Robots May Storm World—But First, Soccer*

By Mikiko Miyakawa
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Robots pose no threat to Ronaldo—yet. But in 2050, a soccer team of humanoid robots may be able to beat the human World Cup champion team.

Chasing this seemingly reckless goal, a group of Japanese scientists in 1997 launched RoboCup, the robotic soccer world championship. From these humble beginnings, the annual event has exceeded the organizers' initial expectations.

"The project started with 31 teams from 10 countries, but it rose to as many as 200 from 30 countries in 2002," said RoboCup Federation President Minoru Asada, a professor at Osaka University.

But as well as seeing the size of the event blossom, organizers—and the field of robot research—have seen dramatic developments in robotics, such as the omnidirectional vision and movement that enables robot players to see and move around the pitch much more efficiently.

In June last year, while Japan and South Korea were busy cohosting the human soccer World Cup finals, RoboCup 2002 also was held in the two countries, in the cities of Fukuoka and Pusan.

The robot players competed in four leagues—small, midsize, Sony four-legged (Aibo) and humanoid. The event also featured simulated soccer, rescue competitions and the RoboCup Junior competition for children. But the crowd favorites were the Aibo and humanoid leagues, Asada said.

In the Aibo league, some of the robot dogs actually celebrated their teammates' goals by standing on their hind legs—a sign of communication between the robots.

While the ultimate goal of RoboCup is to reach a point where robot teams can beat human players, the event is expected to spawn useful technologies as designers of the robot players strive toward that goal, according to Asada.

Asada likened the situation to the major impact the space race of the 1960s had on society. That the U.S. National Aeronautics and Space Administration won

the space race with the Apollo moon landing was not as significant in the wider scheme of things as the multitude of technologies that were generated in the race to the moon—technologies that would have far-reaching effects in our daily lives.

"RoboCup opened up a new horizon for multirobot research," Asada said. One application of multiagent system research will be in rescue operations where a squad of robots would be able to work together more efficiently than if each robot worked alone.

The event is also aimed at developing robotics that work in harmony with human beings, Asada said.

"Robotics research actually involves all sorts of studies on humans," he said. "In this regard, a robot is an artifact that mirrors people."

Asada is confident that Japan is and will remain the forerunner in the field of robotics.

"The government is trying to promote information technology and biotechnology, but I believe robotics is the industry that will save the country in the 21st century," he said.

EMBEDDED IN OUR UNCONSCIOUS

The history of robots dates back almost 2,800 years. In the ancient Greek epic the "Iliad," written in the 8th century B.C., Homer depicted what is believed to be three prototype robots—a robot that moved around on wheels, a humanoid robot and a robot designed to work in a factory.

"People have long dreamed of creating something to help them in their work," Tokyo University Prof. Susumu Tachi, an expert in robotics, said.

The term itself comes from the Czech word robota, meaning drudgery or servitude—a robotnik is a serf—and was first used in the 1920 play "R.U.R." (Rossum's Universal Robots), by Czech author Karel Capek. "R.U.R." depicts a society that has become completely dependent on mechanical workers capable of doing any kind of mental or physical work.

The play takes on a tragic dimension when the robots develop humanlike feelings and begin to rebel against their human masters, eventually slaughtering them and starting a robot nation.

Tachi said the play was a cautionary tale for scientists about the ethics of developing robots and technology in general.

He cited the Three Laws of Robotics written by the late U.S. science fiction writer Isaac Asimov in 1950:

- A robot may not injure a human being, or, through inaction, allow a human being to come to harm.
- A robot must obey the orders given to it by human beings except where such orders would conflict with the First Law.

- A robot must protect its own existence as long as such protection does not conflict with the First or Second Law.

While the laws have their origin as a literary device, "as robotics became more advanced, people began to realize the significance of the laws," the professor said.

In the 18th century during the Edo period (1603–1868), karakuri ningyo, or windup dolls, were developed in Japan. Osaka University's Asada said the dolls were early Japanese robot prototypes.

But it was only after World War II that robots had any practical use. In 1960, Joseph Engelberger developed Unimate, the world's first robot with a real-life function. Simplistic by today's standards, this first-generation robot simply did the same thing over and over again.

Kawasaki Heavy Industries, Ltd. bought Unimate technology from Engelberger's firm, and in 1969, Unimate robots took to the factory floors for the first time in Japan.

In 1980, three out of every five robots worldwide were in Japan, earning the country the nickname "robot kingdom." Since then, Japan has led the world in this field.

Second-generation robots, also called sensor robots, used built-in sensors to collect data on their surroundings.

Third-generation robots, which first appeared in the 1970s, could move autonomously, and found uses in maintenance and inspection work in seabed oil fields and nuclear power plants.

