Featured Articles

Robotics Solutions Opening Up New Service Markets

Atsushi Baba, Ph.D.
Tatsuhiko Kagehiro, Ph.D.
Hisahiro Koshizuka
Masahito Togami, Ph.D.
Hideya Yoshiuchi

OVERVIEW: Expectations for robotics have been increasing recently as a means of solving societal issues such as Japan's decreasing birthrate and aging population. The IoT era will see growing potential for the creation of new service markets driven by robotics technology operating in real space using various types of information and knowledge collected in cyberspace. To help promote the creation of new service businesses through collaborative creation with customers, Hitachi developed EMIEW3 (a new type of human-symbiotic robot), and a robotics IT platform that enables remote robot intelligence processes as well as remote operation monitoring and control of multiple robots in multiple locations. By drawing on these technologies and performing trials jointly with customers, Hitachi is working to create a new service robotics business, while aiming to provide digital solutions that utilize the data collected by robots.

INTRODUCTION

WORLDWIDE expectations for robotics have been growing recently, with the technology viewed as a possible solution to societal issues such as improving labor productivity. The manufacturing industry has been using industrial robots since the 1970s, and recently it has been working on productivity improvements made possible by the Internet of Things (IoT). On the other hand, with Japan's decreasing birthrate and aging population, improving labor productivity in the service industry will become an important issue.

Hitachi's history of involvement in robotics started with servo-manipulators for nuclear power applications in the 1960s. The technologies it developed have been used in widespread applications ranging from mechatronics products such as semiconductor inspection equipment and financial terminals, to robots for extreme environments such as nuclear reactors[(1)]. In Hitachi's research and development (R&D) work, cutting-edge robotics is positioned as a vehicle for technology development, with technology development covering areas such as autonomous control and intelligence processing[(2)–(4)].

Given the societal issues of the future, the state of technology development, and the outlook for growth in the robotics business, there should be opportunities for innovation in the service robotics sector, an area that can be expected to generate new markets. Hitachi has responded by developing a new type of human-symbiotic robot called Excellent Mobility and Interactive Existence as Workmate 3 (EMIEW3), and a robotics IT platform that are designed to help create a new service robotics business.

This article describes the technology development and collaborative creation with customers Hitachi is engaged in to help create the new business.

ROBOTICS SOLUTIONS FOR THE IoT ERA

The arrival of the IoT era, which promotes the connection of things to the Internet, will enable the collection of all kinds of information and knowledge in cyberspace that will be utilized to provide services through the use of robots that operate in real space (see Fig. 1).

In other words, it will become possible to provide advanced services in a timely manner by using robots as IT system interfaces to input/output data and information, and using business and facility information about areas such as products and manuals. It will also become possible to provide digital solutions by linking systems to equipment such as surveillance cameras and digital signage, and by linking acquired data to artificial intelligence (AI) applications for learning and analysis.

Hitachi's recent development work in this area has produced new robots and systems needed to create a service robotics business. The work has involved

