Japan's Underlying Strength: "The Future as Created by Robots"

By Muroyama Tetsuya

Photo : Hirose Lab at Tokyo Institute of Technology

A tank-style robot maneuvers effortlessly through rubble

The Japanese Love for Robots

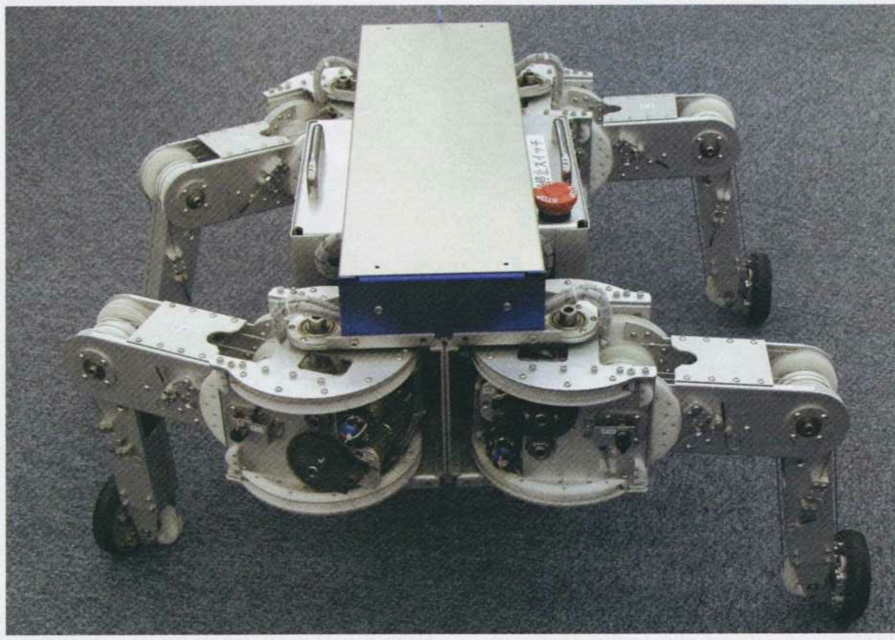
April 7, 2003, an important date in the minds of the Japanese, has arrived at last. It is the birthday of *Tetsuwan Atom* (Astro Boy), a robot known to Japanese people everywhere. As the main character of a comic strip, Astro first grew famous among children about 50 years ago. With a body made of super alloy, the 100,000-horsepower robot could fly into the sky, lift buildings and play chess. His artificial intelligence was injected with love and an overflowing sense of mission to protect the human race. The children of Japan were obsessed with Astro and their after-school hours were captured by comics and TV shows bearing his name.

However, Astro was always torn between the light and dark sides of science. Astro, who tried to adhere to the ethical application of science, fought against enemies who tried to use science for evil aims, but he also wondered if science was really benefiting humankind and whether he was acting righteously, agonizing over these questions.

Nonetheless, children loved Astro. They loved him for his understanding of the paradoxical nature of science and his faith in the possibilities afforded by it. Since then, 50 years have passed, and the children who so loved Astro are now part of the generation that leads Japan.

Today, Japan is regarded as one of

Photo : International Rescue System Institute



A multi-legged robot can climb stairs carrying a heavy load

the world-class robot empires. Japan quickly adopted robots into automated industries and is developing the world's first humanoid.

Why do Japanese like robots? The Japanese have a unique sensibility towards objects. The Japanese perceive spiritual qualities in non-human things and even feel a relationship with them. I believe that the Japanese fascination with robots and the Japanese culture are entwined on some very deep level.

The "Disaster Relief Robot Center"

Last fall, unique research facilities under the name of the International Rescue System Institute (IRSI) were established in Kawasaki (Kanagawa Prefecture) and Kobe (Hyogo Prefecture). The objective of these facilities is the development of "rescue robots," which can perform rescue operations in disaster areas, such as major earthquake sites. With funding from the Ministry of Education, Culture, Sports, Science and Technology, they hope that these robots will be ready for actual use within the next five years. At the opening ceremony, prototypes of rescue robots currently under development at universities and laboratories across the nation were on display. In the middle of the venue stood a mock set-up of destroyed buildings and houses on which a host of robots demonstrated their abilities and movements.