In 1996, Honda Motor Co. developed P2, a humanoid robot capable of walking on two legs and a predecessor of Asimo. In 1999, Sony Corp. released its first Aibo pet robot.

With these developments, Tachi said, robotics has entered its fourth generation, in which human beings and robots coexist and cooperate. "Initially, robots worked in factories and other limited spaces, but they gradually began to be seen in other places such as industrial complexes, and now they have begun entering households," Tachi said.

Tachi is currently involved in the Humanoid Robotics Project (HRP), a five-year program initiated by the Economy, Trade and Industry Ministry. Through technology dubbed real-time remote robotics, robots will be able to relay sensory data back to a distant human, enabling people to "see, hear and feel" as if they were actually standing in the robot's place, according to Tachi. HRP's initial results will be made public in March.

FIRST OUR HEARTS, THEN OUR MINDS

According to the Japan Robot Association, the market for industrial robots was worth 400 billion yen in 2001. If its predictions are sound and robots, including

entertainment robots, are bought by more households, then the domestic robot market will expand to 3 trillion yen in 2010 and 8 trillion yen in 2025.

"Just as almost every household has a computer, we're assuming every household will have a robot," an official of the association said.

The year of 2003 will be "the year of the robot," said Kenji Kimura, president of the Business Design Laboratory in Nagoya, which is planning to launch the world's first robot "that can communicate with people by recognizing their feelings."

Kimura went on to say, "This invention is significant in that our robot understands and expresses feelings."

Certainly, the robot can understand simple questions. Ask its age, and the 40-centimeter-tall, five-kilogram robot tentatively named If replies: "Five years old." But complicated questions confuse If, who replies "I don't understand," and assumes an embarrassed facial expression.

It can distinguish the faces of up to 15 people, "learning" their body language and speech habits.

If's debut is planned for April 7—an important date for robot watchers, as it is the birthday of Tetsuwan Atomu (Astro Boy), the robot boy created by Osamu Tezuka.

The sociable robot, which so far has cost 460 million yen to develop, is able to communicate naturally thanks to the Sensibility Technology software engine developed by the Tokyo-based company AGI. The software "reads" the flow of conversation and makes intelligent guesses about speakers' emotions, according to AGI.

But the robot has yet to undergo a critical step—in February, its software and hardware must be joined.

Kimura, who also serves as the director general of the Human Robot Consortium, a joint venture established by the public and private sectors and universities for the project, hopes that robotics will be as lucrative an industry for the consortium members as the auto industry proved to be for Japan's big carmakers.

Better than People*

Japan's Humanoid Robots

The Economist, December 24, 2005

Her name is MARIE, and her impressive set of skills comes in handy in a nursing home. MARIE can walk around under her own power. She can distinguish among similar-looking objects, such as different bottles of medicine, and has a delicate enough touch to work with frail patients. MARIE can interpret a range of facial expressions and gestures, and respond in ways that suggest compassion. Although her language skills are not ideal, she can recognise speech and respond clearly. Above all, she is inexpensive. Unfortunately for MARIE, however, she has one glaring trait that makes it hard for Japanese patients to accept her: she is a flesh-and-blood human being from the Philippines. If only she were a robot instead.

Robots, you see, are wonderful creatures, as many a Japanese will tell you. They are getting more adept all the time, and before too long will be able to do cheaply and easily many tasks that human workers do now. They will care for the sick, collect the rubbish, guard homes and offices, and give directions on the street.

This is great news in Japan, where the population has peaked, and may have begun shrinking in 2005. With too few young workers supporting an ageing population, somebody—or something—needs to fill the gap, especially since many of Japan's young people will be needed in science, business and other creative or knowledge-intensive jobs.

Many workers from low-wage countries are eager to work in Japan. The Philippines, for example, has over 350,000 trained nurses, and has been pleading with Japan—which accepts only a token few—to let more in. Foreign pundits keep telling Japan to do itself a favour and make better use of cheap imported labour. But the consensus among Japanese is that visions of a future in which immigrant workers live harmoniously and unobtrusively in Japan are pure fancy. Making humanoid robots is clearly the simple and practical way to go.

Japan certainly has the technology. It is already the world leader in making industrial robots, which look nothing like pets or people but increasingly do much of the work in its factories. Japan is also racing far ahead of other countries in developing robots with more human features, or that can interact more easily with people. A government report released this May estimated that the market for "service robots" will reach ¥1.1 trillion ($10 billion) within a decade.

The country showed off its newest robots at a world exposition this summer in Aichi prefecture. More than 22m visitors came, 95% of them Japanese. The robots stole the show, from the nanny robot that babysits to a Toyota that plays a trumpet. And Japan's robots do not confine their talents to controlled environments. As they gain skills and confidence, robots such as Sony's QRIO (pronounced "curio") and Honda's ASIMO are venturing to unlikely places. They have attended factory openings, greeted foreign leaders, and rung the opening bell on the New York Stock Exchange. ASIMO can even take the stage to accept awards.

