The Japanese Love of Robots ❶

Japan, the Robot Kingdom

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The Word 'Robot'

The origin of the word "robot" comes from the Czech word for slave, and it was first used in 1920 drama by Karel Chapek (R・U・R, Rossam's Universe Robots). However, I think that now the image that people hold of the word 'robot' differs significantly between Japan and the west.

Atomboy and Superman

Atomboy and Superman are both science fiction characters with numerous superhuman powers, and they are national heroes in Japan and the west respectively. Atomboy, the supporter of justice who is loved by all, is a robot created by Tezuka Osamu. However, Superman, the invincible man who came to earth from a distant star, is depicted as a being from outer space. In the west, setting Superman as a robot made by human beings would not be acceptable. Now why is this the case?

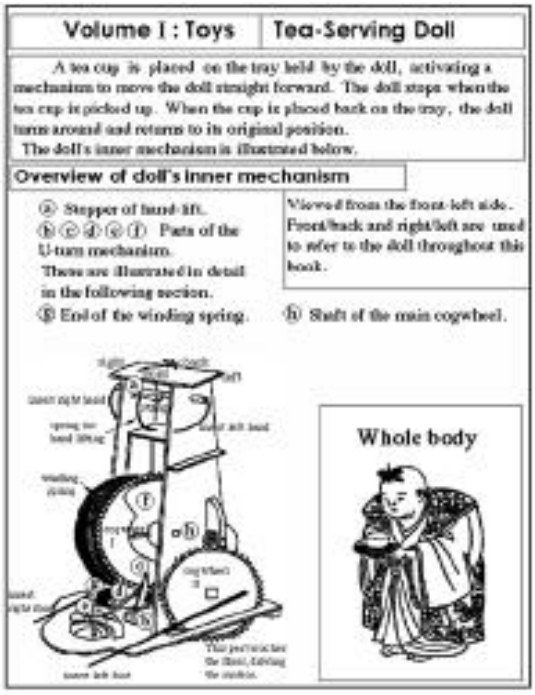
Many science fiction movies in which robots appear have been made in the west. As represented in the movie 'Terminator,' most robots appearing in science fiction movies have massacred humans, and continue to oppose human society. Especially in western countries, we can say that the wariness toward machine civilization, and misgivings about the coexistence of humans and robots have been inherited through their long histories.

"chahakobi ningyo" made by the nineth Tamaya Syobei

Mechanical Puppets, the Roots of Japanese Robots

On the other hand, the roots of robots for Japanese people lie in ***karakuri ningyo***, or mechanical puppets. The tea-serving doll (***chahakobi ningyo***) that can be seen as representative of it, is said to have appeared in the mid-Edo period. In the late Edo period, it appeared in the novels of Ihara Saikaku and the ***haiku*** poetry of Kobayashi Issa, and it was widely known and cherished among the common people.

The tea-serving doll was made completely of wood, and at that time they used the baleen of a whale (the teeth of a right whale) for a spring. It was a robot in which were concentrated the ingenious devices of, in the midst of ordinary entertaining when a host would serve tea to a guest. When the host placed a teacup on the tea tray held by the puppet, it would move straight to the guest, and when the guest took the tea it would stop and wait. When the guest drank the teacup and put it back on the tray, it would turn around and go back to where the host was. While moving, it moves its dragging foot, and moves forward nodding its head up and down. In addition, it was also equipped with a mechanism by which the host, having measured by eye the distance to



"Karakuri - An Illustrated Anthology" in 1796 translated into modern Japanese

the guest, could set in advance the place where it would turn around. The tea-serving doll was not only excellent from the mechanical perspective, but it also had a human essence, and its existence provided entertainment, thus it functioned as a way of deepening communication between host and guest.

The current revival of the tea-serving doll was largely made possible by the three-volume 'Karakuri - An Illustrated Anthology' published by Hosokawa Hanzo Yorinao in 1796. The Karakuri - An Illustrated Anthology explains the making of four types of Japanese clocks and nine types of mechanical puppets with precise diagrams, and this volume must be seen as an original book of mechanical engineering very rare even on the global scene. The diagram shown on the top this page is the first page of the first volume toy section, which I have translated into modern Japanese.

Mechanical Puppet Makers as Pioneering Comprehensive Scientists

If we were to give the names of three famous Edo mechanical puppet makers, we would probably have to include Hosokawa Hanzo Yorinao, who wrote the 'Karakuri - An Illustrated Anthology' and was also involved in the Kansei Reforms; 'Karakuri Giuemon,' or Tanaka Hisashige from Kurume, who after making the mechanical puppet masterpieces 'Child Drawing a Bow' and the 'Eternal Clock,' became the founder of Toshiba Corporation; and Ohno Benkichi from Kaga, whose activities encompassed not only mechanical puppets but also mathematics and medicine.

The common link binding these three men is that all of them, despite the closed country of the time, hungrily absorbed the most advanced western science that entered through the port of Nagasaki, and they were all comprehensive scientists well versed in such areas as mathematics, astronomy, chemistry and medicine. Furthermore, they did not merely imitate western things, but created things suited to the unique Japanese culture and people.

There is no doubt that Japan's mechanical puppet culture represented by these men contributed to industrial modernization after the opening of the country in the Meiji-period.

Differences from the Western Automata

As something to compare with the Japanese mechanical puppets, we can look at the automata (mechanical puppets) that flourished in the early eighteenth century in Europe. An elaborately dressed puppet entertained people with various gestures and movements in time with the beautiful tones of a music box. There were various ones such as ones that drew pictures or wrote letters, ones that played the organ, and ones that performed acrobatic movements.

However, there are essential differences between the western automata and the Japanese mechanical puppet. Simply put, I believe that there are significant differences not only in the technical distinctions between the automata that use metal parts and numerous nut and bolts, versus the mechanical puppets which eschewed screws and concentrated their energy in the wood craftsmanship of the frame, but also in such things as the reasons for which they are made, as well the manner of expressing themselves to spectators.

The goal of the automata appears to be to imitate human movements as faithfully as possible by means of a machine. For example, in the case of the 'Writer' or the 'Musician', early automata masterpieces of the father and son makers Jaquet Droz, the youth dips the tip of the pen

into the inkwell, shakes the pen so that the ink will not drip, and skillfully moves the pen to write characters, while the maiden who plays the organ glances at the audience, fixes her gaze upon the musical notes, and actually plays the piano with ten fingers to play a tune. I wonder if the makers produced these automata to show that machines had come this close to human beings. This sort of design intention is not apparent in Japanese mechanical puppets.

Automata's and mechanical puppets's expression

Another distinction is the way in which emotions are expressed by the puppets. While there are many western automata whose eyes and mouth move in order to show facial expressions, in the case of Japanese mechanical puppets, subtle head movements or the play of light and shadow are utilized to show the emotions of the puppet.

The photos on the middle left are detail photos of the famous automata 'The Snake Charmer", and the apex of mechanical puppets the "Child Drawing a Bow".

