Research and Development for Next Generation Service Robots in Japan

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1. Introduction

Japan, being a global leader in technology, is considered a frontrunner in the development of robots worldwide. Since the 1970s, Japan has developed advanced industrial robots in response to increasing demand from the automotive and electronics sectors. The advantages of Japanese robot technologies arise from Japan's conventional strengths in mechatoronics and information and communication technologies. Japan has been dominant in this area, having the largest number of robotics installations in the world.

Early in the present decade, the Japanese government and companies shifted their spotlight from industrial to service robots in response to an emerging ageing society. More specifically, Japan's population growth rate is coupled with a growing elderly population, such that severe shortages of people providing care, as well as young workforce are inevitable. Faced with this type of demographic crisis, the idea of using robots in nursing and housework support, as well as in therapeutic applications for elderly people, is rapidly gaining ground. Indeed, a range of service robots displayed at the Aichi

Expo in 2005 drew much attention from abroad. The Japanese government has made concerted efforts, launching large-scale research projects with the aim of achieving full-scale commercialisation by the year 2025.

This report is intended as an overview of the strategies and major research and development projects for next generation service robots in Japan. It begins by describing the salient features of Japanese robotic technologies in terms of their theory and practical application. The report moves on to summarise robot strategies taken by the Council of Science and Technology Policy (CSTP), as well as major projects launched by the New Energy and Industrial Technology Development Organisation (NEDO) and the Ministry of Internal Affairs and Communications (MIC). It then selects the latest achievements made by major consumer electronics and automotive companies such as Hitachi, NEC, Toshiba, Mitsubishi Heavy Industry, and Toyota. The report also reviews the research programmes of leading research institutes, the National Institute of Advanced Industrial Science and Technology (AIST) and the Advanced Telecommunications Research Institute International (ATR).

2. Overview of Japanese Robot Development

Background of Japanese Robot Technologies

Robot technology is characterised as an integrated system technology. One robot unit consists of various elemental technologies, such as mechanical, electronics, materials, and information and communication technologies. Creating advanced robots requires overlapping technologies in each process. Thus, vertically collaborative work that relies on multiple elemental technologies, in addition to good systemisation, is of significant importance.

Most of the achievements in Japanese robot technologies have largely derived from conventional strengths in electronics and mechatoronics. Specifically, Japan has technological advantages in the fields of advanced manipulation, learning and planning in movements, and sensing recognition. Japanese robot experts have been very keen to develop hardware for human interfaces, specifically in the form of small and high performance devices.

In terms of manipulation theory and algorithms, Japanese researchers have made sound achievements, as exemplified by their mechanisms and control systems for fingers and hands, as well as for ultra-fast visual feedback. In particular, the following research programmes have attracted attention from world-leading robot experts:

1) Ultra-fast manipulation research at the University of Tokyo
2) Development of multi-fingered hands at Kyushu University and Gifu University
3) Flexible fingertip research at Ritsumeikan University
4) Home arm manipulation research by Riken.[1]

Japan is also a world leader in the field of humanoids. A number of ongoing research and development projects have been carried out, focusing on humanoid robots and intelligent robots. For instance, Prof. Minoru Asada of Osaka University serves as a principle leader of a research programme funded by the Japanese Science and Technology Agency (JST). The main goal of this programme is to develop a synergetic intelligence mechanism for humanoids, using methods developed from cognitive and brain sciences.

Japanese researchers, whose area of expertise is mobile robots, tend to put priority on the mechanism and create actual equipment such as mobile mechanisms and walking vehicles. Some have successfully achieved commercialisation of robots for use in search-and-rescue operations. However, in general, Japan has lagged behind in the field of theoretical research of locomotion, particularly, in mobile robots based upon mathematical background and Simultaneous Localisation and Mapping (SLAM). The academic research in the UK and other European countries has competitive advantages in these areas. An increasing number of advanced research programmes in Europe are focused on the understanding of mobile robots and self-localisation. On the other hand, few research programmes have investigated new architectures for control systems intended to work in the real world in Japan.[2]

[1] Center for Research and Development Strategies in JST, ”International Comparative Study of Science and Technology, and Research and Development”, CRDS-FY2007-IC-06.
[2] Center for Research and Development Strategies in JST, ”International Comparative Study of Science and Technology, and Research and Development”, CRDS-FY2007-IC-06.

