The Age of Artificial Intelligence

By Hajime Karatsu

The Japanese-language word processor is a unique product. Unlike English-language word processors, this astonishing machine is a typewriter with a built-in ability to infer what it is the writer wants to say. Inputs of phonetic characters (the Japanese *kana* syllabary) are translated into semantic characters (the Japanese *kanji* characters derived from Chinese characters), with the machine choosing which of the many possible characters sharing the same pronunciation are most likely to occur within the context of the sentence. The translated sentences are then printed out.

An estimated 3 million of these writing and editing machines are now in use, clear testimony to their popularity. Moreover, their capabilities have grown by leaps and bounds.

In 1986 I bought myself a model–the very latest at the time–for some ¥140,000, or about $1,000 at the then exchange rate. Yet only a year later a new machine was on the market with a host of new functions. It was such an attractive gadget, with its improved editing operations and new graphic functions far more attractive than my old one, that I bought one despite myself. I have continued to use it since, putting my old machine in mothballs. It is amazing to me that a ¥140,000 machine can be rendered obsolete in a single year. Yet such is the age in which we live.

There is more to this tale than a moral about obsolesence. Information technology has been making astonishing progress, thanks to the equally remarkable progress in semiconductor technology. These compact Japanese word processors each contain a 16-bit microprocessor that gives them the same information processing capacity as a medium-sized office computer of 15 years ago. A massive machine that might have cost $100,000 back then can now be had for only $1,000.

In Japan's case, the technological spiral in information-processing technology will come to be closely associated with the highly touted fifth-generation computer and the neuro-chip. Yet an important point to remember about such technology is that every one of these machines uses a microprocessor, and this is not such an exotic device at all. In fact, nowadays a microprocessor chip costs only about $20. They are widely used in home electrical appliances, including washing machines and even vacuum cleaners.

Of course, they are also used in automobiles. In fact, it is not unusual to find a dozen of them at work in a single car, helping run the engine control system, the air conditioner and the brakes. Auto fuel consumption has been slashed by more than 20% thanks to microprocessors which monitor engine temperatures, rotations and exhaust emission in order to supply the optimum amount of fuel to the engine with each push of the accelerator.

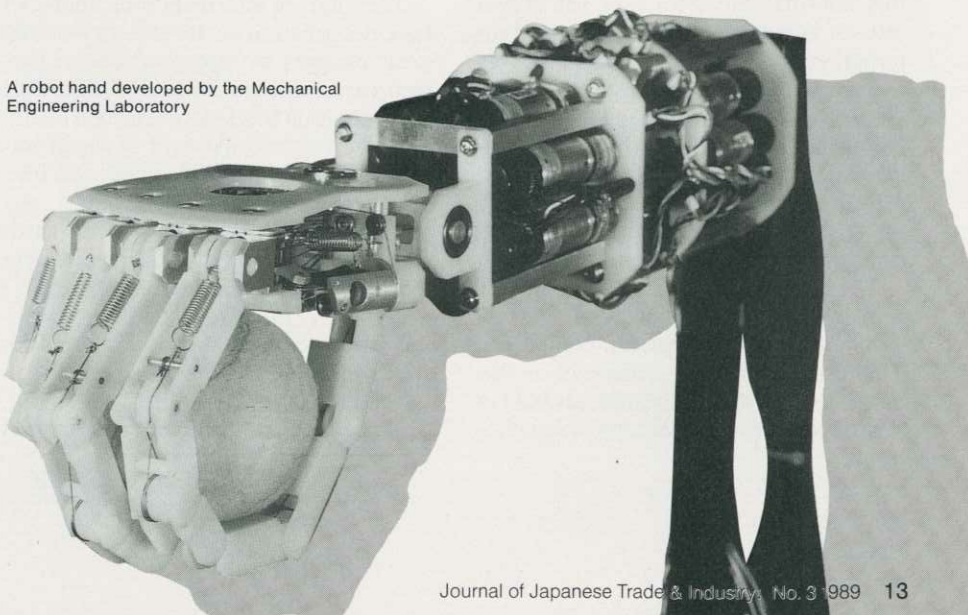
What a microprocessor does is measure its own surroundings, and make a "judgment" about how to create optimum conditions. It works, in short, very much like the human brain. And that is why the phrase "artificial intelligence," or AI, is used to describe the functions of such sophisticated computers.