The 'Snake Charmer' skillfully handles the snake, slowly closes her eyes and shows an expression of rapture, and the snake lies down as her breasts sway. It is really erotic.

On the other hand, the 'Child Drawing a Bow' is a room puppet that with its right hand picks up one by one the five arrows on top of the arrow stand, sets them in the bow, takes aim at a target about two meters away and releases the arrows. If the arrows hit the target, he joyfully grabs the next arrow, but if the arrow doesn't hit the target, he picks up the next arrow with an expression saying 'Next time.' Six strings subtly change the movements of the head and neck, and the tilt of the head and the shadows convey the puppet's emotions to the spectators. Mechanical puppet makers finish the faces of the puppets so that they can express the fundamental emotions of joy, fear, anger and sadness by the inclination and shadows of the puppet's face. I would like to explain a little further. The mechanisms by which the puppet rejoices if the arrow hits the target, and attains a serious expression if the arrow misses the target, is as follows. The puppet makes the same movements whether the arrow hits or misses. It makes use of the fact that the psychological state of the spectators changes a lot when the arrow hits versus when it misses. If the arrow hits the small target, the spectators cheer and look at the puppet's face, while if the arrow misses, they look at the puppet with a psychological state of 'Don't miss the next one.' Not only the performance of the 'Child Drawing a Bow' has this technique, but also those of many mechanical puppets including mechanical puppets on festival floats, are directed by taking the psychological state of the spectators into account.

Suematsu Yoshikazu. Born in Nagoya in 1943. After completing the doctoral course in Engineering from Nagoya University Graduate School of Engineering, became a Research Associate, Assistant Professor and then Associate Professor at Nagoya University. In 1988, became Professor of Mechanical Engineering at Nagoya University, and since 1994 at the same graduate school has been a Professor in the Graduate Course of the Department of Electronic-Mechanical Engineering. In 1986 won the Third Nagai Organization Science and Technology Prize. Published books include the Illustrated Mechatronics Series 'Introduction to Computers for Control,' 'Introduction to Mechanical Control,' etc.

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The Dawn of the Home Robot Era

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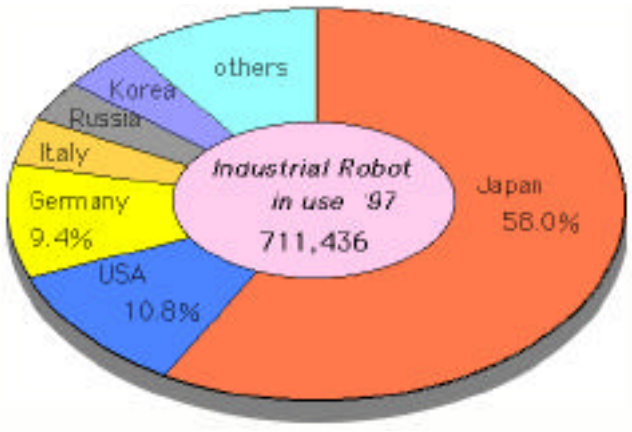
Why Are Most Industrial Robots Concentrated in Japan?

Among robots which work in place of humans, those robots that perform various tasks such as assembly, material handling, painting, welding, electronic chip mounting at manufacturing plants are referred to as industrial robots.

According to 1997 statistics, there were about 700,000 industrial robots in use in the world, and 410,000 of these, or about 60 percent, are working in Japanese factories. This situation has persisted for more than fifteen years. The United States, the birthplace of industrial robots, accounts for no more than ten percent of the total. Why are industrial robots concentrated in Japan?



Industrial robots in use in the world

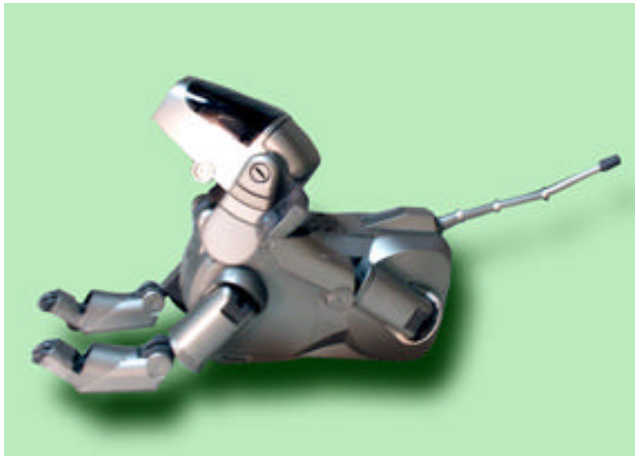
Generally speaking, differences in the labor environment such as conditions of employment or labor-management relations, or differences in industrial structure such as the fact that there are many easy to mechanize industries such as home electrical appliances or automobile makers are cited, but there exists a more essential difference between Japan and western countries with regard to robots. Westerners associate the word 'robot' with 'slave', and they harbor wariness that some day robots will attain the same or greater ability than humans, and will threaten the people's lives. In contrast, Japanese people, as represented in the case of Atomboy, even harbor affection for robots. If we ask where this Japanese liking for robots came from, we would have to say that it comes from room puppets such as the tea-serving puppet, the over three-hundred-year tradition of festival float mechanical puppets that play the main role each year in festivals, and the existence of the tradition of mechanical puppets can be said to be the roots of robots in Japan.

The Advent of the Home Robot Era

In 1997, the appearance of three robots surprised people all over the world. The first was the American Mars Pathfinder probe, and the other two were announced from Japanese corporations. These were Sony's 'Pet Robot' and Honda's 'bipedal walking robot.' The latter two robots had in common that while they were criticized within their companies for 'having no practical application,' they pursued the dreams of engineers, surprised robotics engineers all over the world, and earned more favorable reviews than expected after their announcement.

Sony's Pet Robot was marketed under the name 'AIBO', and in June of 1999 it sold 3,000 units in Japan, and 2,000 units in the United States on a limited sales basis. At that time, by internet orders, in Japan it took 17 minutes, and in the United States 4 days to complete the sale. Then in December of 1999, they attempted to have global sales of 10,000 unites. The number of buyer applicants totaled 150,000, and it is reported that 97 percent of them were Japanese. Americans made up 2 percent, and apparently orders from Europe made up less than 1 percent. This shows the Japanese liking for robots, and it also shows the existence of a European

antipathy even now toward bringing a robot into the household.



"AIBO" produced Pet Robot Boom

AIBO and imitation goods

Sony's AIBO was sold at 250,000 yen. It is certainly not cheap, but it is a high technology product unrivalled by others with a specialized CPU, micromotor, camera, etc. On the other hand, among the imitation goods that appeared in the train of the AIBO boom, from rubber balloons sold at festival stands, to things that performed cute movements with spring mechanisms, to things that sang songs, and ones that were controlled by remote controls, most ranged from several hundred to ten thousand yen.