Table 1. Examples of elemental technologies and systemisation technologies related to robotics

Elemental technologies	**[Driving Technologies]** -Motor machine -Reduction gears -Mechanical design -Oil hydraulic machine -Pneumatic machine -Hydraulic machine -Artificial muscle, etc.	**[Sensor Technologies]** -Image-recognition technologies -Voice-recognition technologies -Gyro sensor -Force sensor -Self-location recognition	**[Battery Technologies]** -Fuel cell -Lithium ion battery
	[Material Technologies] -Memory metal -Carbon material -Artificial skin, etc.	**[Communication Technologies]** -Communication security -Stabilisation of communications, etc.	**[Software Technologies]** -Artificial intelligence technologies
Systemisation Technologies	-Integration technologies -RT middleware -Environmental structuring technologies		

(Source: The Robot Industry Policy Committee, METI)

Service Robots in Japan

Service robots usually include all robots that provide value-added service at home, in the office, and in public spaces. Classification of major service robots is shown in the Table 2.[3] The Japanese government and large consumer electronics and automotive companies have created service robots that can be used as homemakers to perform tasks such as washing, vacuum cleaning, and communicating, as well as carrying and tending to elderly people. A range of some of these achievements was displayed at the Aichi Expo in 2005.

Since 2005, continuous efforts have being made to accelerate the commercialisation of service robots, rather than just increasing their appeal of these robots. However, unlike the situation for industrial robots, the commercialisation of service robots requires repeated experimental demonstrations in order to supply the user with a sense of safety and security in their use.

Japan has accumulated knowledge and various technological strengths in robust industrial robots. About 40% of the industrial robots in use in the world are estimated to be operated in Japan. The total value of shipped units in 2007 amounted to 585 billion yen. Advanced and intellectual robots for industrial sectors, such as robot cells, are about to go

[3] The robots whose application is very specialised and limited area such as space and deep waters and technologically

into the market.

Table 2. Classification of Service Robots

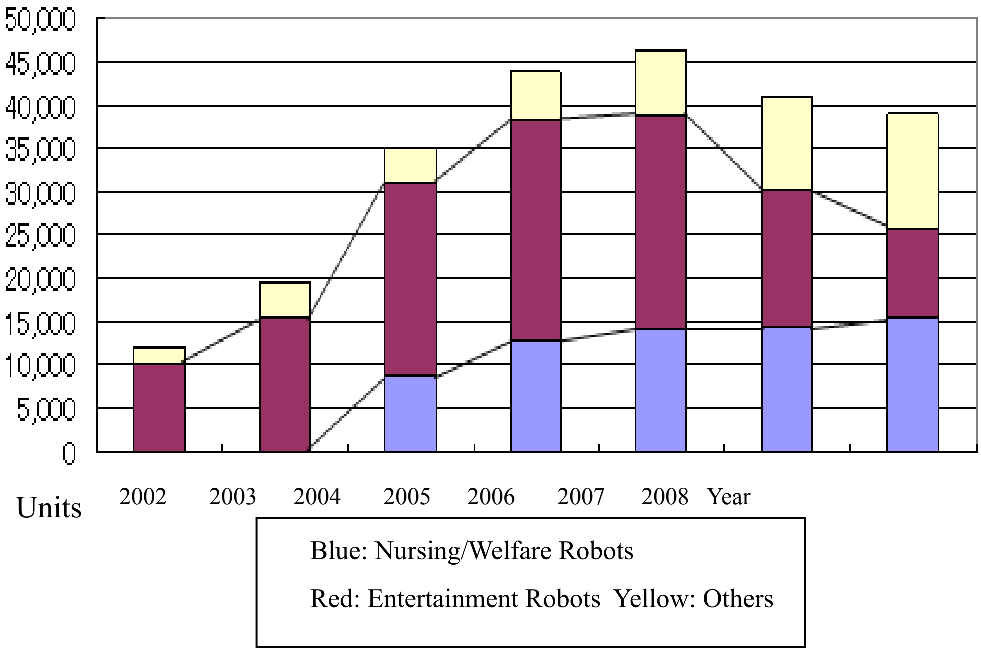
Field	Examples	Application
Practical Communication Service Robots	-NEC "*PaPeRo*" -Hitachi "*EMIEW/EMIW2*" (communication robots) -Advanced Industrial Science and Technology (AIST) "*PARO*" (mental commit robots) -ART "*Robovie*" (communication robots)	-Home Security -Remote monitoring -Information terminal -Nursing care/medical care/welfare with no power control
Homemaker Support Robots	-Fuji Heavy Industry (cleaning robot system) -iRobot (USA) "*Roomba*" (self-cleaning robots) -Toshiba "*ApriPoko*" (home life support robots) -Mitsubishi Heavy Industry "Wakamaru"	-Domestic Help -Air conditioning -Cleaning -Home Security -Remote monitoring
Mitigating Work Burden Robots	-Matsushita Electric Works "*HOSPI*" -Secom "*Secom Robot X*" -Cyberdyne (work assist robots) -Toyota IRT (nursing robots)	-Support for duties in hospital -Security -Nursing/medical care with no power control