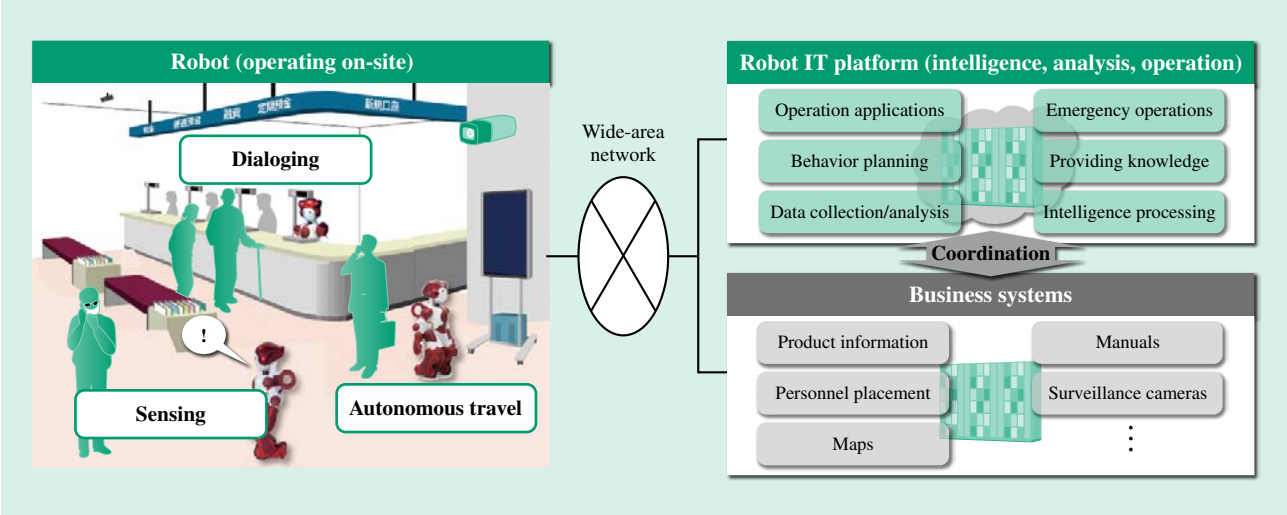


Fig. 1—Overview of the Service Robotics System.
A mobile on-site robot performs dialoging and sensing operations to provide various on-site services by coordinating with a cloud-based robot IT platform and business systems.

sharing issues with customers, creating proposals for solutions, and performing demonstration testing at customers' sites.

First, existing robots were completely renovated from the basic design to ensure stable operation and safety at customers' sites. In terms of systems, Hitachi applied a remote brain it had developed that took expandability into consideration early on and ran advanced intelligence processes such as recognition and communication outside the robot on the cloud, and then extended it to provide services that coordinate with business systems. It also developed a new robot IT platform that adds a mother brain component, which provides centralized operation monitoring and control of multiple robots in multiple locations.

Details of the development of each of these technologies and the work Hitachi is doing on creating a new service robotics business through collaborative creation with customers are described below.