Since the announcement of Sony's Pet Robot, release announcements of robots modeled upon dogs, cats, bears, seals, etc, or home robots such as communication robots for independently living senior citizens, or personal robots have followed one after another in Japan.

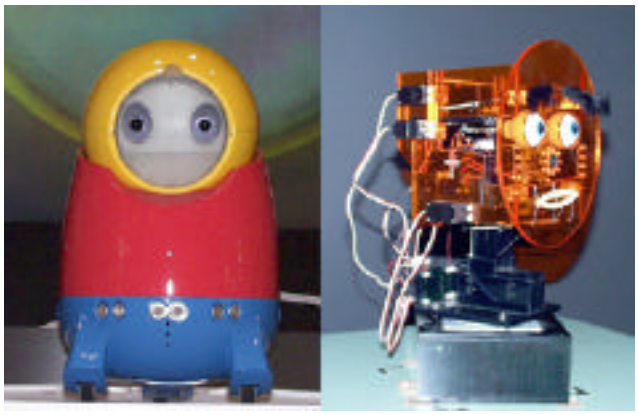
The cat-shaped robot (Tama-chan) developed by Omron for the purpose of promoting rich communication between humans and nature. As a tool for relieving the stress of modern society, if you call it, it looks back at you, if you pet it, it closes its eyes blissfully, sleeps, gets angry. It is a robot directed at the general user, and is planned to go on limited sale by the end of this year.

Tama-chan(Omron) and bear(Matsushita Electric Industrial Co.)

The home robot developed by Matsushita Electric Industrial Co., Ltd., with the purpose to serve as a communication support device for senior citizens living alone, has the external appearance of a stuffed animal bear or cat. In order to offer support for the home visit surveys of senior citizens living alone conducted by city and town welfare facilities, it is equipped with a voice communication function. According to the person in charge of the development, the image communication function using cameras could not be introduced because it encountered strong negative reactions from the elderly.

After that, at the end of August 1999, NEC's 'Personal Robot R100 has appeared to the scene. As shown in the photograph, the R100 had a spherical head, and the external appearance has a relatively simple shape. In terms of technology, it can move over flat ground by means of three wheels, and with a voice recognition technology, it can distinguish the voice of its user, and can understand spoken commands. In addition, it is possible to take in images from two cameras, can distinguish who it is, and memorize this. Also, it can emit words and music, and is also equipped with verbal message function. In this way the R100 is equipped with every kind of high technology, and since its announcement, they have begun to ask the society, via the internet and other means, for the wide opinion on what kinds of uses can it be made as a home robot.

Another robot I would like to introduce is 'PONG' which is currently under development by IBM. This robot, with the slogan of 'See,' 'Speak,' 'Understand,' aims to achieve real conversation with humans. Realization of functions such as calculations based on voice recognition, website searches, reading of displayed websites, translation into English, etc, are scheduled.



R100(NEC) and PONG(IBM)

The Route for Home Robots to Progress

Sony's AIBO that pioneered the market for home robots, broke the prevailing ironclad rule of utility and efficiency, and was developed strictly with amusement in view. Some people in Europe have criticized such robots as AIBO and said that it is just a toy and not an industrial product, and questioned why let a machine that looks like an animal come into the household. To respond to these sorts of criticisms, the establishment of a system to theoretically evaluate the contribution level of amusement and entertainment products to human happiness would be desirable.

It is said that the 21st Century will be the age of individuals and the age of sensitivity. It is certain that we are approaching the limit of the twentieth-century mass production pursuit of efficiency. Another reason that AIBO achieved popularity is because it made use of artificial intelligence technology that was not useful for industrial goods, and thereby made it into an autonomous robot in which the behaviors of individual AIBO units could be distinguished.

The R100 and PONG that followed after the coming of AIBO, are trying to bring to fruition the role of a 'moving, speaking terminal unit' to bring about a more human friendly application of the yearly increasing computer technology into the household.

I would like to briefly introduce the 'pleasant lifestyle support robot; Duck's Robot' development in which I am participating. This home robot, with the themes of 'entertainment, security and communication,' aims to provide relaxation and flavor to the user's household lifestyle, and equipped with residential environment and user security features, it aims to promote communication between the users and society. The photo below shows a zelkova wood model of the Ducks Robot now under development.

The route in which home robots must progress toward, is not to try to get closer to the thought and behavior of humans, but rather, to increase people's zest in life, and to cheer up people's lives. In that sense as well, I think that Japanese traditional mechanical puppets can contribute a guiding principle for home robots of the future.

The model of the Ducks Robot now under development

It is my sincere wish that the home robots originated in Japan will one day be accepted favorably with people in the west.

No. 3 Japanese as Robot-Lovers

Edo Karakuri Masters were Universal Scientists

Suematsu Yoshikazu
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Edo Karakuri (Gimmick) Masters Were Universal Scientists

If I were to choose the three greatest Karakuri masters in the Edo Period, the following would be listed:
Hanzo Yorinao Hosokawa (Karakuri Hanzo)
Hisashige Tanaka (Karakuri Giemon)
Benkichi Ohno (Benkichi Nakamura, Itto)

When the Tokugawa Shogunate sealed off this country from the rest of the world, it also declared new innovations and inventions unlawful and prohibited industrial mechanization in an attempt to concentrate administrative control, save for those related to religious and festive services. The common factor among the aforementioned three Karakuri masters is that they were more than skillful artisans of Karakuri mechanical dolls. They were universal scientists, with extensive knowledge of various science and technology fields such as mathematics, astronomy, and medicine. Edo Karakuri masters like them have absorbed the Western science and technology obtained through Nagasaki and contributed to the industrialization of Japan after its opening in the Meiji era. It is not too much to say that these Edo Karakuri masters have built the foundation of what became the technology giant that is the Japan today.

The following is a brief history of these three greatest Karakuri masters.

Hanzo Yorinao Hosokawa and His Work "*Karakuri Zuii* (Illustrated Machinery)"

Hanzo Yorinao Hosokawa (1741 – 1796) was born in the feudal domain of Tosa . He learned carpentry and architecture when his father was building their family house. He then took off to Kyoto to study astronomy and Confucianism. Record states that he built an astronomical globe and a pedometer there. There is a well-known episode: when Hanzo left home to Kyoto at the age of around 50, he inscribed a promise on a bridge built across a small river in his hometown, saying, "I will not cross this bridge again before I win a fame".

His engineering blueprint "Karakuri Zuii (Illustrated Machinery)" was published after Hanzo's death in 1796.