So Japan will need workers, and it is learning how to make robots that can do many of their jobs. But the country's keen interest in robots may also reflect something else: it seems that plenty of Japanese really like dealing with robots.

Few Japanese have the fear of robots that seems to haunt westerners in seminars and Hollywood films. In western popular culture, robots are often a threat, either because they are manipulated by sinister forces or because something goes horribly wrong with them. By contrast, most Japanese view robots as friendly and benign. Robots like people, and can do good.

The Japanese are well aware of this cultural divide, and commentators devote lots of attention to explaining it. The two most favoured theories, which are assumed to reinforce each other, involve religion and popular culture.

Most Japanese take an eclectic approach to religious beliefs, and the native religion, Shintoism, is infused with animism: it does not make clear distinctions between inanimate things and organic beings. A popular Japanese theory about robots, therefore, is that there is no need to explain why Japanese are fond of them: what needs explaining, rather, is why westerners allow their Christian hangups to get in the way of a good technology. When Honda started making real progress with its humanoid-robot project, it consulted the Vatican on whether westerners would object to a robot made in man's image.

Japanese popular culture has also consistently portrayed robots in a positive light, ever since Japan created its first famous cartoon robot, Tetsuwan Atomu, in 1951. Its name in Japanese refers to its atomic heart. Putting a nuclear core into a cartoon robot less than a decade after Hiroshima and Nagasaki might seem an odd way to endear people to the new character. But Tetsuwan Atomu—being a robot, rather than a human—was able to use the technology for good.

Over the past half century, scores of other Japanese cartoons and films have featured benign robots that work with humans, in some cases even blending with them. One of the latest is a film called "Hinokio," in which a reclusive boy sends a robot to school on his behalf and uses virtual-reality technology to interact with classmates. Among the broad Japanese public, it is a short leap to hope that real-

world robots will soon be able to pursue good causes, whether helping to detect landmines in war-zones or finding and rescuing victims of disasters.

The prevailing view in Japan is that the country is lucky to be uninhibited by robophobia. With fewer of the complexes that trouble many westerners, so the theory goes, Japan is free to make use of a great new tool, just when its needs and abilities are happily about to converge. "Of all the nations involved in such research," the Japan Times wrote in a 2004 editorial, "Japan is the most inclined to approach it in a spirit of fun."

These sanguine explanations, however, may capture only part of the story. Although they are at ease with robots, many Japanese are not as comfortable around other people. That is especially true of foreigners. Immigrants cannot be programmed as robots can. You never know when they will do something spontaneous, ask an awkward question, or use the wrong honorific in conversation. But, even leaving foreigners out of it, being Japanese, and having always to watch what you say and do around others, is no picnic.

It is no surprise, therefore, that Japanese researchers are forging ahead with research on human interfaces. For many jobs, after all, lifelike features are superfluous. A robotic arm can gently help to lift and reposition hospital patients without being attached to a humanoid form. The same goes for robotic spoons that make it easier for the infirm to feed themselves, power suits that help lift heavy grocery bags, and a variety of machines that watch the house, vacuum the carpet and so on. Yet the demand for better robots in Japan goes far beyond such functionality. Many Japanese seem to like robot versions of living creatures precisely because they are different from the real thing.

An obvious example is AIBO, the robotic dog that Sony began selling in 1999. The bulk of its sales have been in Japan, and the company says there is a big difference between Japanese and American consumers. American AIBO buyers tend to be computer geeks who want to hack the robotic dog's programming and delve in its innards. Most Japanese consumers, by contrast, like AIBO because it is a clean, safe and predictable pet.

AIBO is just a fake dog. As the country gets better at building interactive robots, their advantages for Japanese users will multiply. Hiroshi Ishiguro, a robotocist at Osaka University, cites the example of asking directions. In Japan, says Mr Ishiguro, people are even more reluctant than in other places to approach a stranger. Building robotic traffic police and guides will make it easier for people to overcome their diffidence.

Karl MacDorman, another researcher at Osaka, sees similar social forces at work. Interacting with other people can be difficult for the Japanese, he says, "because they always have to think about what the other person is feeling, and how what they say will affect the other person." But it is impossible to embarrass a robot, or be embarrassed, by saying the wrong thing.

To understand how Japanese might find robots less intimidating than people, Mr MacDorman has been investigating eye movements, using headsets that monitor where subjects are looking. One oft-cited myth about Japanese, that they rarely

make eye contact, is not really true. When answering questions put by another Japanese, Mr MacDorman's subjects made eye contact around 30% of the time. But Japanese subjects behave intriguingly when they talk to Mr Ishiguro's android, ReplieeQ1. The android's face has been modeled on that of a famous newsreader, and sophisticated actuators allow it to mimic her facial movements. When answering the android's questions, Mr MacDorman's Japanese subjects were much more likely to look it in the eye than they were a real person. Mr MacDorman wants to do more tests, but he surmises that the discomfort many Japanese feel when dealing with other people has something to do with his results, and that they are much more at ease when talking to an android.