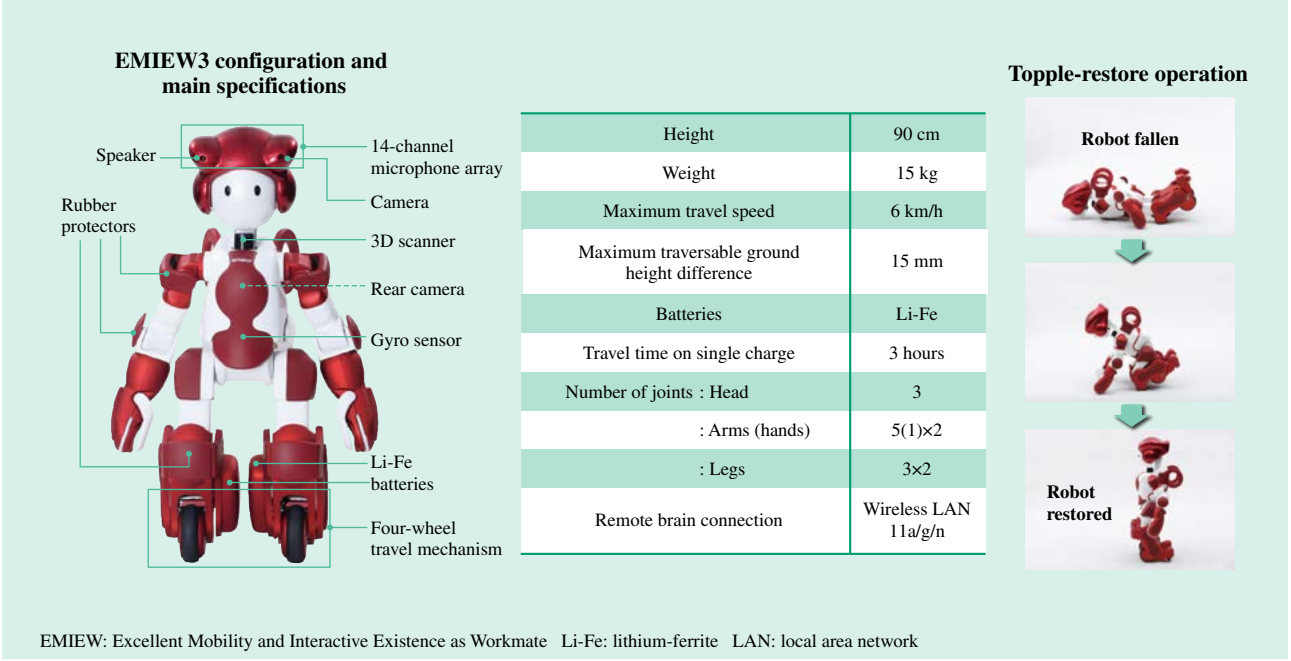
EMIEW3: Human-Symbiotic Robot

Aiming to create service robots with versatile communication skills and the ability to safely coexist with humans, Hitachi has been working on developing robots that can live with humans since EMIEW was first announced in 2005.

The first generation of EMIEW was given a small footprint and a nimble, inverted two-wheel travel mechanism to create a design with about the same height and weight as a human, being able to match the speed of human movements in the same space. It could travel stably, with the wheels driven in accordance with the body tilt as measured by a built-in gyro sensor[3]. These features enabled it to successfully complete a performance with an artist at the 2005 World Exposition, Aichi, Japan (EXPO 2005 AICHI, JAPAN) held in Aichi prefecture.

To provide practical use in offices and inherent collision safety, EMIEW2 was given a compact, lightweight body (with a height of 80 cm and a weight of 14 kg) in a remote brain configuration. Its robotic functionality was made more advanced by developing functions such as an autonomous travel function using self-generated maps, an active suspension function enabling stable and smooth travel, a posture control function that predicts outside forces about to act on the body, a hazard avoidance function that predicts the risk of humans suddenly emerging from robot blind spots, and object recognition/search functions from web- or network-linked cameras.

The latest generation (EMIEW3) is intended for use at customers' sites and was developed for safer and more stable operation than the previous generations. It has the same highly human-centric design and size as the previous generations and the same maneuverability, but has been given a more stable four-wheel travel mechanism. A topple-restore function has been developed, which uses the built-in gyro sensor to detect the robot's posture (face up, face down, or lateral) after a fall and take the corresponding restorative action to return it to a standing posture. In the rare event that EMIEW3 falls over, this function enables it to automatically stand up by itself and return to the task at hand (see Fig. 2).



Height	90 cm
Weight	15 kg
Maximum travel speed	6 km/h
Maximum traversable ground height difference	15 mm
Batteries	Li-Fe
Travel time on single charge	3 hours
Number of joints : Head	3
: Arms (hands)	5(1)×2
: Legs	3×2
Remote brain connection	Wireless LAN 11a/g/n

EMIEW: Excellent Mobility and Interactive Existence as Workmate Li-Fe: lithium-ferrite LAN: local area network

Fig. 2—Overview and Features of EMIEW3.
EMIEW3 communicates with users and provides services using devices mounted in a compact, lightweight body with a height of 90 cm, and weight of 15 kg. A topple-restore function enables the robot to stand back up by itself in the rare event that it falls.

Remote Brain: Robot Intelligence Processing System

Creating human-symbiotic service robotics will require more advanced intelligence processing such as voice, image, and language processing. Remote brain-based system configurations enable lighter robots, improved intelligence processing by drawing on a wealth of computing resources, and functions that can be expanded to coordinate with outside systems.

To be able to dialog in human environments, robots will need to recognize sounds correctly in environments containing various types of unwanted sounds such as noise and echoes. Hitachi has done previous R&D work on sound source separation technology that uses multiple microphones to remove unwanted sounds[6]. EMIEW3 runs a 14-microphone-array sound source separation application on the remote brain to emphasize and extract the voice of only the speaker addressing it, enabling voices to be recognized correctly in noise-filled environments[5]. Its remote brain configuration also enables system coordination of business information such as product catalogs and manuals. This feature enables drill-down question-and-answer flows using business information to be generated automatically to enable dialog with humans with no additional effort from the robot operator. As a result, EMIEW3 can respond to customer issues using its voice dialog function (see Fig. 3).