(Source: Based on NRI)

Compared to industrial robots, the market share of service robots still remains at a modest level. Yet, according to Seed Planning Company, the market scale of service robots grew from 1.9 billion yen to 6.7 billion yen in 2006. In 2007, while large companies withdrew from entertainment robots like pet robots, the sales of nursing and

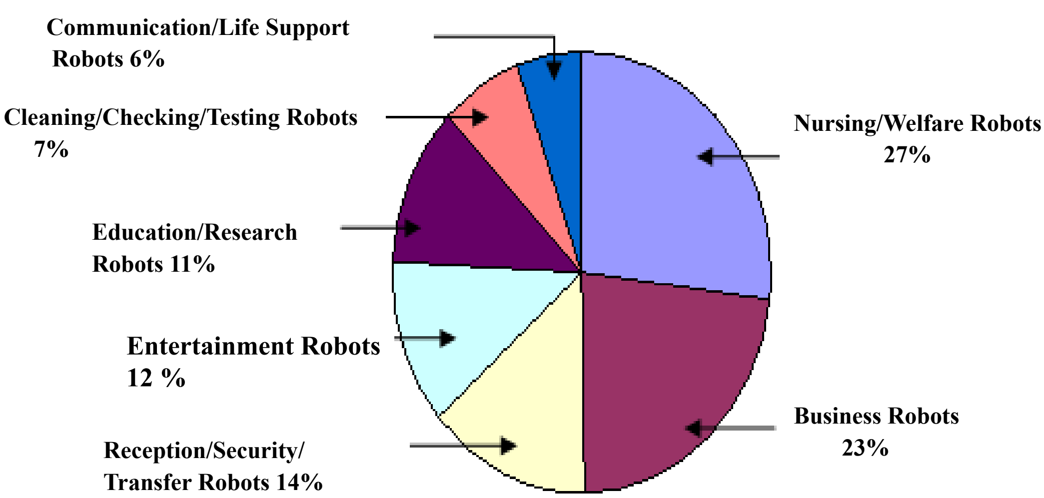
extremely distinguished robots are not included in the Table.

Figure 1. Trend of service robots sales in Japan since 2002



(Source: Seed Planning Inc.)

Figure 2. Breakout of service robots



(Source: Seed Planning Inc.)

welfare robots, as well as others such as cleaning and testing robots have continued to grow. (Figure. 1) The breakdown of service robots sales, service robots scheduled to go on sale, and those developed for commercialisation is shown in figure 2. Nursing and welfare robots dominate the largest share, followed by business and entertainment robots.