A tank-style robot with caterpillars, equipped with lights, a camera and a sensor installed in the front, maneuvered effortlessly through the rubble. A snake-type robot slithered into small crevices, inspected the interiors, and sent information along with pictures to the monitor outside, while another robot of the multi-legged animal-type climbed stairs carrying a heavy load. Although they could not be brought to the venue, there are even unique robots that can jump over piles of rubble as well as sea snake robots that are capable of swimming.

However, all of these robots are still in the developmental stage. The research findings from these robots will be used as the basis for full-fledged developmental research.

One particular disaster in Japan was the catalyst for the founding of this organization. That disaster was the Great Hanshin-Awaji Earthquake. In January 1995, a quake with a magnitude exceeding 7 on the Japanese scale, devastated the Kobe area. There were over 6,400 fatalities, and the earthquake, centered in the major metropolis of Kobe, instantly paralyzed the functions of the city, destroyed buildings and houses, and triggered fires everywhere. The Great Hanshin-Awaji Earthquake was an extremely significant disaster that demonstrated what can happen when a quake hits the center of a modern city.

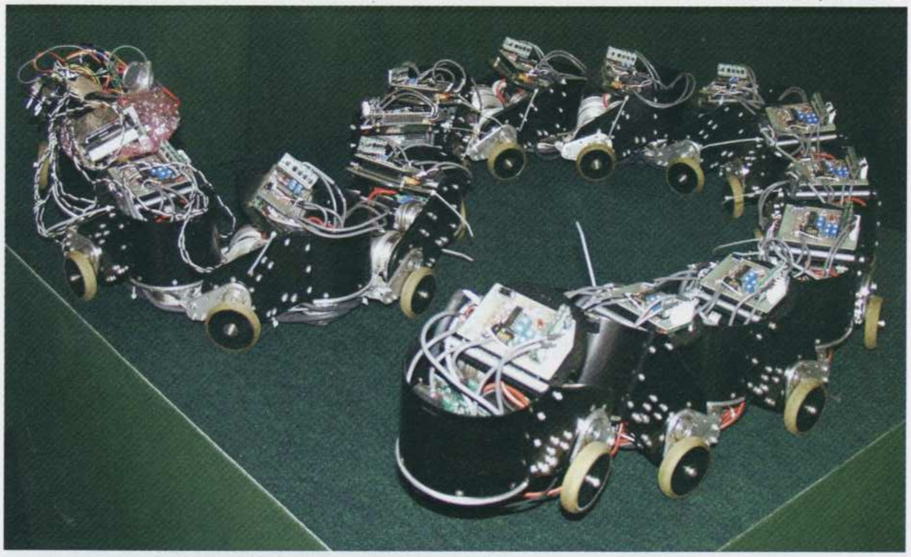
There's a saying that goes, "With the evolution of a city comes the evolution of disaster." Modern cities consist of traffic networks traveling at high speeds and lifelines including electricity, gas and water arranged in complex layouts. Buildings rise ever higher and reclaimed land spreads out towards the sea like a thin carpet. In such a modern city, a single disaster can turn our convenient systems completely on their head, and threaten our existence with unbridled fury. Buildings can sometimes act as corridors, steering and strengthening fires; reclaimed land liquefies, preventing the approach of rescue teams; gas overcomes people; and trains traveling at high speeds become death traps.

Two associate professors from Kobe University, who are currently central figures at the IRSI, witnessed for themselves, along with their students, the terror of the Great Hanshin-Awaji Earthquake. Many of their students were injured, while others perished amid the crumbling city. Tadokoro Satoshi, the President of the IRSI, said, "The first floors of wooden frame houses were flattened, and the occupants were only recovered as corpses. Intense heat and insecure footholds made the rescue work more difficult. Rescue teams and rescue dogs can be rendered helpless at some disaster sites. Seeing the loss of precious young lives, I felt ashamed as a robot researcher, and I was compelled to do something." This experience compelled the two professors to found the IRSI.