For a microprocessor is in itself a computer, and even requires its own software programs. In fact, that is one of the reasons behind Japan's serious shortage of computer programmers. According to a study by the Ministry of International Trade and Industry (MITI), Japan will have a shortage of 900,000 computer programmers in the next 10 years. Not an easy problem to solve by any means. And it is in light of these and other circumstances that various proposals have been made regarding the next generation of computers, artificially intelligent computers. Even now, these proposals are being put into practice under the auspices of a wide range of technological development projects.

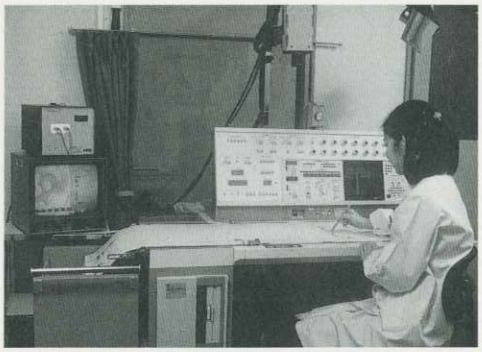
Software crisis

Last November, 1,600 scientists, engineers and other experts gathered in Tokyo for the third international conference on fifth-generation computers. Japan's fifth-generation computer project, which has garnered so much attention worldwide, formally started in 1981, and its original goal was to solve the coming software crisis.

Project formulators decided there was, and still is, a need for computers using natural languages, computers that can "talk" with their operators rather than requiring elaborate machine-language instructions for each task. But to meet this need, the project had to be designed to create something else: a machine that



A robot hand developed by the Mechanical Engineering Laboratory



A computerized system for assisting in diagnosis. Some methods of early diagnosis would be virtually impossible without the aid of computers.

can infer, understand and solve problems on its own.

The concept of "intelligent computers" is nothing new. In the past, however, it was for all practical purposes impossible to achieve. Conventional computers, designed primarily for computation, required voluminous and complex programs, were horrendously expensive to build, and worked at relatively slow speeds. What was needed was a new computer architecture, or fundamental computer structure, based on an entirely new concept.

Affordable cost

The new architecture works in parallel rather than in serial form, allowing multiple operations to take place at the same time. And it got a tremendous boost from another source—the rapid progress occurring simultaneously in semiconductor technology. Semiconductor breakthroughs have made it possible to develop highly sophisticated computers of a kind unthinkable only a generation ago, and to do it at commercially affordable costs.

To push this project, Japanese researchers formed a consortium and promoted exchange with foreign colleagues at yearly international forums. Over time, this informal superstructure has grown into an important force. At the third international meeting, the group was able to present an impressive report on the results of such exchanges. Eight Japanese companies have gotten on board the project. Their research facilities are open in principle, and in fact. Almost daily they are visited by foreign researchers and other interested parties from abroad.

The range of new-generation computer research has also widened, with the spotlight now zeroing in on neuro-computers. The first international conference on this exciting new area of research was held in Kyushu last year, and featured a satellite-relayed television debate with researchers in the United States. A number of companies have already announced the development of semiconductors designed specifically for the neuro-computer. The chips, with their unique ability to "learn," should themselves find wide applications in pattern recognition and robot control.

In the meantime, there is growing demand for more conventional computers that can do their jobs faster. One possible answer is an "optical computer" based on optical technology, an area in which Japan is in the forefront in R&D. A range of element technologies, including optical fibers, semiconductors and lasers, is already available in Japan, and a neuro-computer chip using optical technology has already been test-manufactured.

Like other advanced computer technologies, this research work also has wide-ranging spin-offs. Large-capacity optical fiber cables are one commercial application with important ramifications. A 200 kilometer-long fiber cable has recently been installed in Japan that can transmit information without relay switching at a rate of 4 gigabits per second. With such developments knocking the bottom out of communications costs, we can expect that scarce "communications resources" like the usable radio waves in the electromagnetic spectrum will in time be parceled out only for mobile communications, satellite communications and other special fields, with optical fibers playing the key role in non-mobile communications, including television.

The kinds of information technology I have described so far are already working great changes in Japanese society. Prepaid cards, one of the most fashionable innovations in this field, are a good example. The first prepaid card in Japan was developed by Nippon Telegraph and Telephone Corp. (NTT) for public pay phones. The convenient NTT cards proved so popular that similar cards were introduced for buying railway tickets.