Nomura Research Institutes (NRI) assumes that the functional level of the robots would gradually meet with the user's needs, and that the future market of service robots would grow as their cost declined. It forecasts that the market scale will grow through new government policy strategies and strong efforts by private companies.[4]

3. National Projects for Next-generation Robots

Inter-Ministry Coordination Programme by CSTP

Looking towards the year 2025, the Japanese government aims to become the world leader of service robots through the creation of autonomous robots. The Third Science and Technology Basic Plan (FY2006-FY2010) underscores the need for robots in the 21st century. It is widely believed that robots will be required for support of daily activities, especially those of the elderly. Since 2006, an array of strategic policies has been employed by the central government with the aim of bringing service robots into the market.

The Council of Science and Technology Policy (CSTP), which serves as a key commander in determining the course of national science and technology policies, has identified next generation robots as one of the strategically prioritised areas. The next generation robot development must have intensive investment over the next five years. CSTP has selected the following three areas as being the most important for development:

1) robot technology systems that integrate collaborative technology
2) robot module technological augmentation
3) human-robot interaction technologies.[5]

The CSTP has also established the Inter-Ministry Coordination Programme of Science and Technology Project, aimed at promoting next generation robot technologies through five ministries, including the Ministry of Economy, Trade, and Industry (METI), the Ministry of Education, Culture, Sports, Science and Technology (MEXT), the Ministry of Internal Affairs and Communication (MIC), the Ministry of Agriculture, Forestry, and Fisheries (MAFF), and the Ministry of Land, Infrastructure, Transport, and Tourism

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4 http://business.nikkeibp.co.jp/article/tech/20080220/147642/

5 CSTP, "Overlook of strategically important Science and Technologies in ICT areas", June 24, 2008.

(MLIT). The focus of MEXT is to create a research basis by provision of competitive public funds and educational support. MAFF is to launch a project aimed at developing practical robots suitable for use as harvesters. MLIT focuses on robots capable of performing underwater tasks, such as repairing and checking of harbours. While each respective ministry has its own policy agenda, all share the same goal of developing a common robotics technology platform that can promote the diffusion of service robots by the year 2025.[6]

NEDO Projects

Among these five ministries, METI has primary responsibility for the largest funded projects. METI will create a robotics technology roadmap based upon market analysis as well as scientific evidence obtained from academic and business people, with the 2025 goal in mind. In order to implement METI's specific technology policy, NEDO, a public R&D management organisation financed by METI, has established three new strategic research projects. These projects build on the achievements made in the previous national project, "Robot Technology (RT) Middleware" carried out from 2002 to 2004. Previously to the Middleware project, METI had also launched a large project from 1997 to 2002 for the production of humanoid robots for industrial use.

The human-assistance commercialisation project, which was completed in 2007, also made a major step forward in the practical use of robots. For instance, Prof. Sankai of Tsukuba University, who developed robot suits under this project, established a start-up company called *Cyberdyne*. *Cyberdyne*'s robots are built based upon knowledge from the fields of neuroscience and mechanical engineering. *Cyberdyne* will start mass production of robot suits with the aim of producing more than 5 million suits per year.[7]

Currently, NEDO has conducted three projects that can be categorised as prioritized robotics technologies. The respective research purposes, areas, budget, and project leaders are listed in Table 4. In addition, at the end of December 2008, METI requested 2 billion-yen (GBP 14.5 million) for a new project, to begin in 2009, related to life assistance robot technologies for elderly people, entitled the Life Assistance Robot Technology project. This project is intended to develop and demonstrate the safety technologies of life assistance robot technologies to be used primarily for elderly person

[6] Kensuke Murai and Akira Okubo, "Government Policy for Next Generation Robots" in *Journal of the Robotics Society of Japan*, Vol. 26. No.5, 2008.

care, as well as for mobility. The project will also carry out data aggregation and analysis required for confirmation of high safety standards.