What is Meant by Disaster Rescue?

I was one of the reporters who

Photo : International Rescue System Institute



A snake-type robot can slither into small crevices

entered the site of the Great Hanshin-Awaji Earthquake and witnessed the situation. One who has not seen it personally cannot imagine the horror of an earthquake disaster site. Fires sparked everywhere; gas and water spewed, and there were sudden explosions. The rubble beneath my feet was unstable and collapsed without warning. Glass and metal jutted out from the liquefied ground, injuring my legs. Rescuers could not get into the fallen houses. A chaotic mess of newspapers, blankets and electrical wires littered the streets, getting in people's way. Even when you knew victims had been buried under a heap of rubble, you couldn't get in to help them.

To cope with a situation like this, disaster rescue robots have to be mobile. The scene of a real disaster is completely different from the situation in a laboratory or exhibition. By nature, rescue robots are machines that can only be evaluated after performing in the face of real disasters. Let us now take a look at how rescues are actually conducted at disaster sites.

The first step is the search for victims. Robots must move into extremely treacherous places to search for victims. In some cases, people call for help from under the debris, while others are unable to do so. At the site of the Great Hanshin-Awaji Earthquake, it seems that it took rescue teams several times longer to locate victims buried under houses than it took to actually pull them out from the wreckage. The search for victims is extremely difficult for rescue teams. Rescue robots can enter into tiny crevices and inspect the interior using cameras and sensors that detect body heat, voices and exhaled breath to locate victims.

The second step is an assessment of a victim's condition. An evaluation of a victim's condition is the second most important factor in determining the success or failure of a rescue attempt. Are they alive or dead? If they are alive, it is necessary to know what kind of injuries they have sustained and what their medical condition is. Proper treatment must be administered based on the gauging of the victim's pulse, body temperature, blood pressure and bleeding. Oxygen and water should be given if necessary, and the facilitation of dialogue between the victim and the rescue team may provide essential mental support.

Thirdly, rubble should be removed. The next task, unlike the delicate procedure explained above, is the removal of large and heavy pieces of debris from the area. For this, a large body and arms for lifting heavy objects and a substantial amount of energy is needed.

And the fourth step is the removal of the victims from the rubble. This process is not simply the dragging out of bodies. For example, just as you should not grab a broken arm, victims should be handled with care, in accordance with their medical condition. This is the sequence of a rescue.

Looking at the process, from discovery to rescue, disaster sites involve a range of contradictory operations. The locating of people, the assessment of situations, the removal of rubble, and getting victims out of danger are entirely different functions. Rescue robots are required to be compact and nimble because they must go into small crevices, and yet their small size would not enable them to climb over large pieces of debris. In addition, they must be able to stand up quickly after a fall, must be mobile on liquefied ground with glass and wire scattered about, must be tolerant of high temperatures and must not be easily broken. Rescue robots are charged with simultaneously solving such tasks, so contradictory in nature.

We can conclude that it is necessary to develop robots geared toward varying circumstances; this is why rescue robot development calls for flexible thinking and ideas as well as time and effort.

Rescue Robot Tested at the Terrorist Attack Site in New York

The same movement that is underway in Japan is happening in the United States. The simultaneous terrorist attacks, which took place on Sept. 11, 2001, horrified the world and vividly illustrated the nightmare of crumbling high-rise towers. Though it is not commonly known, 17 rescue robots were sent to the site of the destroyed buildings to provide support for the rescue missions. Robin R. Murphy, an Associate Professor at the University of South Florida, led the four teams that controlled the robots.

The rescue robots that were sent to the terrorist attack site entered the fissures, which were too dangerous for people to explore, and advanced toward the interior, sending visual images. In all, the robots discovered the parts of 10 bodies. Unfortunately, they were not able to locate any living victims, but members of the fire brigade marveled at the searching capabilities of the robots and extolled their performance.

"We continued our research and development always believing that robots are effective lifesavers. Though we had never brought robots to an actual disaster site, we felt that this was a good opportunity to make the best use of our research results," said Dr. Murphy. This incident in New York was the first time when rescue robots were used at an actual disaster site.

