Mobile Robots in Japan

A REPORT BY PHILLIP WHITE
DTI INTERNATIONAL TECHNOLOGY PROMOTER
This report was prepared by Phillip White, DTI International Technology Promoter for electronics and communications in Japan, following a trip to Japan. The report represents his findings and views expressed do not necessarily reflect those of DTI.

Matsushita Electric Industrial
Dr Kazuo Eda, Advanced Technology Research Laboratories, Matsushita Electric Industrial Co Ltd made a presentation on ‘Tool-Oriented Type Robots (Mechanorg)’ at the UK-Japan High Technology Industry Forum in Osaka on 25 May. He outlined the development trends and drivers for robotics in Japan and gave a concrete example with their ‘Porter Robot’. Demographics trends in Japan are leading to an increase in the number of people who are either elderly, living alone, sick or handicapped. People expect tools, such as robots, to help them realise their aims, to save time and to become self-supporting. Dr Eda sees a paradigm shift from the automatic machines and production robots to the life-assistance and partner robots. The production robots helped improve efficiency and provided power assistance but the humans had to adapt to the robots needs. The partner robots aim to provide care and act as a submissive supporter so the robot must adapt to human needs.

He characterised this new paradigm by 3As: Anshin (relief), Anzen (safety), Assist. He foresees application in the fields of Household (carry, power-assist, nursing care, agent), Public (carry, power-assist, nursing care) and Business (distribution, medical, nursing care). As chair of this session, and from experience as an engineer in the robotics industry in the 1980s, I pointed out that this contrasts with the early applications of industrial robots characterised by the 3Ks: Kitsui (hard/heavy work), Kiken (dangerous), Kitenai (dirty). Dr Eda introduced a roadmap for the development of these new robots.

Finally, Dr Eda showed a video of one robot developed by Matsushita Electric which he calls a Porter Robot. It is used to carry heavy objects and follow behind a walking human being, using its own vision system. This is a good example of a ‘tool-oriented’ robot which combines practical usefulness with the possibility of realisation in the near future (photos can be obtained by contacting Phillip White). Dr Eda coined the term Mechanorg for this combination of machine and organism. In the future, monitoring coordination and communication between various 3As type robots and service providers will become possible within the home and within public spaces.

Sony
Mr Kohtaro Sabe, Sony Intelligence Dynamics Laboratories, Inc presented a keynote speech entitled ‘Development of Entertainment Robot and Its Future’ at the IEEE Vlsi Symposium in Kyoto on 16 June. He introduced the various type of robots developed by Sony. The AIBO quadruped robot was launched in 1999 and 5,000 units were quickly sold in spite of the high price (exceeding £1,000). The QRIO humanoid robot, introduced in 2002, stands 580 mm high and weighs 6.5 kg. Its joints have 38 degrees of freedom in total, including 10 for the fingers.

Mr Sabe explained the importance of the OPEN-R standard, proposed by Sony in 1998, in enabling a modular hardware and control software architecture for their robots. This was demonstrated video showing equivalent behaviour when the two rear limbs of an AIBO were replaced by a base driven by two wheeled motors.

Current research on behaviour and pattern recognition makes use of the two CCD camera and other sensors in the QRIO together with its wireless connection to link to a PC cluster. This is used to implement a ‘behavior-based architecture’ with learning ability. This allows the researchers to verify a computational model by interaction between a robot and the real world.
The IEEE International Workshop on Safety, Security and Rescue Robotics was held in Kobe on 6-9 June.

The workshop was hosted by the International Rescue System Institute which manages the Special Project for Earthquake Disaster Mitigation in Urban Areas. This project was started by the Japanese Ministry of Education, Sports, Culture, Science and Technology in 2002 as an urban renaissance programme. The objective of this five-year project is to develop science and technologies to drastically reduce damage expected by large-scale urban earthquake disasters such as the Kobe earthquake of 1995.

A sub-project ‘Advanced Disaster Management Systems – Development of Advanced Robots and Information Systems for Disaster Response’ aims at development of robots, intelligent sensors, ubiquitous terminals, human interfaces etc, which aid emergency response such as search and rescue. It especially focuses on searching for victims, information collection and distribution.

Some of the more interesting presentations by Japanese speakers are outlined below.

Motion control of soil removal operation for a tele-operation based demining operation
This system used a ground penetrating radar to detect a mine and a robotic arm to move a soil removal scoop. The control system for the robotic arm used a ‘virtual place’ to precisely limit the depth to which the tool penetrated the soil.