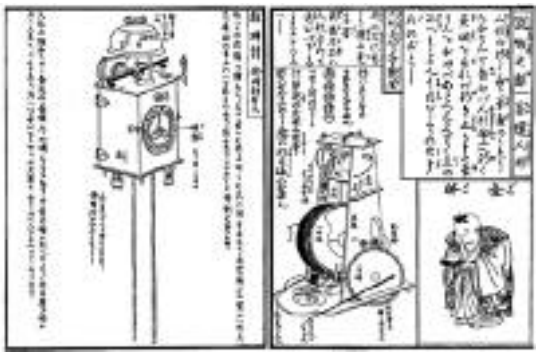

Fig. 1 First Pages of "Karakuri Zuii", Volumes One and Two

"Karakuri Zuii" consists of three volumes. The first volume describes how to design and build four Japanese typical ancient clocks; a wall clock, a tower clock, a bedside clock, and a measuring clock. The second volume contains how to build 9 types of mechanical karakuri dolls such as the tea serving doll, the tumbler doll, and the magician doll, all with detailed drawings. The book reveals the karakuri's mechanical structure, which is a brilliant utilization of gravity, magnetic force and elasticity, complete with tips and hints on the actual manufacturing.

Published no less than 200 years ago, "Karakuri Zuii" is a very rare manuscript even in global standards, and is a very precious text of classic mechanical engineering. Shoji Tachikawa and Shobei Tamaya VII were able to reconstruct the "tea serving doll" thanks to this "Karakuri Zuii". Hanzo has pursued Western calendarology and has mastered mathematics, physics, and astronomy. He was part of the shogunate calendar researcher during the calendar reform of Kansei period.

Hisashige Tanaka, an Edison–typed Inventor

Hisashige Tanaka (1799 – 1880) a.k.a. Karakuri Giemon was born as a son of an ornament craftsman in Kurume. As a child he has been fascinated by looms and karakuri shows during festivals. He hit the trail at the age of 25, settled down in Osaka when he was 35, and studied astronomy under the "Tsuchimikado Family". He opened his "Kikoudo (Karakuri-house)" in Kyoto when he was 53. He was full of curiosity, always eager to learn all his life, and he kept on creating "what the world wants, and what the world needs".

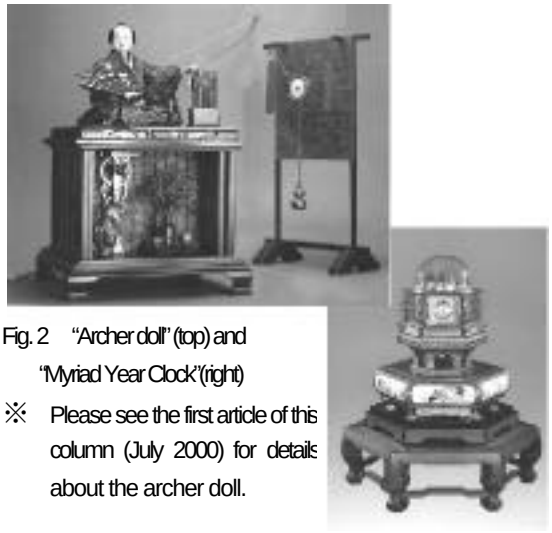

Fig. 2 "Archer doll" (top) and "Myriad Year Clock" (right)

※ Please see the first article of this column (July 2000) for details about the archer doll.

The name "Myriad Year Clock" is said to have come from its durability that lasts all year if you wind the spring just once (220 days as investigated in Showa 20), or from its function as a daily calendar clock. "Myriad Year Clock" has 6 faces. The first one is a Western time display that uses the Swiss clock, the base mechanism upon which all hands, including the ones on the other faces, are moving. The second face is the Japanese time display (hour of the rat or the hour of dawn). The third face is to remember the 24 season divisions in the Japanese old calendar; the fourth displays the seven days of the week (Monday, Tuesday, Wednesday). The fifth face shows the Oriental Zodiac dates, and the sixth shows the moon phases and dates. The hexagonal base on the bottom of the clock has some cloisonné pictures of rabbits, turtles and cranes, which is of high artistic value. Furthermore, the top holds a display device that indicates the current position of the sun and the moon over a map of Japan. What's surprising is that the angles of the sun's career of the four seasons are identical to that at Kyoto.

Hisashige Tanaka is not only famous as the builder of the "Archer Doll" and the "Myriad Year Clock", but also as an inventor of many useful products for the common people, one of which being the "Mujinto (Never Failing Lamp)".

Fig. 3 Hisashige Tanaka and the Mujinto (Never Failing Lamp)

The "Mujinto" utilizes the air pressure to improve the lamp oil supply and the light power. Some say it is this lamp that made possible night stalls.

Hisashige was invited as the refinery manager of the Feudal Domain of Saga, where he made models of steamboats and locomotives. shows samurais surrounding the running locomotive model in the center, as well as a model of a steamboat in the right.

Fig. 4 The Saga-han Seirennkata Ezu (Saga Refinery Staff Illustrated) and the Locomotive Model

In 1873 (Meiji 6), Hisashige (75 years old) established Japan's first machinery company, Chinki Seisakujo, and engaged in building Morse telegraphs and prototype telephones. His successor, Hisashige Tanaka II, has established Tanaka Seisakujo and produced measuring devices, home appliances, machine tools, cables and even iron bridges. This Tanaka Seisakujo became Shibaura Seisakujo to Tokyo

Shibaura Seisakujo, which led to the current Toshiba.

Benkichi Ohno,Japan'sLeonardo Da Vinci

Benkichi Ohno (1801 – 1870) was born as a feather ornament crafter's son in Kyoto. He lived in the same age as Hisashige Tanaka, though the paths he took were a striking contrast to that of Hisashige.

At the age of 20 he traveled to Nagasaki and studied medicine, astronomy, physics and chemistry, and reached Korea from Tsushima and mastered equestrian art, gunnery, and mathematics. When he was around 30 years old he moved to his wife's hometown in Ohno Village, Ishikawa Prefecture; a small mountain village where he stayed for the rest of his life. Unlike Hisashige, who established an illustrious career in Kyoto and Tokyo, Benkichi stayed serenely poor and hid himself in the shack up a mountain village. He was occasionally considered weird or freak, but as more researches of Benkichi are done, the more his great deeds were revealed, and his appraisal soared until it eventually led to the words of head researcher Kazuyoshi Suzuki of the National Museum of Science, saying that he was Japan's Leonardo Da Vinci.

Fig. 5 Netsuke Tea Serving Doll and "The Electricite"

A netsuke is something like a mobile phone strap ornament. It is about a few centimeters tall, and if you put a small ivory plate on it, it will move just like a tea serving doll. It is a masterful work that proves the talent of Benkichi's sculpture.

"The Electricite" is an equivalent of a modern electric massaging machine and it creates electricity by Volta battery. The patient holds two rod with both hands and will be inflicted with an electric shock as someone else rotates the disc. Back in the days where there were no enamel wires, Benkichi used silk threads to cover them; he even invented a machine that wraps fine silk threads around the wire.

Benkichi wrote books about astronomy and calendar mathematics such as "Hassen Sansuu Hyo (Eight-Lined Calculation Chart)" "Sokuryo Sankakuho (Survey Trigonometry)" "Ohsho Kanreki (A Review on Kanreki Calendar)", and made globes showing the Copernican system and surveying equipments for bank construction. He also made a camera by his own, and there still exists a sheet of photograph that he took himself together with his wife. "Itto Shikyuroku (All that Itto has seen)", another of Benkichi's writings, is an equivalent of what we now call a science encyclopedia, reviewing the latest science technology at that time in medicine, physics, chemistry, and mechanical engineering.