Eventually, interactive robots are going to become more common, not just in Japan but in other rich countries as well. As children and the elderly begin spending time with them, they are likely to develop emotional reactions to such lifelike machines. That is human nature. Upon meeting Sony's QRIO, your correspondent promptly referred to it as "him" three times, despite trying to remember that it is just a battery-operated device.

What seems to set Japan apart from other countries is that few Japanese are all that worried about the effects that hordes of robots might have on its citizens. Nobody seems prepared to ask awkward questions about how it might turn out. If this bold social experiment produces lots of isolated people, there will of course be an outlet for their loneliness: they can confide in their robot pets and partners. Only in Japan could this be thought less risky than having a compassionate Filipina drop by for a chat.

The Robotic Economy*

Brave New World or a Return to Slavery?

By Arnold Brown
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A world run by robots is no longer a notion exclusive to science fiction. The first glimmers of the coming robotic era are already visible.

There are now more than 1.5 million robot vacuum cleaners in use. Robot rovers explore the surface of Mars. Microsoft has created robot teddy bears capable of monitoring kids. Another Microsoft robot, SmartPhlow, will monitor and control traffic flows. There are now even robot camel jockeys in the Middle East.

Signs of the growing prevalence of robotic technology are all around us. But we have yet to fully explore the consequences of our increasing dependence on these machines and the numerous ways they are inserting themselves into our daily lives.

The mechanical slaves of the twenty-first century will perform tasks deemed too hazardous for humans, such as cleaning up toxic waste. Others, deliberately made to resemble humans, will be companions and teachers of children. Some will even be chimeras made up partly of human cells. And, increasingly, they will be both self-repairing and self-reproducing.

If you discard the word "robot," which was coined by Karl Capek in the play *R.U.R.*, you might find that the most apt term for the machines that will increasingly do our manual labor, operate and direct interactions between people and institutions, perform domestic services, fight our wars, take care of children and seniors, clean up our messes, and so on may be slaves.

Robots are not free. They are owned. As of now, they enjoy none of the rights we associate with free human beings. At the same time, our economic prosperity (and much else) is dependent not only on the competency of these increasingly intelligent devices and systems, but also on their compliance.

JAPAN LEADS THE WAY

Much of the impetus for robot development comes from Japan, where demographic trends and labor costs are creating a growing market for machines that can replace humans. Hitachi's robot EMIEW can be trained to do any number of factory and office jobs. Virtual pets, such as Neapets, are astoundingly popular in Japan, and their popularity is spreading. One robot toy—Pleo, a dinosaur—is designed to elicit emotional responses from children and adjust its own behavior in turn. A group of Japanese scientists has invented a soccer-playing robot called ViSiON; they claim a team of such robots will win the World Cup by 2050. Japanese engineers are rushing to produce humanoid robots to care for the aged as well as children. Also in development are robots that can monitor and assist the elderly in taking medications and help blind people navigate and shop in grocery stores.

The South Korean government intends to roboticize that country, based on a vision of a robot-centered intelligent society.

The U.S. military is another major supporter of robotics. The Pentagon is developing managed "trauma pods" to perform battlefield surgery and plans to spend more than $120 billion to develop what will eventually become autonomous robot soldiers.

As these machines become more humanoid—in appearance, in personality, in thinking—how will their relationship to humans develop? The proliferation of these robots will surely generate much controversy as society ponders what such machines might be legally entitled to. One can imagine a fair amount of resistance to the notion of extending robots (or semi-human robots) the same rights afforded to people, such as the right to own property, vote, or run for office. But discrimination against bionic or semi-bionic entities may be difficult to defend on legal grounds, especially as growing numbers of humans incorporate machinery into their biological functioning.

"OTHERSOURCING" HUMAN JOBS

Much of the sound and fury in U.S. politics in the 2004 election arose from the volatile issues of outsourcing—the movement of work to other entities and other places. The most contentious part of that issue was offshoring, which refers to moving work and jobs to other countries. This particular issue is now creating concern in Europe, as well.

As the effort to break down work processes into components progresses, more and more knowledge work can be outsourced to countries with a lower living wage than places like the United States. As is usual with political sound and fury, the real underlying issue has been obscured by all the noise. That real issue is othersourcing—the increasing ability to have work done not only off-site and by other entities (such as unanticipated competitors) but by nonhumans.

"Over the next 10 years, the rate of IT job loss that can be attributed to auto-