Table 4. NEDO Robot Projects

1. FY 2006-FY2010 (Budget 800 million-yen (FY2008))

"Project for Strategic Development of Advanced Robotics Elemental Technologies"
Project Leader: Dr. Shigeoki Hirai
Director of Intelligent Systems Research Institute, AIST
(http://unit.aist.go.jp/is/main/welcome/welcome_e.html)

●**Main purposes**: to achieve the mission specified by the government, based on the "Strategic Technology Roadmap" for robotics and derived from future market needs and social needs, by developing and utilising necessary for robot systems and associated elemental technologies to help fulfil expected needs.
●**Principal research areas**: 1) Flexible objective 2) Human-Robot collaborative cell product 3) Cleaning up Manipulation 4) Communication Robots for Elderly People 5) Transport RT 6) Mobile RT System in Buildings after Disaster 7) Disposal RT system (Italics are categorised as service robots)

The project is carried out by 45 members
(12 universities, 27 companies, and 6 public research institutes)

2. FY 2008-FY 2011 (Budget 1,500 million-yen (FY 2008))

"Intelligence Technology for Next Generation Robots"
Project Leader: Prof. Tomomasa Sato, the University of Tokyo
(http://www.ics.t.u-tokyo.ac.jp/)

●**Main purposes:** To develop intelligence technologies that are robust even under drastic changes in the external environment, as well as to increase recognition and autonomy estimation and assessment capabilities.
●**Principal research areas**: 1) Intelligent software platform for robot 2) Intelligent software reuse Technology; 3) Operation intelligence for production; 4) Operation intelligence for social life and Living; 5) Transportation intelligence for service business; 6) High-speed transportation intelligence for public space; 7) Transportation intelligence for social life and living; 8) communication intelligence for social life and living.

The project is carried out by 39 members
(15 universities, 6 public research institutes, 18 companies)

3. FY 2008-2010 (Budget 100 million-yen (FY 2008))

"Open Innovation Promotion Project for Utilisation of Basic Robot Technologies"
Project leader: not decided

●**Main purposes**: To improve the development base of robot technology systems and to expand the scale of environment adaptable to robot technologies. To develop supporting industry through providing opportunities for SMEs to carry out new businesses.
●**Principal research areas:** To develop basic communication modules and tools, elemental parts of robot technology using basic communication modules, robot technology systems and to carry out demonstrations.

(Source: NEDO)

[7] October 4, 2008, Nikkei Shimbun.

MIC Project

MIC has launched the second largest project next to METI. MIC expects that the application of robot technologies, defined as flagship technologies, will be expanded to almost all areas surrounding our daily lives; for home use and in business, medical care, nursing care, and education. Its ongoing project is intended to develop robots capable of being connected at any time everywhere throughout a network. These robots will provide a completely new lifestyle through integration with a ubiquitous network (Table 5). The most ideal network robots will be able to assist and support elderly and disabled people in any movements. Alternatively, they will be communications robots, which can communicate with people in a more natural way and provide suitable information. [8]

MIC also attempts to accelerate robot research and development, especially from prototypes to commercialisation, by helping to overcome a number of institutional and regulatory barriers. Recently, MIC made a budgetary request of 1,000 million yen in FY 2009 for a new ubiquitous network focused on elderly and disabled people, to include technologies such as control of multiple interactive robots, web administrative and analysis technologies of information recognition, as well as robot service coordination system technologies.

Table 5. MIC Robot Project

1. FY 2004-FY2008 (Budget 220 million-yen (FY 2008))
"Network Robots technologies"
●**Main purposes**: In response to an increasing need for various robot services to support people's daily lives, service robots with high communication capabilities and high recognition abilities are a prerequisite. This research project is intended to pursue new technologies capable of uniting various sensors and networks to realise network robots. ●**Principle research areas**: 1) Robot Plug&Play technologies: Communication technologies between robots etc. 2) Advanced dialogue technologies: Behavioural-recognition technologies and situation recognition technologies for more natural conversation.

