

# Developing Robots for Daily Life

*A robot running around with children, a robot playing a musical instrument, a robot missing the bus—robots have recently begun to appear on television commercials and at event sites in Japan, where research and development of humanoid robots is active and advanced. And not only researchers but an increasing number of amateurs, too, are enthusiastic about making robots. In this issue we report on the robot scene in Japan.*

## What is a Robot?

The word “robot,” derived from the Czechoslovakian word *robota* (worker), was first used in the play “R.U.R.” (Rossum’s Universal Robots) first performed in Czechoslovakia in 1920. Robots appeared in the play as artificial humans who function only as workers. A robot in female guise appeared in “Metropolis,” a movie made in Germany in 1927. Both “R.U.R.” and “Metropolis” were box office hits, firmly establishing the idea of the robot (a humanoid machine that works for human beings) in the popular consciousness.

Exactly what a robot is, nevertheless, is not clearly defined. De-

vices called “robots” today are extremely diverse in both shape and function. For example, the robots that work in manufacturing plants mainly perform a certain task programmed into them by human operators and are usually shaped something like a human arm. Robots that help with rescue operations at disaster sites include those that move away debris and other obstacles through manipulation via remote control, as well as self-controlled robots that can get around obstacles in their path and search for victims, thus assessing the situation and acting accordingly.

## Roles of Robots

What do people expect of robots? One area of expectations is in working in place of human beings. Industrial robots take over some jobs in manufacturing. There are also robots that perform dangerous tasks in disaster areas and in the deep sea. Progress is being made in developing robots for daily life to help out with jobs such as carrying heavy things or moving bedridden patients from one bed to another.

Attention has turned recently to robots that recognize and respond to human speech and can be part of people’s daily lives.

If you were asked to develop a robot, what kind of robot would you like to make? What do you think the future holds for the relationship between human beings and robots? It is a subject really quite fascinating to think about.



© Prof. Kuniyoshi Yasuo,  
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## Animation and Robots

What images and functions come to mind when you hear the word “robot”? The heroes of quite a few well-known Japanese cartoons are robots. There is Astro Boy (Tetsuwan Atomu), created by Japan’s most famous twentieth-century cartoonist, Tezuka Osamu. Popular all over the world even today is Doraemon, the robotic cat that thinks and acts like a human being. All sorts of robots figure in Japanese animation, including giant robots like Gigantor (Tetsujin Nijuhachi-go) and Mazinga Z (Majinga Z) that are controlled by humans. Because of the associations created by these animation heroes, Japanese often think of robots as friends or heroes, and not a few people began developing robots because of the inspiration of such cartoon characters. The engineer who developed the world’s first two-legged robot, ASIMO, says that when the assignment began, his boss said, “I want you to make Astro Boy.” The same idea, reported the creator of AIBO, was behind the four-legged robot that is capable of learning through communication with humans.

### Chronology of Robots in Japan

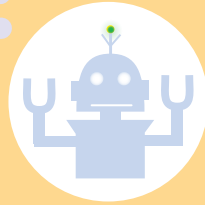
<b>1960s</b>	(Creation of the world’s first industrial robot in the United States) <ul style="list-style-type: none"> <li>❖ Industrial robots imported to resolve labor shortage in the manufacturing industry</li> <li>❖ Beginning of industrial robot R&amp;D in Japan</li> </ul>
<b>1970s</b>	❖ Industrial robot production figure in Japan highest in world
<b>1980s</b>	<ul style="list-style-type: none"> <li>❖ More than 19,000 industrial robots manufactured*</li> <li>❖ About 70 percent of the industrial robots in use worldwide are operating in Japan.**</li> <li>❖ Advances in artificial intelligence</li> <li>❖ First Technical College Robocon held (1988)</li> </ul>
<b>1990s</b>	<ul style="list-style-type: none"> <li>❖ More than 79,000 industrial robots manufactured*</li> <li>❖ First University Robocon held (1991)</li> <li>❖ Honda announces creation of two-legged humanoid robot P2 (1996)</li> <li>❖ Sony announces creation of four-legged robot AIBO (1997)</li> <li>❖ First RoboCup soccer match held (1997)</li> <li>❖ Sony markets the AIBO robot for the consumer market at ¥250,000; 3,000 units sold out in 20 minutes (1999)</li> </ul>
<b>2000 first decade</b>	<ul style="list-style-type: none"> <li>❖ More than 89,000 industrial robots manufactured*</li> <li>❖ Honda announces creation of first model of ASIMO robot (2000)</li> <li>❖ First ROBO-ONE held (2001)</li> <li>❖ First ABU Robocon held (2002)</li> <li>❖ Toyota Partner Robot shown at Aichi Expo (2005)</li> </ul>