Coordination with outside systems is the main benefit of the remote brain configuration. This feature can be used to coordinate with surveillance cameras. For example, a forgotten watch left behind in the environment can be found automatically using image information from multiple cameras, and the mobility of EMIEW3 can be used to guide the owner to the location[4].

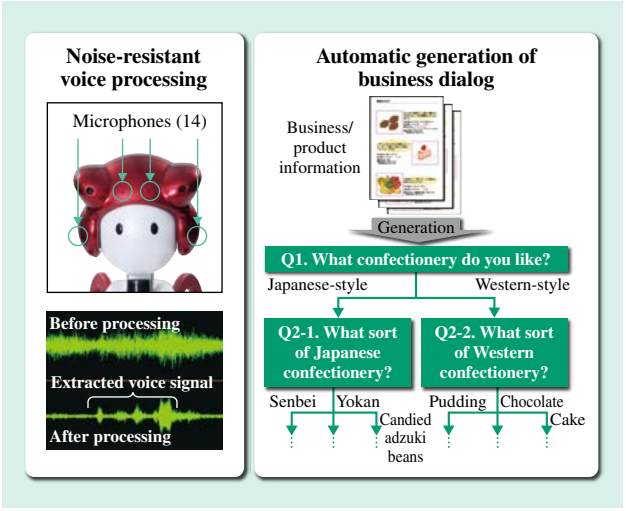


Fig. 3—Overview of EMIEW3 Communication Technology.
EMIEW3 can recognize human voices even in noise-filled environments using multiple microphones, and can automatically generate dialog flows from business/product information.

Mother Brain: Robot Operation Monitoring System.

Once EMIEW3 services have been created and made available at the facilities of customers in various industries, it becomes important to improve the robot utilization rate, maintain stable operation, and ensure the safety nearby workers. It will also be important to provide services that coordinate multiple robots. Hitachi's recent development work involves work on operation monitoring systems for centralized monitoring, control, and maintenance of multiple robots in multiple locations[7].

The benefits of using a robot operation monitoring system for device monitoring, remote operations, and data sharing are described below (see Fig. 4).

For device monitoring, there are functions that provide integrated monitoring of information gathered from robots installed in multiple locations, and from the remote brain, cameras, and sensors. For example, if a problem occurs in a robot or other devices, it can be immediately reported to an operator to enable early recovery. For remote operations, problems or emergencies that are detected by sensors or cameras can be handled by operating robots remotely from a monitoring/operation center, improving system utility through features such as recovery operations when problems occur, and functions for forced shutdown during emergencies. For data sharing, the results of services provided by robots for humans can be conveyed/shared with other robots to provide coordinated, seamless services from multiple robots.

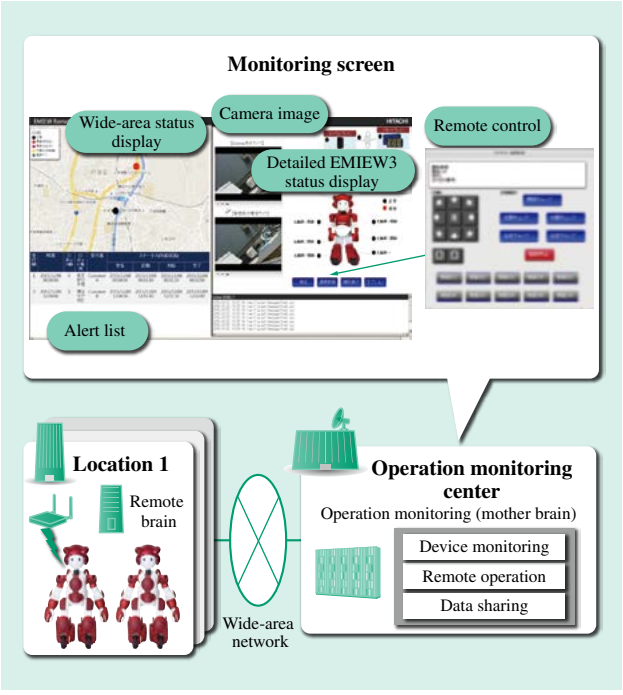


Fig. 4—Overview of the Robot Operation Monitoring System. The system collects information from multiple robots and devices in multiple locations, providing integrated monitoring. When failures occur, remote operation increases system utility.