Why were Dr. Murphy and the others developing rescue robots? The reason is as follows. In 1995, a U.S. Federal Building in Oklahoma City was bombed in a terrorist attack. The building was severely damaged and a blazing fire ensued. Despite the voices that could be heard from within the rubble, the rescue teams were unable to provide assistance, and many victims perished. "If only we had a rescue robot at a time like this...." Such regretful sentiments drove engineers to begin the development of robots in the United States. The year 1995 was in fact the same year as the Great Hanshin-Awaji Earthquake. It is an unnerving coincidence that similar events triggered the commencement of research and development at the same time in both Japan and the United States.

Now, let us go back to Sept. 11, 2001. At home, Dr. Murphy and her team learned of the tragedy in New York. They loaded robots and other equipment into their cars and arrived at the site of the destroyed World Trade Center 36 hours later. Four teams rushed to the site from various parts of the United States and began their disaster rescue operation under the command of the fire brigade, with the understanding that the first 48 hours were critical to the recovery of survivors.

The World Trade Center had collapsed to the extent that no one could enter the structure. The robots made their way in through crevices, but could advance no more than 10 meters without meeting barriers, and even small robots were unable to move about. Dr. Murphy and her team discovered a steel beam one meter in width sticking out from the rubble. The inside of the beam being hollow, she determined that it would be possible to send a robot down through the shaft. According to Dr. Murphy's plan, the robot could be sent down deep into the wreckage. In this manner, the rescue robots, employing methods only possible for robots, performed tasks at the level of equivalent to a fire brigade unit.

Dr. Murphy and her team stayed at the site for more than 10 days. Using the robots, they surveyed the damage to the buildings from the interior and collected information that would prevent a secondary disaster, giving the rescue robots broad worldwide exposure.

In the United States, an organization called CRASAR (Center for Robot-Assisted Search and Rescue) is presently developing a variety of robots including those for combating terrorism that are able to detect chemicals and radiation as well as rescue robots that can withstand the extreme heat of fires. They are striving to enhance their function, and if requested, they are prepared to load the robots onto a huge trailer nine-meters long and be on the road within four hours.

Rescue robot development in the United States is one step ahead of that in Japan in that American robots have actually been used in real situations. Moreover, in those situations, Dr. Murphy and her colleagues discovered a vital point with regard to rescue robots.

Information and Robots

According to Dr. Murphy, "The most important factor in conducting rescue missions which employ robots is 'information.' We should first aim to make robots effective tools in collecting information. Are there people down there? If so, are they alive? What is their location? Can supplies be transported there? Is it possible to communicate with them? Can the safety of the location be assured by looking at the surrounding situation? What is the fastest method of getting down to these people? Would it be safer for the victims to be reached by a rescuer rather than a robot? Is there sufficient oxygen for breathing? Might there be an explosion? Such information about the disaster site should be collected and assessed before the commencement of any type of operation.

"Rescue robots provide the overseeing commander and crisis management administrator with valuable information that can help to determine what to do and where to send the rescue teams. What I found problematic in the case of the World Trade Center is that whenever we discovered a body or parts of bodies, it took at least 12 hours for someone other than the task force to be informed. The sorting and sharing of information such as radio communication and transmission of pictures was also very problematic to everyone at the site."

Japanese robots have not had working experience at an actual disaster site. However, based on the lessons learned from the Great Hanshin-Awaji Earthquake, research on coordinating information and robots at a disaster site is already advancing. In this earthquake, many lives were lost due to a lack of information. At that time, we could not assess who was inside the demolished houses. It could not be established how certain rooms in the house had collapsed and to which rooms victims had fled. Despite the will to provide assistance, the whereabouts of equipment and rescue teams were unknown. Even if victims were to be pulled out of the wreckage, rescuers did not know who to cooperate with and to which hospitals the victims could be taken, or which hospitals had not been destroyed. There was not even any way of knowing which roads had been closed by fire and liquefaction. The lack of information created numerous barriers of this sort and prevented the rescue of people whose lives could possibly have been saved.