Why Benkichi did not move uptown to Kyoto or Tokyo can be speculated by his words; "One cannot create an ultimate invention without three things: knowledge, money, and seclusion". Benkichi used as little expense as possible and respected knowledge and seclusion. That is indeed the reason why he wrote all those books and attended the scientist's salon that existed in the Feudal domain of Kaga in the late Edo period, and taught younger people. One of his pupils was Kichinosuke Tsuda, whose legacy is kept by the current silk textile machinery specialist "Tsudakoma".

Thus I have described how the three greatest Edo Karakuri masters were not only gimmick artisans but universal scientists that founded the modern Japan's industrialization.

20th Century was the time of Differentiation. Then what about the 21st Century?

Ever since Adam Smith indicated in his book "The Wealth of Nations" the economic results of differentiation and segmentation, the 20th Century has been an era of specification and labor division.

Invention of transistors, innovations of semiconductors, and developments in microcomputers have accelerated the automation and mass production, enabling state of the art products to become available to consumers at a price that is unbelievable some few decades back. At the same time in the academics specification and segmentation has progressed rapidly.

I wonder if there are any universal scientists like Hisashige Tanaka and Benkichi Ohno in Japan today. Am I the only one who wishes the 21st Century to be an era of integration and fusion? These days I deliberately try to see and feel various things out of my specialty and try to squeeze out more time of seclusion from my days of wallowing in never-ending meetings.

No. 4 Japanese as Robot-Lovers

Robot Contests Attract Young People

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Robot Contest Fever

One social phenomenon that indicates the Japanese people's affection for robots is the robot contest popularity. "Robot Sumo" "Micro Robot" "Soccer Robot" are only few of the long list of regularly held robot contests. In this article I would like to pick up two robot contests as an example to show the backgrounds of its appeal.

Idea Showdown: Technical College Robot Contest 2000

Students from technical colleges throughout Japan enter this competition to win through the regional tournaments to national championships. I just happened to get a chance to commentate on the Tokai and Hokuriku regional tournament this year, an opportunity that enabled me to observe what the students are doing from up close.

The topic of this year 2000 was "Millennium Message". The robot is to move from the starting area and place objects on 4 poles with different heights; an object of which it depicts the message to the 21st Century.

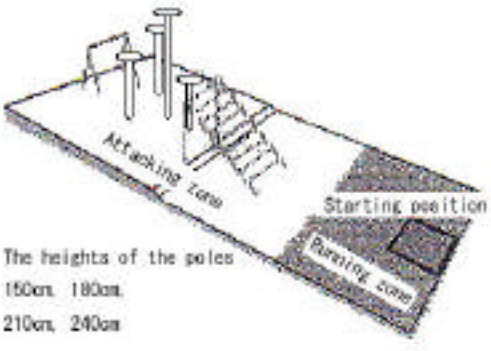

Fig.1 Contest field

Please look at Fig. 1. The first half of the assignment is a time trial, in which you compete how fast the robot will run from the starting position of 1m squares and place the 4 objects on the poles 8m away. The later half competes the performance, in which the robots must demonstrate for more than 10 seconds their message to the 21st Century using the objects placed on the spots within a certain time range.

What was unique about this year's tournament is that its assignment not only offered technical challenges such as how fast you can make the robot put the objects on the poles with different heights ranging from 150cm to 240cm, but also ones that require sensitivity, such as how to express the millennium message and appeal to the audience.

How Technical College Students Tackled the Problem

Each year's robot contest assignment is presented to the technical college students in the beginning of June. Students apply by first sending a paper that shows their ideas as to how they plan to clear the assignments presented. 2 teams can participate from each school. Tournaments in the Tokai and Hokuriku regions are getting bigger by the year, and this year, all technical colleges and commercial colleges in the area have applied, which made a total of 20 teams from10 schools to challenge the tournament on Nov. 5.

The students' solutions to the technical assignment of how to put an object on the 4 poles were in wide variety, such as:

① The robot climbs up the ladder and puts the object from above
② 4 assistant robots holding the objects climb up the poles and place the objects
③ The robot shoots the object aiming for the spot
④ The robot grows taller than the 4 poles and place the objects from above

I was astonished by such a wide range of

mechanism used.

Toyama Commercial College's attack arm team made a robot that uses wooden star-shaped gear to climb up the ladder, after which the robot will stretch out 4 arms as it reaches the top and place the object on the poles with different heights. Its extended arms moving for the spots reminded one of a swan flapping its wings; a very beautiful sight indeed. This machine worked perfectly in the trial before the tournament, but at the tournament the next day the robot did not fully get fixed on to the ladder top. It was a shame the audience did not have the chance to see its lovely form.

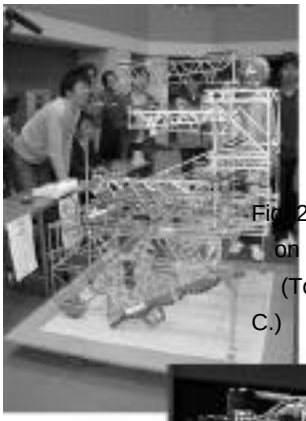

Fig. 2 Attack arm on measuring (Toyama C. C.)

Fig. 3 Teppenjack on trial (Toyota T. C.)

The Toyota Technical College team's Teppenjack won the Tokai and Hokuriku Tournament this year, whose machine had a very original mechanism. Starting from a robot with the size of 1 cubic meters, it ended up 2m wide and 3m tall at the running zone, stepping over all the 4 poles and placing the objects from above.

The students' ways of presenting their thoughts for the millennium message were diverse also. Some raised environmental problems and showed dinosaurs, extinct species, and plant growth. Others expressed the dream of space development projects and the past events of the 20th Century. Their display methods varied too, from electronic boards to printer outputs. Teppenjack of Toyota Technical College astounded the others by its object on the highest pole swelling to become a Victory sign shaped balloon 5m large by the air pumped into from the blower fan.

Fig. 4 Teppenjack's Victory Sign

At the pit backstage, the students were making final adjustments on their robots, and the place was always heated up with excitement. The students, making their best fine-tunings in this cramped space, were very serious and the audience saw their overflowing passions.

Both the regional tournament and the national championships for the Technical College Robot Contest are aired on TV by NHK Television every year, enjoying a great deal of popularity.

There was another robot competition called "Robot Fishing Tournament 2000 in Tokushima", where 192 robots from 42 prefectures participated. There was a new meet for Junior High School students called Creative Idea Robot Contest JHS Tournament, in which 66 teams mainly from the Kyushu region have participated.