Sources: \*Japan Robot Association; \*\*International Federation of Robotics, National Robot Associations, and UNECE

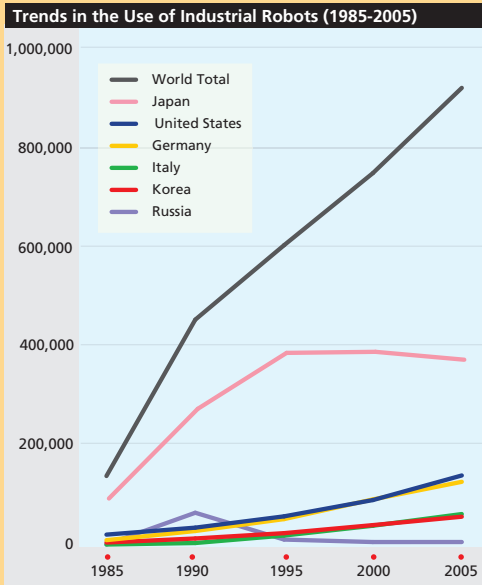
# Manufacturing

ものをつくる

The vast majority of robots in use today are industrial robots that have been employed for more than 40 years in automobile and precision-equipment manufacturing plants. As of the end of 2005, about 40 percent of the 920,000 industrial robots in use worldwide were at work in Japan.



© Toyota Motor Corporation

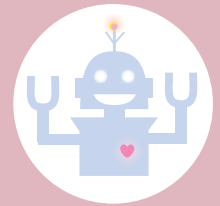


Source: International Federation of Robotics

# Part of Daily Life

ひととくらす

Robots that play various roles in our daily lives are now drawing great interest. Research and development of humanoid and communicative robots is currently very active.



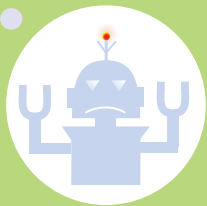
## HRP2-JSK

In 2007, University of Tokyo's Joushou System Kougaku Laboratory (Department of Mechano-Informatics, Graduate School of Information Science and Technology) gave a demonstration of HRP2-JSK, an improved version of the HRP-2 prototype, that will perform household tasks. HRP-2 was developed by the New Energy and Industrial Technology Development Organization (NEDO), Japan's largest public R&D management organization supported by the Ministry of Economy, Trade and Industry.

# Rescue Work

きゅうじょ 救助する

The day is not far off when robots will play an important role in disaster zones and other dangerous situations.



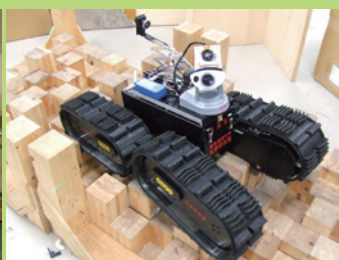
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## T-52 Enryu

Rescuing victims trapped in collapsed buildings is dangerous work that also requires great strength, so hydraulically-operated robots like this are indispensable. They can be operated by remote control or directly controlled by a driver seated inside the vehicle.

## Kohga, Kohga2

This snake-like robot can crawl into the ruins of broken buildings to locate victims. A fact-finding robot can explore inside partially destroyed structures and underground passages.



© Matsuno Lab. at the University of Electro-Communications



© Honda



なにをして あそぶ?  
What are we going to play?



いっしょに歌を歌おう!  
Let's sing a song!



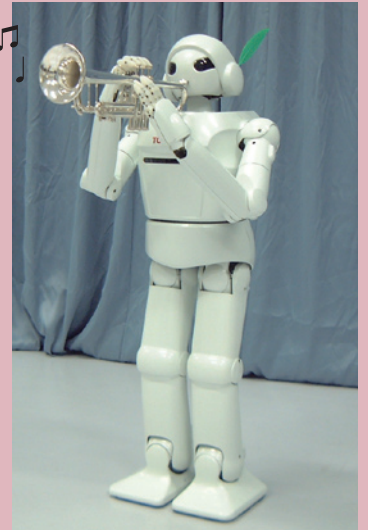
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## PaPeRo

Developed by NEC, PaPeRo was created as a personal robot to be part of a household as a companion to family members. Special attention has been given to how it can make gestures and talk in communicating with humans. It can recognize the voices of up to 10 persons. The designers hope to create a robot that will help take care of children at daycare centers, kindergartens, and elementary schools.

## Partner Robot

This robot was developed by Toyota. Equipped with artificial lips imitating the movement of human lips, it can play the trumpet.