The Earthquake Disaster Mitigation

Research Center of the National Research Institute for Earth Science and Disaster Prevention is located next to the IRSI in Kawasaki. Here, the processing of disaster information is being studied. The highlight of this study is the development of "Time and Space GIS (geographical information system)" being led by team leader, Kakumoto Shigeru. GIS, the same type of system as the one used in car navigation, utilizes a geodetic earth-orbiting satellite to indicate a transmitter's location on a digital map. "Time and Space GIS" tries to apply a time factor to the existing GIS. Let us consider it in the context of disaster sites.

With "Time and Space GIS," perpetually changing factors like the flow of people and disaster situations are plotted in real-time onto spatial information such as where certain buildings and roads are situated. The information is compiled and administered in the disaster center's computer, and an assessment of the situation is made. Then based on analysis and situation simulations, instructions are immediately released to the rescue team. Moreover, information collected by the rescue team and rescue robots on the scene is sent as it is received and entered into the "Time and Space GIS" system. Through this repeated process, information is shared and relief activities are undertaken.

This year in Japan, information-gathering satellites and observation satellites will be launched successively. Satellites are extremely effective systems through which disaster information can be understood from the viewpoint of outer space. And the pet robots and house-sitter robots that are making their way into more and more homes these days can also be equipped with the means to transmit disaster information. The robots are intimately familiar with their masters' faces and patterns of movement, so in times of disaster, they may be able to locate their masters and provide information on their location and the situation inside the house to rescue teams. And transmitters or information exchangers can be mounted onto buildings themselves as part of a plan that employs an information network to be used in the event of a disaster.

In order to survive a disaster, a variety of people and organizations must unite in an all-out battle. An understanding of the situation must be achieved by merging all the information collected at the site into a network, and a real-time system must be established so that rescue teams and robots can be mobilized.

How Should Privacy be Protected?

Disaster information administration, as explained, is undoubtedly a key point in saving lives. But there is one problem, and that is the issue of privacy. In order to facilitate the efficient functioning of "Space and Time GIS," it is essential for local governments to use the system on a daily basis and to gain familiarity with their towns and citizens. In employing such a system, it is necessary to consider the protection of personal information. In an ideal administrative system, the life and safety of citizens can be protected in the face of an unexpected situation, while completely protecting personal privacy.

A system is currently being developed that can accommodate the protection of privacy and disaster information administration by utilizing the characteristic traits of the "Time and Space GIS." Protection of personal information, including training programs for the staff of local governments administering the system, is an issue that we must give priority to from now on.

The Rescue Robot Cheered in Robot Contests

Two researchers, respectively from Japan and the United States, and engaged in the development of rescue robots, are linked by a strange coincidence. The common link is "robot contests."

In 1995, concurrent with the start of rescue robot development, Associate Professor Tadokoro Satoshi of Kobe University participated in a robot contest called "RoboCup," with the aim of "Victory over the human team in the 2050 World Cup" and created the "RoboCup Rescue" competition.

In "RoboCup," the world's researchers develop robots in line with a concept such as football or rescue work. The contest provides a venue for the researchers to compete and to advance technological development. Tadokoro's "RoboCup Rescue" was an annual gathering of researchers with the common goal of developing rescue robots and is a place where their creations could compete in a simulated disaster site. In fact, Dr. Murphy and her colleagues were participants in this competition. A few of the robots that were dispatched to the disaster site in New York had just competed in a "RoboCup Rescue" event in Canada.

Rescue robots make progress through practice. Constant test runs in fields duplicating disaster sites further their technical development. For this reason, it can be said that robot contests are the best settings for mutual stimulation among researchers and for the cultivation of technology toward the same goal.

Japan's Challenge

From the perspective of rescue robot research, I have reported on the status of robot development in Japan. However, in Japan, there are a number of other trends related to robots, and there are several dozen robot contests. And the development of autonomic robots equipped with artificial intelligence like the humanoids being designed by Honda Motor Co. and Sony Corp. is advancing at a rapid pace. Humanoids are creating a new world where the real and the virtual are linked via the Internet. Japan and its robots are now in the midst of a voyage through a sea of great change. JJTI

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