Toyota Idea Olympics 2000

The Idea Olympics by Toyota Motors had always been a contest in which the contestants express their dream vehicles in shape, but from this year, it was changed to a robot contest style that has more battle–like aspects, intended to invoke participation.

The 6 types of super–difficult assignments met by the professional engineers included the following:

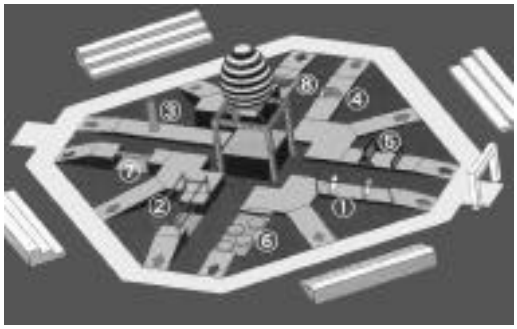

Fig. 5 Toyota Robot Battle competition course

① Barricade breakthrough
② Rope walking
③ Chimney climbing
④ Raising Door
⑤ Climbing Over Wall
⑥ Net climbing
⑦ Log crossing
⑧ Rock jumping

This is an idea match of how many of these tasks the contestants can carry out within a limited time. 19 robots ranging from 4kg to 68kg have challenged these deadlock obstacles.

Fig. 6 A robot attempting chimney climbing

"Chimney climbing" imposes the robot to climb a 60cm diameter vertical cylinder up 2m. The engineers solved this issue by worm-crawls, climbing ropes, and ladders.

The most difficult assignment was the "Net climbing". The machine must climb up the rope net we generally see in amusement parks, but the net sways and swings, creating a poor foothold for the robots. Many of them actually were not able to climb as much. However, it was amazing that 3 machines out of the 19 contestants were able to clear all 8 of the assignments, proving the contest's to be truly a professional tournament.

What Draws Attraction to Robot Contests

I had the chance to oversee personally in detail the 2 robot contests, and was met by many common circumstances in both tournaments; the contestant's passion, sudden malfunctions of robots, and the audiences' big, warm hand when the performance ended in success. The "allure of the robot contest" can be cut down to the following points:

① Spirit of craftsmanship that gives shape to ideas
② Mood created by a trinity of robot, operator and the audience
③ Variety and happenings
④ Originality and teamwork

Another appeal for participants of this contest is that it is a rare chance to challenge something other than their regular studies or jobs. If I dare say further, I believe the recent robot contest fever is contributed by the national trait of "robot-loving ".

The current environment surrounding Japanese youth is not necessarily a society that invokes interest or intrigue to science and technology. The current engineering education in Japanese universities are beginning to focus not on teaching one–sided knowledge but on introducing "Creative subjects" that allows the students use their own minds and bodies to seek out solutions for a problem.

I am hoping the robot contest boom we have these days will continue as a presence to play a part in creating engineers that support 21st Century Japan, a country that aims for a creative science technology giant.

No. 5 Japanese as Robot-Lovers

Dashi (Carriage) Karakuri at Work in Festivals Everywhere

Suematsu Yoshikazu
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The Chubu District as Center of Dashi karakuri

"Karakuri dolls", the root of robots to the Japanese people, are categorized into Zashiki karakuri (room dolls), Butai karakuri (theater puppets), or Dashi karakuri (carriage puppets), depending on where it is performed. Tea-serving dolls and archer dolls are some of the representative Zashiki karakuri dolls, and the Takeda Karakuri, a show that raged the Japanese people back in the Edo era is a Butai karakuri. And the karakuri puppet performed on the top stage (called Uwayama) of carriages used in festivals throughout Japan is the Dashi karakuri.

Dashi karakuri dolls are the leading stars of festivals in 50 areas all around Japan every year, from Hitachi City in Ibaragi prefecture up north and Ojiya City in Niigata prefecture to Yame City in Kyushu down south.

Stretching from Handa City in the Chita peninsula as well as Hekinan, Nagoya, Inuyama, Tsushima cities in Aichi prefecture via the cities of Mino, Takayama, Furukawa in Gifu prefecture to Shinminato and

Fig.1 print of Toshogu Festival in Nagoya(Meiji era)

Takaoka Cities in Toyama prefecture, are areas called the Dashi Karakuri Road. 70% of the country's Dashi karakuri concentrate in this region related to the former feudal domain of Owari.

Back then, the 8th Shogun Yoshimune Tokugawa prohibited the creation of new machinery and devices (inventions and innovations) (1726). However, its sole exceptions were those related to religious and festive affairs. On the other hand, Muneharu Tokugawa, the 7th Lord of Owari who was deprived of his shogunate by this Yoshimune, was a party lover and festival-goer by nature. With his backup, the Toshogu Festival became grander and flamboyant despite Yoshimune's economy thrift policy. Dashi karakuri of regions surrounding Nagoya shows greats influence of the Toshogu festival. Puppet masters(called Degushi) of Owari such as Shobei Tamaya, Jibur Kito, Tokichi Takeda, and Nihei Sumida produced intricately worked-out karakuri dolls (wooden robots) one after another.

The Mechanism of Dashi karakuri

A Dashi karakuri is usually composed of 2 to 3 karakuri puppets. Most likely they deal with Noh plays or myths or folklores. The Seven Lucky Gods such as Daikoku and Hotei, or characters like Urashima Taro and the Benkei are popular materials for karakuri dolls. Also there are many dolls that depict children in Chinese or Korean costumes called Karako. This Karako was obviously derived from the influence of the Korean periodical ambassador that had continued since the Ashikaga government till the Meiji era.

How to operate the Dashi karakuri is roughly divided into "string karakuri" and "stunt karakuri".

A "string karakuri" is a karakuri that uses 10 to 30 something strings to move the puppet, which takes 2 or 3 people to manipulate from above. These puppets hold drums, bells, and fans and dances along with the beat. Some karakuri changes masks instantly from a priestess to a dragon god, bodhisattva to a lion, or a handsome boy into a Shojo(an imaginary monkey-like animal). Some other karakuri transforms itself into shrines or shrine gates, entertaining the eyes of the audience.

A "stunt karakuri" are puppets such as the Karako dolls pulling stunts, such as jumping onto platforms / branches and doing a one-arm handstand, climbing up a bar and

doing giant swings, jumping onto branches one after another (Aya watari), or climbing up stakes positioned like staircases one step at a time (Rangui watari).

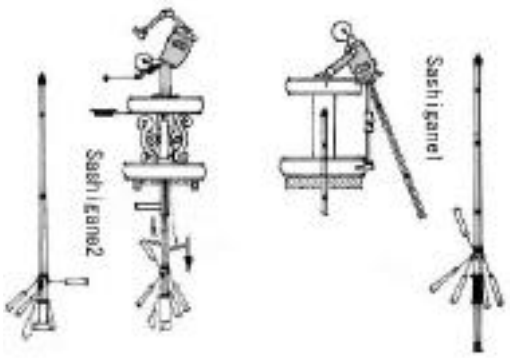

Fig. 2 Two sashiganes (rod with strings to manipulate dolls) are used to make a Karako handstand on the platform

As shown in above figure, the puppet's head, arms and legs are manipulated by a rod called sashigane, which are inserted from the doll's bottom. First the puppeteer place the puppet's hand on the platform then pulls the sashigane out. Then he inserts a new sashigane through the hand placed on the platform and makes the puppet do a handstand, and operate so the puppet will ring the bell while shaking its head.