© Toyota Motor Corporation



© JSK Robotics Laboratory, Graduate School of Information Science and Technology, The University of Tokyo

おはよう、パロちゃん。  
Good morning, PARO!



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## PARO

PARO was researched and developed as a mental care robot designed to realize the therapeutic benefits of pets in relieving stress and promoting communication. It was first used in medical welfare institutions for children and elderly around 2000. Today some 1,000 PAROs worldwide are providing therapeutic comfort as animal substitutes in households as well as in environments such as hospitals where pets cannot be permitted.

## Reborg-Q

Equipped with four cameras front, back, right and left, and with sensors that can detect fire and water leakage, the Reborg-Q automatically patrols a pre-mapped path through a building and can monitor certain conditions by remote control. In Tokyo, these security robots were put into use at Aqua City Odaiba starting in December 2006.



パトロール中!  
On patrol!

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## ASIMO

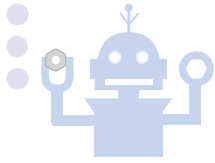
The pioneer humanoid robot is ASIMO, introduced by Honda in 2000. Its performance improves each year. It can now run and walk pushing a cart.

You can see short film clips of ASIMO running around with children, walking around a museum and showing surprise at things it sees at the following site:  
<http://www.honda.co.jp/ASIMO/gallery/>



## Original Robot Tournaments

Not only specialists at manufacturing companies and research institutes but amateurs and hobbyists, too, have grown increasingly involved in building original robots. A number of competitions designed to stimulate the advance of robot technology draw widespread interest.



## RoboCup

Competitions in two main divisions, featuring soccer and rescue operations, have been held annually since 1997. The objective in the soccer division is to “develop a team of humanoid robots that can win against the human world soccer champion team” by the year 2050. The rescue division goal is to form a rescue team of automated robots—Robots Without Borders—that can be sent in to help wherever disasters occur. The “RoboCupJunior” is a similar tournament for elementary school students and other people interested in making robots.



© The RoboCup Federation

## ROBO-ONE

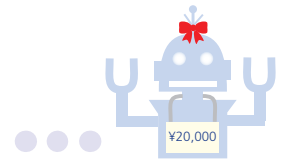
The “combat tournament” among two-legged humanoid robots begun in 2001 is aimed to “popularize the enjoyment of robots,” and emphasizes outstanding technological innovation and entertainment qualities. Division play-offs are held according to a chosen theme and in the finals the goal is to knock the opponent out of the ring. A tournament is planned to take place in outer space on October 10, 2010.

## Robocon (see Meeting People)

The rules of the tournament change each year but basically involve manipulation of remote-controlled robots. Competing with original ideas and technology-advancing innovations, the robots win points for successfully carrying balls, blocks, or other items over a prescribed course. Begun in 1988 with the technical college-centered tournament, it expanded to a contest among universities in 1991. The ABU Robocon began in 2002, a competition among students of universities and engineering colleges representing the member countries and regions of the Asia-Pacific Broadcasting Union (ABU). Japan sends winner of its university-level Robocon as its representative to the ABU Robocon.

## Robot Kits on Sale

Nowadays it is easy to purchase simple robot-making kits. Designed for home assembly, these kits are based on robots that won prizes at various robot tournaments. There are shops specializing in robots and robot parts and even classes are offered giving guidance in building and creating robots.



## KHR-1HV

The 2004 ROBO-ONE J-class winning robot was the prototype for this commercially sold robot. Software for easily programmable robot movement is part of the kit, allowing even beginners to get a taste of the fun of robot making. This robot was a great hit at one point because it was sold at extremely low prices. ¥124,000 (tax included).



© KONDO KAGAKU CO., LTD.



[http://www.kondo-robot.com/html/Product\\_main.html](http://www.kondo-robot.com/html/Product_main.html)

## ATR/VSTONE Robovie-i

Beginners’ robot designed to be handled by anyone with ease. Can be stepped up to walk on two legs. Movements are made possible with special software. ¥29,400 (tax included). VSTONE also put on the market a robot for research use, based on a RoboCup world competition-winning robot.



© ATR

## Tsukumo Robot Kingdom

Japan’s first robot specialty store opened in 2000 in Tokyo.



© TSUKUMO CO., LTD.





# Love of Robots Makes for Strong Team Bonds

## Love of Making Things Got Me Interested

—What made you decide to participate in Robocon?

**Toshihide:** Ever since I saw a Robocon on television when I was in kindergarten, I've been a Robocon maniac. When I was little, I loved the way the robot could move. When I entered junior high school, I made up my mind to go to technical college just so I could enter the Robocon.