Evaluation of a snake-like rescue robot ‘KOHGA’ for usability of remote control
Articulated snake-like robots are currently the favoured solution for crawling through narrow space in rubble to search for survivors. They have a camera on the front so the operator can see where the robot is going however they can get stuck somewhere between the ‘head’ and the ‘tail’. In many situations, the camera on the front, or head, is unable to view the blockage. This project team, from the University of Electro-Communications, uses a second camera on the ‘tail’ and a scorpion-like raising of the ‘tail’ to view the body of the robot and the obstruction with the tail-mounted camera.

FUMA: Environment information gathering wheeled rescue robot with one DOF arm
This robot, developed by the University of Electro-Communications, employs two cameras on a one degree of freedom arm. It can quickly navigate and survey a disaster area using a camera with a long-range of focus. If the robot encounters and obstruction or a possible victim, the arm can tilt to point a shorter-focus camera at the robot itself or the victim.
A mobile jack robot for rescue operation
Hydraulic jacks and hydraulic cutters are essential tools for rescue services. These two robots developed at Okayam University allow them to be deployed more deeply into a collapsed building or other disaster environments. What was unclear was how well the jack robot would work when it was sitting on a surface which was unstable or not perpendicular to the direction of required lift.

A study of robot mobile surveillance system using spatial temporal GIS
Surveying a scene is an important step prior to a rescue robot navigating a path through it. However, two papers by Waseda University took a different approach aimed at surveillance and security application. A wheeled follows a predefined path using GPS and an inertial navigation system. A camera and optical system mounted on top of the robot surveys 360 degrees around the robot as it moves. After completing the predefined routes, the camera data is to build a ‘point cloud’ of objects seen. This is done by triangulating to a point between successive camera frames as the robot moved.

On subsequent circuits, the robots camera can be used to detect that new objects have appeared along side the route, such as a recently parked vehicle or an intruder.
Robomec Conference and Exhibition

At this conference, 880 posters were presented indicating the wide variety of research being funded at Japanese universities on subject related to robotics, control, sensing and mechatronics. The range of topics is too broad to cover here but if any UK company seeking access to developments in robotics in Japan I would be pleased to identify contacts and R&D relevant to your specific requests.

Prof Kintomo Takakura, President, Tokyo Women's Medical University gave a keynote presentation on the Application of Robotics and Mechatronics in Medicine with videos of these devices in use.

Also there were live demonstrations of some of the robots which featured in presentations at the workshop on Safety, Security and Rescue robotics. The photographs have been included above. Further videos were taken. For details, please contact philip.white@pera.com

Aichi Expo – NEDO Practical Application Robot Project

At the Aichi Expo, Japanese companies and universities exhibited robots developed under two project funded by NEDO (the New Energy and Industrial Technology Development Organization, an Incorporated Administrative Agency of the Japanese Government):

- Practical Application Robot Project
- Prototype Robot Project
- In the Practical Application Robot Project nine types of robot have been developed focusing on five fields in the market is expected to expand by 2010. These robots were working at the Expo site in a demonstration test

- TAO Aicle, an Intelligent Wheelchair Robot developed by Aisin Seiki Co Ltd and Fujitsu Ltd
- Wakamaru, a Reception Robot developed by Mitsubishi Heavy Industries
- Actroid, a Reception Robot developed by Kokor Co Ltd, and Advanced Media, Inc
- Mujirio Ligurio, a Security Robot developed by tmsuk Co Ltd
- Guard Robo i, a Security Robot developed by Sohgo Security Services Co Ltd
- SuiPpi, a Cleaning Robot developed by Matsushita Electric Works Ltd
- Subaru Robohiter RS1, a Cleaning Robot developed by Fuji Heavy Industries Ltd
- Subaru Robohiter T1, an Garbage Can Carrying Robot developed by Fuji Heavy Industries Ltd
- PaPeRo, a ChildCare Robot developed by NEC

TAO Aicle, an Intelligent Wheelchair Robot developed by Aisin Seiki Co Ltd and Fujitsu Ltd
This wheelchair can navigate to one of a short list of preset destinations. The user selects the destination from a menu on a small display. The long pole in the photo below is the GPS antenna and the VHS cassette-sized block on the floor is the radio frequency identification (RFID) tag which is embedded in the pavement. This RFID tag cause the wheelchair to stop at crossing or the final destination until the user presses a button asking it to proceed.