Of course the two sashiganes will be manipulated where it cannot be seen from the audiences. From the crowd the puppet will dance as it approaches the platform, places one hand on it and flips over for a magnificent handstand, ringing the bell proudly.

Next I would like to introduce the 2 characteristic examples of the carriage festival that has been held for more than 3 centuries in this area, from a tradition keeping and development points of view.

Succession, Creativeness, and Development of the Inuyama Festival

The origin of the Inuyama Festival is said to be Kanei 12 (1635). It has been held every year since then, except Showa 20(1945), and it is the 367th this year. The Inuyama Festival began as an event for the Haritsuna Shrine, located on the mountainside of Inuyama Castle, a national treasure.

Fig. 3 Karakuri performance in front of the Harigane Shrine in the Inuyama Festival

I first saw the Inuyama Festival about 5 years ago. 13 carriages with triple decks from each district lined up at the Harigane Station Square, just 15 minutes walk from Meitetsu Inuyama Line. Each carriage will perform their tricks that date back to the Edo era. In the evening, the carriages are illuminated by 365 lanterns and the Yoyamas, with its candlelight swaying, line up to parade the town. My first impression of the Inuyama Festival, while being swept along in the crowd, was "I can see all I want here to the full extent". Since then, I visit the Inuyama Festival every year. Below are the reasons why this festival has been more alluring by the year:

(1) In an attempt to have more people see the magnificent "Dashi karakuri" or "Yoiyama", 6 carriages move not only to Harigane Shrine Square but also to the Inuyama Station Square to perform the karakuri.
(2) In the autumn festival karakuri dolls from 13 districts are lined up in Harigane Square, making sure the karakuri is shown in front of the audience.
(3) Inuyama people are interchanging with Kashimo Village, Gifu prefecture, and Nichinan City, Kagoshima prefecture, and invite each other to their festivals, broadening the scope of the cultural performances.
(4) Various cultural spreading efforts are being made; there are facilities such as karakuri doll displays and reference library with Shobe Tamaya IX's Karakuri Craft Center, and "Dondenkan" where 3 carriages are regularly exhibited.
(5) The Inuyama Festival Perseverance Committee is very open and keeps active interaction with Takayama, Chichibu, and Gion Festivals, trying to keep in touch with neighboring perseverance committees.

The karakuri culture is Inuyama's pride, and Mayor Yoshihiro Ishida's attempts in adopting this to elementary and junior high school's classes. The activities of high school student's karakuri promotion clubs are some of the other sources that support and develop the Inuyama Festival.

The Kutami Festival – Its Unique Technique and Rare Succession Style

Kutami is a part of Yaotsu Town in Kamo County, Gifu Prefecture, and is located in the highlands spreading in the mountains above Maruyama Dam. The Kutami Festival has a 400 years history since the early Edo period, and is held in the 3rd weekend of April in Shinmei and Shirahige Shrines, which are the guardian gods of Ryoguchi and Kutami. 6 glamorous carriages are pulled out and on the stage of the carriages we see some unique karakuri doll plays every year.

First, the carriages are 2 wheeled, double-decked structure so it can move easily through narrow roads and steep hills. When offering the karakuri performances, the carriages are supported from all 4 sides by bamboo poles, where the second deck will rise up. Its roof is lacquered and varnished, decorated by gold and silver fittings and impressive carvings. The sight of 6 carriages neatly lining up in front of the shrine surrounded by trees is astounding.

The karakuri technique of Kutami is called a "string-cutting karakuri", a unique technique that is neither "string karakuri" nor "stunt karakuri".

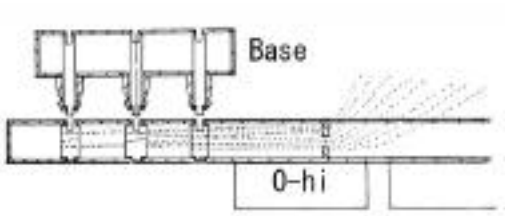

Fig. 4 Base of string-cutting karakuri (base and foot)

The foot of the base is a wheel, in which 4 men pull with ropes inside the O-hi to rotate. Then they will place the stage where the karakuri is performed on top of that base. In other words, they use the 4 wheel's crank effort to create various karakuri tricks enjoyed by the audience. What's amazing is that the karakuri performances change every year!

I will speculate as to why this Kutami Festival in such a small town up a mountain was able to continue for more than 400 years.

(1) Every year, each district must produce a new karakuri doll play. From classic tales of a long-neck woman, a shrine priest's step-climbing, and Benkei on a bridge, to contemporary issues such as national capital relocation issue and space walking, ideas of karakuri dolls are made freely.
(2) The strict protocols of festival staffs of non-drinking, no romantic flirtation, and security restriction in releasing the karakuri tricks are still observed.
(3) Karakuri doll stages are wrapped securely except in karakuri performances for the shrine, and are covered as soon as the performance is over. It is the one and only chance for the creator, operator, and audience. This seriousness is akin to the robot contest.

Fig. 5 The string-cutting karakuri for the Kutami Festival in "Capital Relocation"

Thus I have introduced two contrasting Dashi karakuri festivals of Inuyama and Kutani; but they are common in that they try to pass down the fun of creating to the children and the young generation. It should not be a mere coincidence that the areas concentrated with Dashi karakuri festivals are the center of the global industrial technology today.

Where the Path of Robot Should Lead

Suematsu Yoshikazu
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For one year I have had the privilege of writing 6 episodes in this series entitled “Japanese as Robot-Lovers”. In this series I have presented my opinion that the Japanese people’s robot image was developed in the Edo era by karakuri technology, and unlike Europeans, they have a favorable image toward robots, and that is what enabled the massive industrial robotization that supported the Japanese manufacturing industry. Also I have stated that the Edo karakuri masters were universal scientists, and that the technology seen in Dashi karakuri in festivals nationwide and the Idea Robot Contests have contributed greatly in handing down the techniques and technology.

In my final article I would like to mention the way industrial robots and home robots should be and the paths they should take.

Evolution of Industrial Robots

The first industrial robot was introduced by US GM. It was a one-arm robot called Unimate and occupied a lot of floor space. They were adopted for material handling, welding, painting, and assembling. In Japan robots have been introduced widely from the mid 1980s, enabling “good products at low price”.