**Ryosuke:** I love robots that will clean or take care of your house while you're gone—any kind of robot. Robots are kind of cute and full of fun. I entered technical college expressly so I could participate in Robocon.

**Hiroshi:** I saw the Robocon on television and, since I wanted to participate, I chose technical college.

**Yusuke:** I've loved doing intricate things with my hands since I was little. I used to take apart old radio-cassette players and fix bicycles and furniture. I got into technical college that way, but then I found there wasn't much I could do with my hands. I really wanted to make things, and that led me to join the Robocon team.

—Please describe some of the difficult things you encounter and some of the things you most enjoy in your activities.

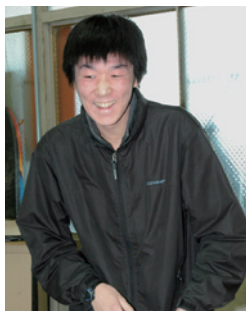
**Hiroshi:** Just before the tournament, we're here working until the last train home every day. Some of us live an hour and a half away, so we sometimes don't get home until 1:00 in the morning, but we have class again from the next morning. We don't think much about such hardships, though.

**Ryosuke:** Actually, more than half of those who joined in 1st year have quit. Those who have stuck with it love robots so much that they forget the time when they are working on them. Sometimes you think it's only 9:00 at night and suddenly it's midnight (laughter).

**Hiroshi:** One of the hard parts is how a robot can get broken because of a mistake in design.

**Toshihide:** But when a robot moves exactly as you planned—that's really cool!

**Ryosuke:** When you know how it feels when you succeed, you'd go to any lengths to make a better, finer robot.



**Toshihide**

Leader of the 2006 Team. Specialist in design and robot operation. Crazy about the Robocon from kindergarten. Unsurpassed when it comes to operating a robot. 4th year.

In November each year, the Robocon (Robot Contest), a national contest for technical college robot-building teams, is held and the competition is broadcast nationwide on NHK public television. This contest is the focus of the passions of talented young people who devote their energies to creating hand-made robot devices. In this issue we interviewed the robot contest team of the Tokyo National College of Technology that competed at the regional level and went on to the national competition in both 2005 and 2006, introducing the activities of the members. TJJ asked some of the members what they learned from the experience.

—Are there connections between your robot making and what you are learning in class?

**Yusuke:** We can use the technology we learn in class and make it really ours when we build these robots. For example, we can get practice using machine tools by making parts for our robots.

**Ryosuke:** Another good thing is that we can apply principles that we learn in class in actual practice. Our *senpai* immediately feed into the club the latest information they've just learned in class.

## Collaboration Through Trust

—I see that you have divided up responsibilities, with Toshihide taking charge of design and operation, and Ryosuke and Hiroshi in charge of construction. Is the leader the person who coordinates everybody's ideas and sets your schedules?

**Yusuke:** I was the 2005 Team Leader but I don't remember getting up in front and acting much like a leader. Each of us has certain things we take responsibility for and we just end up working together that way.

**Ryosuke:** Each one of us has something we're especially good at, like Toshihide with the robot operation and manipulation, Yusuke, who's really good at detail work, and so on. When you know that everybody is passionate about the Robocon, you don't have to worry; we know we can trust each other. There isn't much sense of hierarchy among us, although we call our seniors *senpai*, but otherwise we are pretty open and frank with each other.

—Do you ever come in conflict with each other?

**Hiroshi:** Of course. Sometimes we have an idea but we can't convince the others, so then the only thing to do is to actually make what we have in mind. So I might say, "Okay, I'll make a robot with my idea, and you make the one you're thinking of, and we'll use the one that performs best." So it's give and take, and we use the robot that has the best chance of winning.

**Yusuke:** Once we were making a robot that would stick balls on a target with a velcro surface. We had two ideas. One was to use a hand device that would grip the balls, like a "magic hand" - or



**Hiroshi**

2006 Team member in charge of design and construction. A cheerful "mood maker" for the team. 4th year.

“UFO catcher”-type grabbing arm (such as found in the game arcades), and stick them on accurately, though perhaps only a few at a time. The other was to use a large board-like hand covered completely with velcro with which many balls could be stuck on all at once. We discussed the two ideas but we couldn't agree. We made test robots and found out that the second design actually worked well and even more effectively than we thought, so we used the board hand idea. If we make a test robot we can determine whether what we thought in principle was a good idea would actually work, and those who backed the ideas that don't work are therefore convinced.

**Ryosuke:** When we compete in the contest and something goes wrong, we sometimes realize only then: “Darn, if we'd only noticed that when we were building the robot.” When we discuss something together and come to a conclusion, but then turn out to be wrong, what can you do? You have to accept it. As long as you take a lesson from such mistakes in the next thing you do, that's just the way it is.



