Cleaning and tidying technology
for home-assistant robots

1. Overview

The Information and Robot Technology (IRT) Research Initiative at the University of Tokyo has developed technology that allows home-assistant robots to perform cleaning and tidying tasks in the home environment. This will be a core technology for domestic and nursing-support robots in Japan's shrinking and aging society.

2. Details

Since 2006, the University of Tokyo, Toyota Motors Corp., Olympus Corp., Sega Corp., Toppan Printing Co. Ltd., Fujitsu Laboratories Ltd., Panasonic Corp., and Mitsubishi Heavy Industries Ltd. have been participating in the planning of the "Special Coordination Funds for Promoting Science and Technology " project, supported by science and technology incentive funds offered by the Ministry of Education, Culture, Sports, Science and Technology (MEXT). This has also involved cooperating in a project entitled, "IRT Foundation to Support Man and Aging Society" The project is directed by University of Tokyo President Komiyama, and conducts R&D with the goal of producing major innovations in the next 10 to 20 years. The University of Tokyo, IRT Research Initiative, which is the main proponent of this project, has developed technology allowing home-assistant robots to perform cleaning and tidying tasks that can be used to support domestic and nursing care in the home.

Japan is relatively advanced in these issues, and its aging and shrinking population is becoming an issue for the whole society, including not only the generation in need of nursing care, but also those about to retire, and those of working age through to children. In an aging and shrinking society, there are many causes for concern, such as labor shortages due to declining numbers of workers, increasing health concerns and social security costs due to increasing numbers of elderly people, an increasing domestic workload due to more single-person and elderly households, and an increasing nursing-care workload as the number of people requiring it increase. The use of robots can play a major role in addressing these types of concerns.

Creation of "New industries in support of people and society" through a joining of universities with industry holds great promise to help bring robots into practical use even one day earlier. By integrating Information and Robot Technologies (IRT) with the Social Sciences, the " IRT Foundation to Support Man and Aging Society " project will create new innovation to support people and society and help Japan maintain its level of prosperity in light of an aging and shrinking population. Its goal is to produce leading-edge, joint creations and new industries through equal industry-academic cooperation, to follow after automobile and computer industries. This innovation will become a part of the lifestyle and even the culture of Japan, as a leader in these issues, and may be able to set precedents for other countries experiencing the same issues.

Two important aspects of using IRT-style robots in an aging and shrinking society are that the robot and the person become familiar and attached to each other within the household or other environment, and that information from the real and cyber-world environments can be used more proactively. The technology we are announcing here is one of the core scientific technologies for this process, allowing robots to use the ordinary tools and utensils that we have in a household to help with domestic and caring activities.

In everyday life, human beings use many types of appliances and tools to perform household tasks; obviously, such objects are designed for human use. The IRT project has developed a robot that is capable of cleaning and tidying up rooms. Our robot can perform other routine tasks such as (1) carrying a tray from a table to the kitchen, (2) gathering clothes from rooms and putting them into a washing machine, and (3) cleaning the floor with a broom. We have also developed the technology necessary for a single robot to perform each of these tasks in succession. The home-assistant robot that we are announcing at this time has been a platform for developing and providing proof-of-concept for the various technical elements and the design of eventual robot products will incorporate changes based on further study of the needs of society, and society's acceptance of such a robot.

○ Characteristics of recognition and behavior system used for performing daily tasks

(1) Recognition

Home assistant robots use cameras and LRFs (laser range finders) as sensors. Our robot can perform object recognition using such sensors. It is capable of recognizing objects such as trays, chairs, and washing machines by matching the image data obtained using the sensors with stored 3D geometric models. The recognition result provides object pose information to the robot; the robot uses this information when handling these objects. This approach enables the robot to recognize appliances and tools even if they do not have textures on their surface. In addition, although it had previously been difficult for robots to recognize flexible objects as clothes, we have developed a method for extracting and learning features such as wrinkles on clothes from images. This enables the robot to search for clothes that need to be washed.

(2) Behavior generation

We develop a motion generation system based on 3D geometric models. Appliances, tools, and the robot are modeled as 3D solid shapes with handling points on their surfaces. This approach can be used when the robot recognizes a target object by means of external sensing, as described in section (1) The robot's behavior is generated from this result. Although this process may cause some errors in recognition and robot motion, our approach allows re-planning so that errors can be avoided. This motion generation also includes self-collision avoidance and angle limits avoidance.

(3) Finding failures and generating recovery behaviors

Human beings always use their senses for observing the conditions when handling a target object. It is necessary for home assistant robots to have a similar ability. In particular, such robots should not give up when several tasks are to be performed sequentially. Vision sensors, force sensors, and pose comparison between the planned state and present state are used to judge failure conditions. For example, during the execution of some task, the following steps may be performed: (1) target clothes are picked up, (2) a button on the washing machine is pushed, and (3) a broom is held in the correct position. If failures are observed, the robot recognizes the failure condition, generates a new behavior plan, and attempts to perform the task again. This ability enables our robot to perform several daily tasks sequentially.

○Hardware configuration of the IRT home assistant robot
・Dual arms (7 DOFs in each arm) and a waist joint
・Three fingers (2 DOFs in each finger) are mounted on each arm
・PWS-type wheelbase to move freely in a room
・External sensors such as a stereo camera, LRFs (laser range finders), and force sensors

3．Contact Information

(1)作業開始

(2)トレイ運搬

(3)トレイ運搬

(4)衣類発見・掴み上げ

(5)洗濯機ボタン押し

(6)ドア閉め

(7)イスどかし

(8)テーブル下掃除

(9)両手掃除