Looking back at the industrial robot development process in Japan, they have constantly leaded the world and have leveled up, becoming more intricate. At first, the robots occupied too much space and were so dangerous it did not allow people near, but as the downsizing and speeding have progressed, we now see many lines with humans and robots working side by side. Also, the robots developed from performing simple tasks such as painting and welding into multiple-armed robots that can complete sophisticated assembly. Fig. 2 shows the two-arm robot that Toyota Motor Company introduced in the 1990s for engine parts assembly.

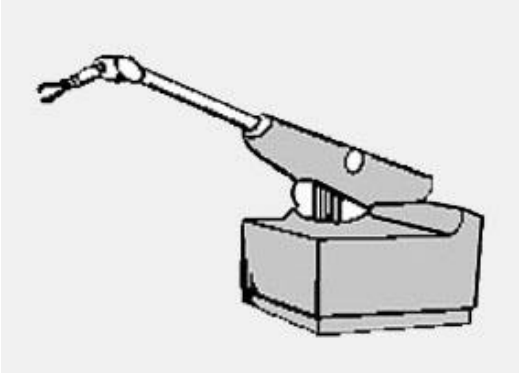

Fig. 1 First industrial robot Unimate

Robots with optical function equivalent to human eyes and mobile robots that can change working position according to the task have also been developed and are currently operating in many plants. Furthermore, some cases show more than one mobile robot autonomously cooperating with each other to assemble parts.

The grouped robot system that Denso Corporation developed 2 years ago is a combination of 6 axis robot arms that handles various tasks and a mobile robot with a running platform that enables it to move in high-speed. It can adjust the number of operating units according to the production volume. The robots can exchange information obtained during the tasks and cope with environmental changes efficiently, a realization of a flexible production system in itself (Fig. 3). Also, the electronic part installer that assembles accurately and in high-speed a micro electronic part on a board is also a robot, which have been leading the world up to this day.

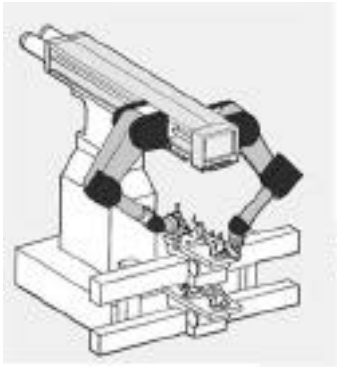

Fig.2 Two-armed Robot (Toyota)

Fig.3 Autonomous Cooperating

In Western countries the robot researches are not as free as in Japan. They have the history of limiting their researches to military, aerospace, and medicinal usages. I have been told by many overseas researchers that they "envy Japanese universities which allows such a wide range of research". This is also caused by the favorable image the Japanese people have over robots, and its origin goes back to the Edo karakuri culture.

Now, I would like to express my thoughts as to the problem points of robot development processes so far and the form in which they should be in the future.

As a point of problem, I would first like to indicate that most of the industrial robots so far are ones that have been introduced to mass production lines, and are limited in doing a specific task. Secondly, that the industrial robot development and introduction is concentrated on large enterprises only; and third, that the multi-purpose robot development for tasks such as visual inspection of completed products and micro products assembly has been staggering behind.

The environment that surrounds the Japanese product making is in a severely challenged stage. The de-industrialization caused by the personnel cost difference between the neighboring Asian countries, as well as the draining of skills as a country as a whole, and the young people's interests shifting away from science and technology are some of those.

The way Japan's industrial robots should take must first be the development of a robot that can replace the work that is commonly shared in the whole manufacturing industry but is still done by human hands (aforementioned visual inspection and small parts assembly, for example). And humans should administer the robot management, carry out inspection and make appropriate adjustment for them. Secondly, it is necessary to create not a robot that specializes in only one task, but a multi-purpose robot, which means a single robot doing multiple tasks. Thirdly, it should be made sure to design a human-oriented robot that operates safely as well as easily.

Development of the above industrial robots that can be introduced to manufacturing industries including small companies are strongly called upon for in forms of national major projects. And many products making lineside should train people that can operate and administer robots, whose ideas will then create another robot. Such circulatory system must be made.

Ways of Home Robots

I have mentioned about home robots in the 2nd article of this series, "The Start of the Home Robot Era" (November issue, 2000). Sony's AIBO, which had become the first of the Japanese home robots are still winning popularity. AIBO, as its developer comments, is an "entertainment robot", not a "pet robot". It must be noted that its dog-like appearance is only because that figure was more familiar to humans. However, when mass media reports about AIBO they compare with real pet dogs and emphasizes points such as it can be kept in apartments, or you can go out without worrying about feeding them, a notion that bothers me. Robots being replacements of live dogs and cats is exactly what the Western countries are apprehensive about. For example, although fake flowers look like real ones and will not wither, it can never replace real flowers that you must water and care. I believe that is exactly why the 2nd generation AIBO has changed its shape to something that is neither a dog or a cat or a lion, so that it will not be identified as dogs.

The root of home robots is the "Tea-serving doll", which I have mentioned before as a perfect role model. It is obvious the tea-serving doll is not used because the host is too lazy to bring the tea

himself. Its primary role is to entertain, so that the guests are delighted to see the tea-serving doll and enjoy the moment.

Fig. 4 AIBO and tea-serving doll

I think that the major purpose of home robots should be limited to entertainment for the time being. Even if nursing and caring robots should come into homes, at this point I would like to distinguish them from home robots. If they were to be installed, I think they should be installed with an operator (human) who can cope with sudden turnouts.

Afterword

This summer, in Suzuka Circuit, there was a joint event of traditional karakuri and the latest state-of-art robots, ending very successful. It was a united performance of Shobe Tamaya IX's stake-hopping karakuri "Karasu Tengu" and Honda's bipedal robot "ASIMO". A stake-opping karakuri is a karakuri unique to the Tokai Area, in which a doll with sandals climbs the stair-lined stakes one step at a time. It can be said it is the father of bipedal robot. ASIMO is the latest model of autonomous bipedal robot P2, P3. It turned into a very compact form, 120cm tall and 42kg in weight.

I looked through the event all day, but the contrast of the two robots was striking. People from adults to children were applauding enthusiastically in both performances of the traditional Karasu Tengu and the ASIMO.

Fig. 5 Karasu Tengu and ASIMO in Suzuka Circuit

There are many factors that link Edo karakuri and the current key technology. For example, the folding techniques that the Dashi karakuri uses when puppets transform into shrines are used in the invention of folding umbrellas, solar battery panels for satellites, and the folding technology of panorama antennas. The karakuri techniques of the long-neck woman whose neck can stretch and retract swiftly are utilized in elephant nose robots that extends freely through cramped spaces, and the motor control technology of endoscopes for colons.

Japanese are robot lovers, all the more reason why we should correctly recognize the relationship between human society and robots, and produce robots that can perform in various fields. Karakuri loving, robot loving Japanese, I believe strongly, will establish the new product-making industrial development under this harsh Japanese environment of administrative reforms and industrial restructuring.

Author's homepage "Karakuri Frontier"
http://suelab.nuem.nagoya-u.ac.jp/-suematsu/karafro.html