WORK ON COLLABORATIVE CREATION WITH CUSTOMERS

To create a service robotics business, Hitachi is planning to initially use the business-to-business (B2B) format to create projects. Many customers are interested in robots, but do not understand how to use or benefit from them.

To appeal to these customers, Hitachi will use its NEXPERIENCE method to hold workshops with them to share the challenges and visions of robotics. The next step will be to consider a trial at the customer's site. To assist this process, Hitachi created the Robotics Co-Creation Room, a facility for prior verification and prototyping of robot functions in Hitachinaka, Ibaraki prefecture (see Fig. 5). The facility is equipped with EMIEW3 and an operation testing environment, enabling Hitachi researchers and customers to work on service robotics development interactively. Trials can subsequently be performed at the customer's site. This process will enable improvements to systems by incorporating the site requirements and site knowledge obtained from the results, which could eventually lead to actual service operation.

Hitachi is currently holding discussions with multiple customers who have demands in areas such as customer service, guidance, and security. They expect robots to have abilities such as multilingual dialoging, responding rapidly to new products, and providing the proper guidance for changes in site

Fig. 5—Robotics Co-Creation Room. The photo shows the new Robotics Co-Creation Room created at Hitachi's R&D location in Hitachinaka, Ibaraki prefecture. The room will be used to develop robot-driven services through collaborative creation with customers.

environments. Many customers want to use robots to expand employee abilities, enabling any employee to perform advanced operations that only experts or other select groups of employees can perform.They are very hopeful that higher sales will result if they can raise customer satisfaction by using robots to supplement their business operations. Hitachi will continue working on collaborative creation with customers to try to satisfy these expectations.

CONCLUSIONS

This article has looked at Hitachi's R&D work with respect to robotics and its future outlook.

New markets are about to emerge as worldwide advances in robots, AI, and other robotics-related technologies bring these areas closer to becoming a practical reality. Hitachi is seizing this opportunity to help expand its Social Innovation Business by providing robotics solutions for the IoT era that will help solve future societal issues.

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ABOUT THE AUTHORS

Atsushi Baba, Ph.D.
Robotics Research Department, Center for Technology Innovation – Mechanical Engineering, Research & Development Group, Hitachi, Ltd. He is currently engaged in the research and development of robotics. Dr. Baba is a member of the IEEE, and the Atomic Energy Society of Japan (AESJ).

Tatsuhiko Kagehiro, Ph.D.
Customer Co-creation Project, Global Center for Social Innovation – Tokyo, Research & Development Group, Hitachi, Ltd. He is currently engaged in the customer co-creation in the robotics and industry segment. Dr. Kagehiro is a member of the Institute of Electronics, Information and Communication Engineers (IEICE), and the Information Processing Society of Japan (IPSJ).

Hisahiro Koshizuka
Robotics Research Department, Center for Technology Innovation – Mechanical Engineering, Research & Development Group, Hitachi, Ltd. He is currently engaged in the research and development of robotics. Mr. Koshizuka is a member of the Japan Society of Mechanical Engineers (JSME).

Masahito Togami, Ph.D.
Robotics Research Department, Center for Technology Innovation – Systems Engineering, Research & Development Group, Hitachi, Ltd. He is currently engaged in the research and development of intelligent processing in robots. Dr. Togami is a member of the IEEE, the Japanese Society for Artificial Intelligence (JSAI), the Acoustical Society of Japan (ASJ), and the IEICE.

Hideya Yoshiuchi
Network Research Department, Center for Technology Innovation – Information and Telecommunications, Research & Development Group, Hitachi, Ltd. He is currently engaged in the research and development of operation and management systems for multiple-type service robots. Mr. Yoshiuchi is a member of the IEEE, and the IPSJ.