(Source: MIC & CSTP)

4. Examples of Service Robots Developed by Companies

Japanese companies have been turning their attention to emerging opportunities for service and personal robots. A number of good research outcomes for service robots developed by Hitachi, NEC, Toshiba, Mitsubishi Heavy Industry will be depicted All of these have pursued sound technologies through the NEDO project. Toyota has emerged

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8 http://www.soumu.go.jp/menu_02/ictseisaku/ictR-D/051020_2_1_1.html

as the first company to commercialise nursing robots for elderly people.

Hitachi

As one of the largest comprehensive manufacturers of electrical machinery, Hitachi was the earliest company to undertake robotics research in Japan, and has contributed much to progress in society through applications of its robotics technology. The first computer-controlled domestic robot with artificial intelligence was displayed at the Hitachi technology exhibition in 1970.[9]

BOX 1. *EMIEW*

EMIEW has physical capabilities, such as agile movement and obstacle avoidance, which was co-developed by Hitachi and Tsukuba University. The technology utilizes the results of cooperative research performed by Associate Professor Takashi Tsubouchi and Vice-chancellor Shinichi Yuta of Hitachi's Mechanical Engineering Research Laboratory.

EMIEW 1 (Source: Hitachi)

EMIEW2 was developed as part of Hitachi's efforts to create a service robot with diverse communication functions. EMIEW2 has autonomous moving technology, which plots how to reach a destination by automatically mapping the robot's surroundings. EMIEW2 can navigate through corridors, around obstacles, weave between moving people, guide visitors to their destinations, and deliver drinks and documents. [10]

NEC

NEC is one of the nation's representative high-tech powerhouses. In 1997, NEC initiated research and development on personal robots that could coexist with people. NEC was also able to achieve hardware modules the size of business cards that were capable of detecting sound resources, sound recognition, and voice synthesis in response to RT middleware. This technology is highlighted by the high performance of its modules despite their small size and lightness, and their low energy consumption through utilization of IC in mobile phones. This module has been applied to their latest communication robot called the "Papero-mini" and its demonstration has been carried out. NEC is currently committed to NEDO's project that focuses on intelligent robot development, started in 2008.

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9 Daiwa Institute of Research, "Robot Industry as Growing New Sector", Autumn 2006.

10 http://www.hitachi.com/rd/research/robotics/emiew2_01.html

BOX 2. *PaPeRo*

PaPeRo-mini (Source: NEDO)

PaPeRo has various basic functions for the purpose of interacting with people. It has capabilities for finding and identifying people through facial recognition technology. This is the technology by which images captured by cameras mounted on the robot are processed to identify a person. The PaPeRo changes its reactions and character to each person depending on how it is approached. It also expresses its own feelings by dancing. It is able to make spontaneous suggestions and autonomous actions as well as create movements and reactions using a visual base editor that is easy to directly understand. PaPeRo-mini is a much smaller version, about one fourth the size of PaPeRo.[11] It also reduces energy consumption. PaPeRo-mini has small voice recognition models installed that were developed through the NEDO project.

Mitsubishi Heavy Industry

Mitsubishi Heavy Industry launched service robot development in 2000 as part of "Mitsubishi's Frontier 21 Project". The company service robots used in the home, humanoid communication robots called "Wakamaru", were developed in 2003 and brought into the market in 2005.[12] Wakamaru was developed under a project supported by NEDO (FY 2005-2007) that focused on creating advanced voice recognition modules. Again, Mitsubishi is currently consigned by NEDO's new project in strategic advanced robot technologies launched in 2008.

Box 3. *Wakamaru*

Wakamaru (Source:NEDO)

Wakamaru contains high capabilities in voice recognition and voice synthesis and various functions enabling more natural communication. Wakamaru consists of multiple sensors as well as imaging process functions, which enables natural conversation using eye contact. It is constantly connected to the Internet through a wireless LAN so that it can deliver news and weather forecasts. Owners are able to check indoor conditions through mobiles.[13]

On October 7, 2008 the company announced that they would boost collaboration with companies in different sectors in order to explore new markets for Wakamaru. Mitsubishi will start collaboration with toy makers, electronic equipment companies, and advertisement agencies, with the aim of exploring new applications in different fields, such as large shopping centres and childcare businesses.[14]