Ryosuke

2006 Team member in charge of construction. Also uses his social skills for Team PR. 4th year.

—What are some of the things you have learned in the process of entering the Robocon?

**Yusuke:** I myself learned that I have to assert myself if I want my idea to be used to make the team's robot. Of course, you have to be willing to listen to other people's ideas, too, or you end up just squabbling, saying things that don't help much, and not finding a solution to the problem. I think I also learned better to listen to what other people have to say.

**Ryosuke:** Yes, I think we have learned to talk things over well.

**Hiroshi:** Back in junior high school, kids used to tease and bully me, and I had gotten so I kind of avoided contact with others. I didn't say a word for about two years after joining the Robocon team. But I've changed a lot because I've learned to trust the other members of the team and know I can talk with them frankly.

**Toshihide:** And now Hiroshi is the mood maker of the team. When we get down and depressed, he's the one who does something to cheer us up and encourage us to keep going.

### We Want to Make Robots That Will Help People

—Please tell us what you want to do in the future.

**Toshihide:** I don't have any specific idea, but I do hope I can find a job in which I can put the experience I've had with the Robocon to some use.

**Ryosuke:** My hope is to make a really cool-looking robot.

**Hiroshi:** I want to make rescue robots or care giving robots—the kind that will be directly useful to people in their daily lives.

**Yusuke:** I want to find a job with a small- or medium-sized parts manufacturer, not a big manufacturer. I don't want to be just one replaceable cog in the wheel of a big enterprise but work for a smaller firm where I can advance my own ideas and see things happen that I have worked on. I want to be directly involved from the design to the production stages. I think I got this idea that I want to “do it myself” from having worked on the Robocon team.

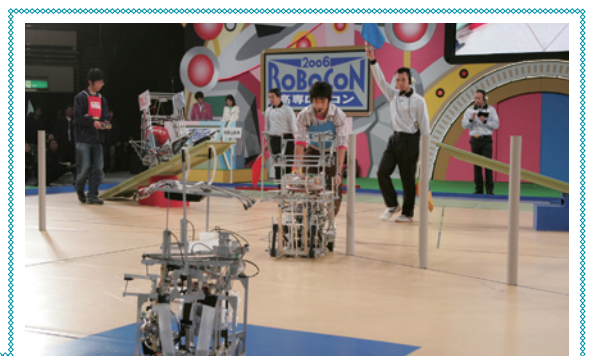
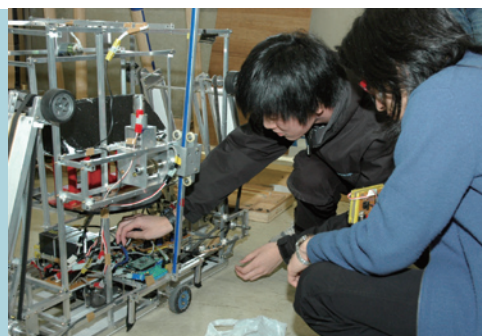


Yusuke

2005 Team Leader. In charge of design. Loves to work with his hands. 5th year.

#### Tokyo National College of Technology's 2006 Robocon Robot

This robot made it to the national tournament, but unfortunately lost in the first match there. Beautifully performing a feat of triple jump rope that is difficult even for a human, it drew close attention at the contest that focuses on technical skills.



© NHK

### What is the Technical College Robocon?

Formally called the College of Technology Robot Contest, it is a competition by the tournament method among teams of students at five-year technical colleges\* who build robots on an assigned theme. Sixty-one technical colleges in Japan participate in the contest, which is now in its twentieth year, having been held annually since 1988. Two teams (of 3 members each) can enter from each school, competing first in regional tournaments held in 8 national districts. The top 25 teams winning in these tournaments compete again at the national contest.

In the 2006 contest, robots crossed a moat, negotiated across a seesaw, moved along a zig-zag path, and jumped rope using fresh technical innovations to carry a load of local specialty products to the goal in record

time. Many unique ideas were devised. For the jump-rope feat, some robots jumped not just once but multiple times on one go, or did somersaults while jumping the rope.

Official Robocon website <http://www.official-robocon.com/top.html>

\*Five-year technical colleges: In contrast to high school, which is three years, technical colleges (*koto senmon gakkō*; “kosen” for short) provide five years of schooling after junior high school. They offer special technical training in such skills as industrial design and aviation. Graduates receive credentials equivalent to a junior college diploma and are eligible to apply for transfer to a four-year university as a third-year student.