This is an example of how companies are applying robotic or mechatronic technologies to assist their population.

PaPeRo, a ChildCare Robot developed by NEC
PaPeRo is equipped with face and voice recognition technology. NEC claims PaPeRo remembers people’s faces, discerns who they are and can ‘communicate’ with them verbally. PaPeRo also reacts favourably to being touched and patted. It can also communicate with a mobile phone.

Whilst promoted as a childcare robot, the robots functions are aimed at entertaining the children. Parents were encouraging their children to queue up to pat the robot and then join ‘play groups’ with one adult introducing them to the robot.
Aichi Expo – NEDO Prototype Robot Project
NEDO supported the development of 65 type of robots aimed at practical use by 2020. The 65 prototype robots exhibited were organised into eight themes. These themes give some indications of the markets anticipated.

- **Service Robot (network robotics and robot technology middleware)**
  These robots provide various services through robot technology middleware and network robotics in which multiple robots are interconnected by means of software and network communications.

- **Service Robot (robot for interaction between humans and robots)**
  Through diverse technologies including pseudo-testing and remote control operations, these robots allow one to experience the feeling of being in unknown spaces.

- **Outdoor Robot (skilled work)**
  These robots can perform complex human tasks outdoors that require skilled techniques and experience.

- **Outdoor Robot (special environment work)**
  These robots can work in special environments, in toxic atmospheres or underwater for instance, where humans cannot easily gain access.

- **Medical Welfare Robot**
  These robots are intended to prove helpful in providing medical treatment and welfare services. They are operated remotely, for instance, to perform detailed surgical procedures. They are also used to give added strength to humans and to provide nursing care.

- **Partner Robot**
  These robots not only talk to humans and interact with them, they can also talk to other robot and act with them cooperatively.

- **Performance Robot**
  These robots have special motor skills. Some can break themselves up into parts, consolidate themselves, jump around and move about in unstable locations.

- **Humanoid Robot**
  These robots are like humans in that they can walk around on two legs and can perform a variety of tasks under remote control.

Details and photographs of some specific robots follow.

**Woody – Waseda University**
This robot is designed to climb trees, cut branches and cut the trunk of a tree. A consortium including Waseda University has been working on this project since 2002. The photograph below shows the two grippers used for climbing the tree and the circular saw for cutting branches and the tree trunk. For a video file of the robot in action, please contact phillip.white@pera.com
Tele-operated robot – Tokyo University

Work at Tokyo University on tele-operated robot arms began under the ‘Humanoid Robotics Project’ and a Global Watch Mission on visited the team in 1999 to discuss work on Virtual Reality Technology and Applications. For a copy of the report from that mission, please contact philip.white@pera.com

The photograph above shows the human operator using his arms, hands and fingers to move the lightweight sensor arms. The signals from the sensor arms are used to remotely operate the robotic arms. Force feedback signals from the robot are delivered to the sensor arm so that the human operator can experience the exactly half the forces applied to the robotic arm as it grasps and lifts an object.
Phillip White is the DTI International Technology Promoter (ITP) with specific responsibility for Japan, widely recognised as one of the world’s leading investors in technology development.

Phillip’s main objective is to access technology-based opportunities in support of the UK electronics and communications industries, though he welcomes enquiries from any UK company seeking a Japanese technology partner. His hands-on experience of a whole range of engineering disciplines means that he can talk knowledgeably to companies about new technologies which could boost their competitiveness.

Phillip graduated from Cambridge University with a degree in Electronic Engineering and a postgraduate course in Production Methods and Management. He has more than 20 years’ experience in engineering, with over 16 years spent working in Japanese companies in the electronics and automotive industries. He hopes that UK companies will be eager to take advantage of his technical experience, language skills and pragmatic approach to working with Japanese companies.

He strongly believes that UK companies who simply watch developments in Japan will suddenly find themselves overtaken by a competitor. Phillip hopes UK companies will seize the opportunities provided by partnering with Japanese companies, and make him their first point of call.

Phillip White can be contacted directly by e-mail: phillip.white@pera.com

Alternatively, for further information about Global Watch Service Technology Partnering, please contact:
The ITP Helpdesk
Pera
Pera Innovation Park
Melton Mowbray
Leicestershire
LE13 0PB

T: +44 (0) 1664 501551
F: +44 (0) 1664 501261
itp@globalwatchservice.com
www.globalwatchservice.com/itp

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