the fifth generation computer, applying AI technology to the manufac-

turing environment to improve the efficiency and reduce production cost; applying AI technology to education to improve the environment in learning and training (ICAI); utilizing AI technology in decision support systems so that the system can make more "intelligent" decisions; using AI technology in management information systems (MIS) to make these systems more flexible.

7. Summary and Conclusions

In this paper we have given a brief introduction to AI research in the People's Republic of China. We do not claim comprehensiveness. As China is a rather large country, lots of universities and institutes are engaged in AI research and applications, and we cannot collect information on all AI research groups in China for our paper. The research projects we mentioned in this paper form the mainstream of AI research in China, and give a representative description of the state-of-the-art.

Artificial Intelligence research has progressed rapidly in the past ten years in China. Chinese scientists, researchers and technicians have made substantial progress in some aspects of Artificial Intelligence, especially since the 1980s. This progress is attributed in part to the official recognition of Artificial Intelligence as one of the important branches of computer science and the subsequent expansion of government support for research facilities and new educational programs.

On the other hand, although AI research has made considerable progress in China, some problems still remain to be solved. The lack of up-to-date facilities, the lack of reliable software and adequate documentation, the paucity of international journals and text books, and the lack of extensive knowledge exchange due to isolation from the international research community are significant problems. These disadvantages prevent the Chinese scientists from learning from, and catching up with the West. We hope these problems can be solved in the near future in China.

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