TOSHIBA REVIEW
2004. VOL.59 NO.9

Special Reports

Home Robot Technologies

Realizing Symbiotic Integration of Robots into People's Lives and Society
EGUSA Shun

Trends in Development of Home Robots Leading Advanced Technologies
MATSUHIRA Nobuto / OGAWA Hideki
In recent years, research and development of robots for use in people's daily lives has been actively pursued in addition to robots for special and industrial environments. Robots are easily constructed nowadays thanks to the accumulation of basic robot technology (RT). With various mechatronic applications being increasingly incorporated into RT, many personal robots and home robots have been introduced in various fields for roles such as security, nursing care, and housekeeping.

A new market for home robots is expected to appear accompanying the advancement of basic RT. Furthermore, an open strategy for robots is being widely planned so as to create a common infrastructure for robots, not limited to home applications. Rather than the conventional approach of individual companies making robots independently, they will be developed through the modularization of basic RT and the standardization of interface and communication protocols. New robot markets can be expected by applying various business models in an open robot architecture environment.

Toward Expansion of Robot Industry Market and Creation of New Robot Business
TANIE Kazuo
To enhance industrial competitiveness and solve various issues in the future elderly-dominated society, a number of efforts have been made to develop daily life service robots to support elderly people and to expand the robot business from manufacturing applications to nonmanufacturing applications. Users' requirements for daily life service robots will be much more complex than those for robots used in manufacturing applications. It will therefore be especially important to implement market-driven R&D, and to create a new industrial structure in which the appropriate product can be provided to each customer according to that customer's specifications.

With this in mind, a new industrial structure based on custom-made robot business supported by open modularized robot component technology was proposed as a suitable future structure for the robot industry.

Designing Home Robots
WADA Tatsuya
Robots have already become entrenched in factories and other settings in various industrial fields. Next will be the turn of home robots, whose deployment in people's homes will begin soon. Although we tend to picture home robots as humanoids, it is necessary to take the ideal future home into consideration when designing them. Only after specifying what is truly needed in the home can we design home robots that are appropriate for the home environment.

In 2003, we had an opportunity to do research whose title is "Design of Home Robot that strikes sympathetic chord at home in 2010." This was a joint research of Toshiba Corporate Research & Development Center and Tama Art University Product Design Course. We are planning to expand the research with a viewpoint of Universal Design.

Open Robot Controller Architecture (ORCA), the Robot Platform
OZAKI Fumio / HASHIMOTO Hideaki
Toshiba has proposed the open robot controller architecture (ORCA) based on the robot technology (RT) reference model proposed by Toshiba, so as to allow RT components to be easily packaged. Many technologies are necessary to develop a home robot that acts in response to its environment. A framework is required that can integrate reusable components for which various companies and individuals contribute their technologies. ORCA is such a framework. ORCA uses distributed object technology to enable such components to be used transparently anywhere via the network. We have developed motion control boards that are compatible with the ORCA architecture. ORCA supports the packaging of robot technologies into components, not only as software but also as hardware.

Locomotion Control System for Home Robots
YOSHIMI Takashi / NAKAMOTO Hideichi / YAMAMOTO Daisuke
In order to work as a moving type service robot providing such services as coming to a user's place, patrolling inside a house, etc., a home robot needs basic movement functions so as to recognize its self-position and go to a specified place while avoiding obstacles.

Toshiba has developed some advanced modules for locomotion control of the ApriAlpha$_{TM}$ robotic information home appliance, to realize these basic movement functions. The locomotion control system of AprIAlpha$_{TM}$ consists of the modules of path planning, route and trajectory generation, trajectory tracking control, obstacle avoidance control using ultrasonic sensors, and self-position recognition. The constructed locomotion control system enables the robot to move to the desired point smoothly.

High-Speed Computer Vision System for Robots
OKADA Ryuzo / OAKI Junji / KONDOH Nobuhiro
Visual information is important for robots working in complicated environments such as homes or offices. Conventional vision systems have used a National Television System Committee (NTSC) video image sequence that is standardized for watching image sequences. However, the NTSC video image sequence, whose frame rate is 30 frames per second, is insufficient for recognizing fast-moving objects such as swift gestures or abrupt intruders.

Toshiba has developed an active camera system that is capable of tracking a fast-moving object by using an image sequence with a high frame rate of 1,000 frames per second. This system achieves outstanding tracking performance even in ordinary home and office environments.

Face Recognition Technology for Home Robot
KOGA Toshiyuki / SUZUKI Kaoru / YAMAGUCHI Osamu
A robot used in the home environment should be able to offer convenient and appropriate services adaptively to each user. It is therefore important for a home robot to be capable of discriminating between family members and other people. Face recognition technology is effective for this purpose.

Toshiba is researching a system on an experimental platform that incorporates a face recognition technology used for the FacePass$_{TM}$ face recognition security system. Conventional face recognition identifies a single person within a fixed distance. We have improved the resolution pyramid and face tracking method to enable the system to simultaneously recognize two or more people over a wide range of distances. The results of experiments have verified that our system simultaneously recognizes people at distances from 0.3 to 2 m.

Sound Spot Forming Technology for Robotic Home
MIZOGUCHI Hiroshi
One of the ultimate forms of home robot is the "robotic home," a system in which a room or house itself is a robot. Pioneering projects in this field include the Robotic Room of the University of Tokyo, the Aware Home of the Georgia Institute of Technology, and Home_*n* of the Massachusetts Institute of Technology.