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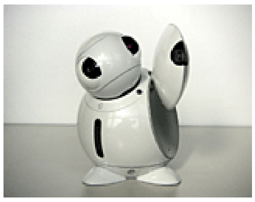
11 http://www.nec.co.jp/robot/english/robotcenter_e.html
12 Daiwa Institute of Research, "Robot Industry as Growing New Sector", Autumn 2006.
13 Daiwa Institute of Research, "Robot Industry as Growing New Sector", Autumn 2006.
14 http://www.mhi.co.jp/news/story/0810074750.html

Toshiba

Toshiba has developed very special robots in the past for use in the fields of atomic energy and space. Since 2003, it has concentrated on service robots, primarily home life support robots called ApriAlpha and ApriAttenda. Toshiba first announced its ApriAlpha in 2003, then developed its new robot, the ApriAttenda, and updated the technology inside the original ApriAlpha version. ApriAlpha has six microphones by which the robot can respond to sound sources from any direction. It can turn off and on, as well as adjust the volume of, home electronic appliances on command. ApriAttenda contains special image processing technology, co-developed by Tokyo University of Science by which it can identify specific people. The robot moves and follows the person and uses an ultrasonic sensor to avoid obstacles. Toshiba has updated the technology inside the original ApriAlpha version. In 2005, Toshiba produced the ApriAlpha V3, which was capable of recognizing the owner's voice from a crowd of talking individuals, using omni directional voice capture, and responding to their commands. Toshiba's latest Apri-family member is ApriPoko developed in March 2008.[15]

***Box 4.** ApriPoko*

In March 2008, the 11-inch tall android called ApriPoko was introduced. ApriPoko is capable of learning how to control electronics by watching the owner and asking questions about the owner's behaviour, acting as a universal remote control. When it senses that a remote has been used in its vicinity, it asks the user of the remote what owner just did. It then records that action and repeats it whenever asked to do so.[16]



ApriPoko (Souce: www.tvsnob.com)

Toyota

Toyota has been developing nursing robots intended to assist with the heavy workload of nursing care, such as carrying people. The company has already implemented experimental tests, and is planning to carry out further experimental demonstrations of nursing robots in hospitals, in order to realise commercialisation by 2010 at the earliest. In order to provide a more rigorous sense of security, the nursing robots are designed to work together with professional caregivers. In January 2009, all robot experts working in Toyota will gather in the newly-established facility in Toyota City to concentrate on the development of nursing robots.[17]

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15 http://kagakukan.toshiba.co.jp/dna/explore/en/nol/technology_con01_2_2.html

16 http://robot.watch.impress.co.jp/cda/news/2008/03/26/958.html

17 18 December 2008, Nikkan Kogyo Shimbun

Toyota has been involved with the new interdisciplinary academic university collaboration research centre at the University of Tokyo, the Information and Robot Technology Research Initiative (IRT, http:www.irt.i.u-toyo.ac.jp/). The main mission of IRT is to develop basic technology based upon robot networks and real-world computing technologies to create innovations that deal with the new challenges of an ageing and low birth society. The centre is supported by public funds called special coordination funds for promoting science and technology. Under this project Toyota developed a prototype of a single-seat car robot for safe and easy indoor use by the elderly. The prototype robots, for indoor use, can recognise a beckoning hand and approach the person. They can also recognise positions and go back to a specific place by detecting a landmark on the floor.[18]

5. Main Activities in Leading Research Institutes

AIST (National Institute of Advanced Industrial Science and Technology)

AIST is an independent research institute mainly funded by the government. AIST has been committed to the national project, next generation robot development, co-signed by NEDO. The Intelligent Systems Research Institute at AIST specialises in robotics, human interfaces, control engineering and mechanics, and computer vision. Main research areas are the following:

1) Application of humanoid robots (Creation of humanoid robots to support people in daily life)
2) Human friendly robot technology (Development of robot technology appliances)
3) Autonomous mobile robots (Data acquisition in a wider environment to keep social security and QOL)
4) Advanced robot vision (Development of 3D, multifunctional and high performance visual observation systems).