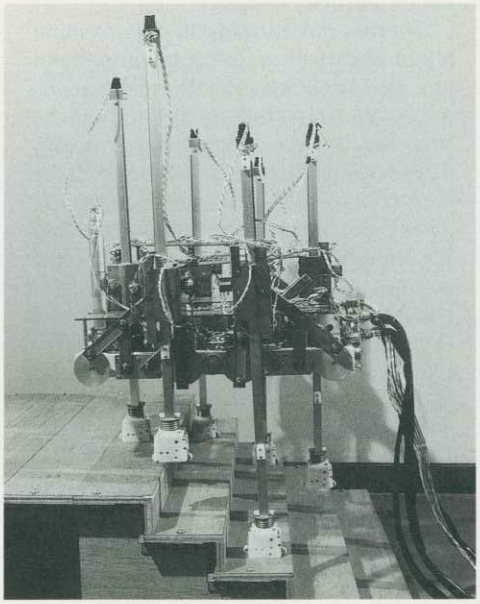
Now there are cards for a host of vending machines, including even cards for the dispensers in *pachinko* pinball galleries. Prepaid cards, unlike credit cards, can be seen as mini-securities, in that they are paper, or in this case plastic, with the same value as cash. The application of computer technology to these "pay now, buy later" cards has greatly increased their utility, and, consequently, their popularity.

The bank notes now in circulation around the world have no "affinity" for computers. That is to say, they cannot be used in the same way that computer-integrated cash cards can. Sophisticated prepaid cards containing computer chips are computer friendly, however, and in time they could replace most of the cash now in circulation. The even more sophisticated IC (integrated-circuit) card can also be used as a prepaid card, but it can be used even more effectively in a wide variety of more challenging applications, including recording personal medical histories, or even for educational instruction. The extensive memory capacity of the IC for information and data has almost endless uses.

Future challenges

In Japan, as in other countries, commerical IC card tests are already under way. Computerized card systems are still only in the development stage here, however. At present we can only speculate on what new types of cards we will be using some day in the workplace, the home, hospitals, schools, or wherever we may be.

Japan's economy is doing very well in this spring of 1989. The sharp appreciation of the yen since the Plaza Accord of



This six-legged experimental AI robot, called "MELCRAB-1," was developed by the Mechanical Engineering Laboratory.

1985 has run full course, and has had a highly favorable impact on the economy after an initial period of shock and adjustment. But it is also true that Japan today is beset with problems of great magnitude, and one is the growing shortage of young workers as the population ages.

Improved productivity in the manufacturing sector has brought down the prices of many products, but increasing costs in the labor-intensive services sector is creating distortions in the price system. Medical costs continue to rise. A new generation—the so-called *shin-jinrui*, or new breed—is seeking out new values, creating a generation gap vis-à-vis its elders. In time, these and other developments could sap Japan's economic vitality. A heavy burden lies on information technology as one of the tools for keeping open potential bottlenecks in the economy.

In education, computers with artificial intelligence will have a revolutionary impact. In medicine, AI-based computerized testing and examination systems can greatly increase diagnostic efficiency, and substantially reduce costs. Information technology can aid in childcare and other essential household work, making it easier for more and more housewives to enter the job market as the shortage of young male workers grows.

It has often been pointed out that Japanese society is remarkably open to technological innovation. Take industrial robots, for example. Although these robots were developed in the United States, Japan now accounts for 70% of the world robot population. Japanese production line workers regard robots not as enemies but as friends, faithful and untiring assistants who perform hard, dangerous and complicted tasks on their behalf.

Indeed, new forms of information technology infused with artificial intelligence will be used increasingly, not only in our place of work but in our homes as well. Artificial intelligence will play an essential role in building a more affluent Japanese society for tomorrow.

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Leading the Search for Superconductors

By Shoji Tanaka

Superconductive wire of the type which was first discovered to be a higher-temperature superconductor.

A remarkable change has come over technology. Once a tool for human endeavors, technology has now become a powerful force shaping society itself. The remarkable technological advances of recent years have triggered the reform of industrial structure, and are even tipping the international balance of power.

Today the whole world recognizes that the true strength of a nation lies in its economic power rather than in its military power. And increasingly, the decisive determiner of economic strength is a country's ability to develop new technologies, and to cultivate the new markets they generate. At a time when the developing countries are entering markets heretofore dominated by the advanced industrial nations, and "deindustrialization" has become an issue of real concern for many of the world's economic leaders, it is no exaggeration to say that the future of the world will be shaped by the success or failure of the R&D in progress now and in the near future, and by the markets resulting from these efforts.

For Japan, these developments pose both threat and promise. Today Japan's ability to generate creative new technology is growing rapidly, and the importance of R&D is a moot point. But even more than that, the new tide of technology offers Japan a great opportunity to at long last make a significant contribution to the rest of the world. The time has arrived for technological cooperation.

From the 1960s through the first half of the 1970s, the greater part of Japan's efforts in technology development was devoted to catching up with the advanced