The author and his colleagues are working on sound spot forming by a speaker array as a novel hands-free human interface applicable to such environmental systems. A sound spot is a small area of higher sound pressure level. A huge speaker array system of 128 loudspeakers was constructed and an experiment was conducted using this system. The results of the experiment demonstrated that the number of sound spots is not limited to one, but that four spots of different sound contents can be simultaneously formed. This paper describes the constructed speaker array and the experiment.

Microphone Array Technique for Speech Recognition
AMADA Tadashi / KANAZAWA Hiroshi
Speech recognition techniques in the real world suffer from the problem of environmental noise degrading speech recognition rates. Toshiba is developing a noise reduction technique that involves using a microphone array with two microphones for the speech recognition front end. This is able to enhance target speech coming from a predefined direction range and reduce signals coming from other directions. We have also developed a new 2-channel spectral subtraction method in order to reduce diffuse noise such as background noise.

Agent Enabling Robots to Join Ubiquitous World
UENO Kouji / HASEGAWA Tetsuo / OHSUGA Akihiko
When cooperation between robots and ubiquitous devices such as PCs, electronic home appliances, and sensors is made possible, robots become able to handle various tasks by means of the ubiquitous world.

Toshiba has developed Flipcast$_{TM}$, an original lightweight agent technology, which permits flexible cooperation between robots and ubiquitous devices. Using Flipcast$_{TM}$, a robot can carry out tasks through cooperation with other devices, even when the given task is too difficult for it to execute by itself. The capabilities of robots can therefore be dramatically improved by taking advantage of the ubiquitous world.

Framework for Cooperation between Networked Appliances and Home Robot
MORIOKA Yasuhiro / AIZU Hiroyuki / TAJIKA Yosuke
With the rapid progress of information technology in the field of consumer electronics, cooperation between a home robot and networked appliances is considered to be a key technology for enhancing the capabilities of home robots. However, numerous communication protocols for home networks have already been proposed and implemented in various products, and it is too difficult for a home robot to support all of these protocols used in all home appliances.

Toshiba has proposed a new framework for cooperation between a home robot and networked appliances. Within this framework, all of the protocols used in the home appliances concerned are combined and structured with UPnP^{TM} technology. All features of the original protocols are provided via the interface of the framework. We have built an experimental model and confirmed the efficiency of our framework.

Vacuum Cleaner Robot Operated in Conjunction with 3G Cellular Phone
IIZAKA Hitoshi / YOSHIDA Toshiyuki
A vacuum cleaner robot that automatically moves around and cleans a room has already been commercialized. However, consumers have high expectations regarding the usefulness of such a robot in the home, and it has not reached the level of consumer acceptance in terms of both functionality and price.

Toshiba TEC Corp. is working on the robotization of a vacuum cleaner based on the company's many years of accumulated achievements and experience in vacuum cleaner development. We are also developing new services making use of the vacuum cleaner robot's mobility. A monitoring function and an alarm function can be realized by operating the robot in conjunction with a third-generation (3G) cellular phone with TV phone capability. This is expected to further expand the market for vacuum cleaner robots.

Feature Articles

TW-80TA Home Laundry
NISHIMURA Hiroshi / KAWABATA Shinichiro
Market demand for washing machines with a drying function has been growing in recent years. Sales more than doubled from about 150,000 units in 2000 to about 380,000 units in 2001, and the figure for 2003 is expected to reach about 650,000 units. With these circumstances as a background, Toshiba HA Products Co., Ltd. (THP) launched the TW-V8630 top-loading washer dryer with a horizontal-axis drum on the market in 2003, following its introduction of front-loading and vertical-axis washer dryer models. This made THP the only company in the industry with a lineup of all types of washer dryers.

THP has now developed the TW-80TA model as the successor to the TW-V8630 top-loading washer dryer. Among the features of the new model are enhanced drying performance, lower noise, easier operation, and improved energy saving.

Application Product of Visible Light Reactive Photocatalyst
MATSUDA Ryotaro / SAITO Akiko / ISHIZAKI Ariyoshi
The titanium oxide photocatalyst is attracting considerable attention as a new substance to enhance environmental purification technology. Following the recent development of a visible light reactive photocatalyst, its applications have been widely researched.

Toshiba Lighting & Technology Corp. verified the effect of this photocatalyst using 400-430 nm light and applied it to fluorescent lamps and various luminaires. We then measured the deodorizing ability of these lighting products and found that they were more effective than the conventional products. These lighting products incorporating a catalyst are expected to play a role as environmentally conscious products (ECPs) because they not only produce light but also deodorize and purify room air while consuming no additional energy for these functions.

High-Performance Internal Antenna for Handsets - Rotationally Symmetric Current Planar Antenna
MIZOGUCHI Satoshi / SUZUKI Hiromichi / AMANO Takashi
In this paper, Toshiba proposes a novel rotationally symmetric current planar antenna with suppression of radiation toward the operator, for use in handsets. We use dipole antennas with balanced feed basically to reduce unbalanced current on the printed circuit board ground (PCB-GND), and parasitic elements in the same plane to obtain rotationally symmetric current. The performance of the antenna in free space was calculated by the method of moments (MoM). The current distribution calculated by MoM was used to elucidate the effect of suppression of radiation toward the operator. The performance of the antenna at the talking position was calculated by the finite difference time domain (FDTD) method. Measurements were carried out to confirm the calculations. The calculation results showed that this antenna has higher radiation efficiency at the talking position that the conventional monopole antenna.

Frontiers of Research & Development

Optical Design Simulation for Products and Devices
Home Network Technology Seamlessly Fusing PCs and AV Devices