AIST recently announced that they are planning to launch a research collaboration with Fuji Heavy Industry and Utsunomiya University, particularly in the area of sensor technologies applicable to robots. Fuji Heavy Industry has a plan to mount AIST's technologies to automatic cleaning robots. Utsunomiya University has a specialised research group in the field of robot control theory, focusing on its algorithms.[19]

[18] The University of Tokyo, "Information and Robot Technology Research Institute (IRT)".
[19] 8 July, 2008, Nikkei Sangyo Shimbun.

A mental service robot called Paro, developed by Dr. Takanori Shibata at AIST, can remember its name and change its behaviour depending upon how it is treated. It has been extensively tested in homes for the elderly and in hospitals. Overseas sales have begun in USA and just recently in Denmark.[20]

ATR (Advanced Telecommunications Research Institute International)

ATR was founded in March 1986 with the support of various partners from industry, academia and government, with the aim of promoting basic and creative research activities in telecommunications and for contributing greatly to society. ATR has obtained public research funds from JST, MEXT, METI, MIC, and the National Institute of Communication and Technology (NICT).

The Intelligent Robotics and Communication Laboratories (http://www.irc.atr.jp/index.html) at ATR have been especially involved with national robotics projects funded by MIC. These laboratories are dedicated to the development of communications robots named "*Robovie*" that are designed to create an intelligent environment for symbiosis with robots and humans in everyday life and for using robots to understand human psychology and sociological interactions.

Since 2004, *Robovie* has gained capabilities of estimating human relationships using RFID tags. Dr. Norihiko Hagita who serves as Director of the laboratories, has been involved with a national project, i.e., "Network Robots Research Project" from 2004 to 2008. This project receives government funding from MIC. The partners for this project include NTT, Toshiba, Mitsubishi Heavy Industries, and Matsushita Electric Industrial Company. Its goal is to elaborate human-like navigation and core technologies capable of sharing information among people. Some experimental demonstrations were carried out at a science museum and a large shopping centre. The IRC laboratories are very keen to explore international collaboration and are currently working with a EU research group under EU funding, FP6.[21]

6. Conclusion

Japan currently enjoys the position of a leading robot superpower, producing high quality industrial robots that rely upon accumulated advanced mechatoronics and electronics technologies. There is ongoing advanced research for further robotics technologies such

[20] 21 November 2008, Nikkei Sangyo Shimbun.

[21] Interview with Dr Hagita, June 19, 2008 at ATR.

as humanoid, mobile, and personal robots currently being carried out by Japanese universities, research institutes, and companies. Academia-industry collaborations have developed notable breakthrough technologies and are actively exploring new applications.

The Japanese government aims to accomplish full-scale commercialisation of service robots by the year 2025. Considering the significant impact of service robots on other industries, as well as on the social and economic welfare of an ageing society, concerted efforts are being made by multiple ministries to develop a basic common technology platform.

Service robots are expected to work directly with people and therefore high safety standards are required. Taking this into account, a special study committee established by METI has analysed institutional and regulatory barriers in conjunction with trade associations such as the Japan Robot Association. It is becoming extremely important for these organisations to cultivate relationships with foreign research institutes in order to overcome and prevent barriers caused by differing standards.

In Japan, the research priority has heavily shifted towards developing hardware rather than working within theoretical and social perspectives. However, the development of user-friendly companion robots is important and, more interdisciplinary research is vital for future service robots. There are ongoing EU funded research projects intended to explore issues in robot human interaction, which requires safe cooperative engagement.
A significant issue is related to international collaboration with foreign counterparts and what aspects of collaboration might generate technological breakthrough and the best market opportunities.

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-http://www.mhi.co.jp/news/story/0810074750.html

-http://kagakukan.toshiba.co.jp/dna/explore/en/nol/technology_con01_2_2.html

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To make sure that this report meets your needs, please may I ask for your assistance in taking part in the on-line questionnaire to give your feedback.
http://www.uknow.or.jp/be_e/science/reports/feedback/