Towards Real Robot Service Application that We Can Use Everyday

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I. Introduction

This paper presents our on-going projects towards the PR2 robot working in a large-scale environment for a long-time period, such as buying sandwiches(Fig.5) at a local restaurant and deliver documents across offices and floors(Fig.4) in everyday life. Compare with the robot system that we have been developed for house-holding tasks[1], robot system that working in such circumstances to requires 1) robust task execution mechanism with fail recovery that easily describe task application and online behavior adaptation features, 2) spatically and temporary large-scale knowledge database that can be utilized as a long-term memory and experience of the robot, 3) friendly and intuitive user-interface that users are able to command, modify and evaluate the application task on-the-fly. We briefly presents these issues that we have been tackling along with real robot experiments. These efforts are getting us one step closer to a real robot service application that we ourselves would like to use everyday.

II. Task Execution System for Inter-floor Navigation

This section describes an overview of the autonomous inter-floor navigation system shown in the Fig.1, which is the basis of our large-scale environment task execution. The system consists of one state-machine based task execution system and three knowledge framework: building, elevator and call button. Each knowledge framework has information for perception and execution as shown in the figure. Fig.2 shows the detail of task execution system. Basically the task is the sequence of navigation and manipulation and each manipulation consists of search, recognize, move, verify. In the pushing elevator button example, the robot navigate to the button front position, look at the button, and localize them, execute the push button motion, and check if the button led by using color information.

We have been tackling two issues in this area. One is online behavior adaptation mechanism that robot learns parameters of each perception and motion in order to maximize the success rate of entire action. The key idea behind this is follows: As a system glows and task becomes more complex, finding the cause of the task failure becomes more difficult since each perception and motion has parameters and these affects each another implicitly. Thus, our idea is, instead of tuning parameters of each perception and motion modules, try to find the set of the parameters that maximize of the success rate of the entire action, such as “ push button ” from numerous realworld trials. Fig.3 shows an example of

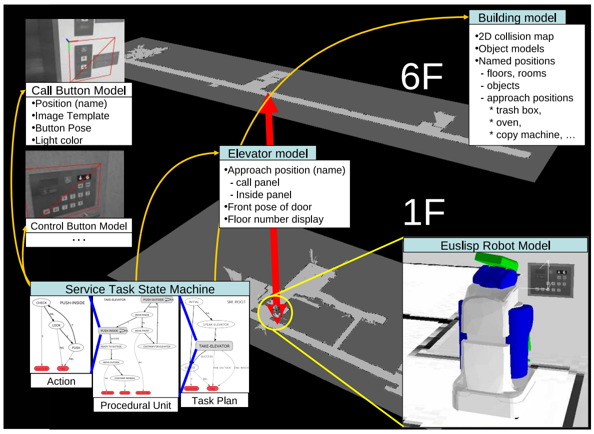

Fig. 1. Overview of the autonomous inter-floor navigation system.

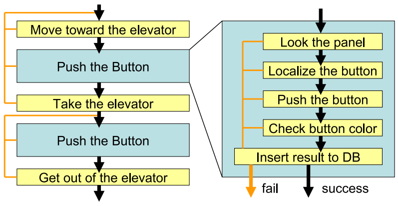

Fig. 2. Example of task execution system of the button push behavior in the inter-floor navigation module

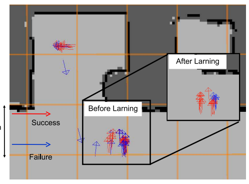

Fig. 3. Overview of the autonomous inter-floor navigation framework.

this learning scheme. In this example, the system find the goal position of the navigation modules after 52 times trials and the success rate increases from 54% to 64 %.

Another issue is automated generation of state-machine code from high-level task planning description so that service application designers are easily add or remove tasks. Our aim is to generate state machine as described in Fig.2 from PDDL description set such as `move`, `push`. States such as `look`, `localize`, `check` and transition including failure recovery motions will automatically generated by the proposed system. We have just started feasibility study of this issue.

From the implementation point of view, inter-floor navigation system is implemented as an action server on the top of the default `move_base_node` navigation system and provides the same interface as normal `move_base_simple` action message. Thus uses simply run inter-floor navigation system(`elevator_move_base_pr2`) and send the same messasge to the `elevator_move_base_simple/goal`.

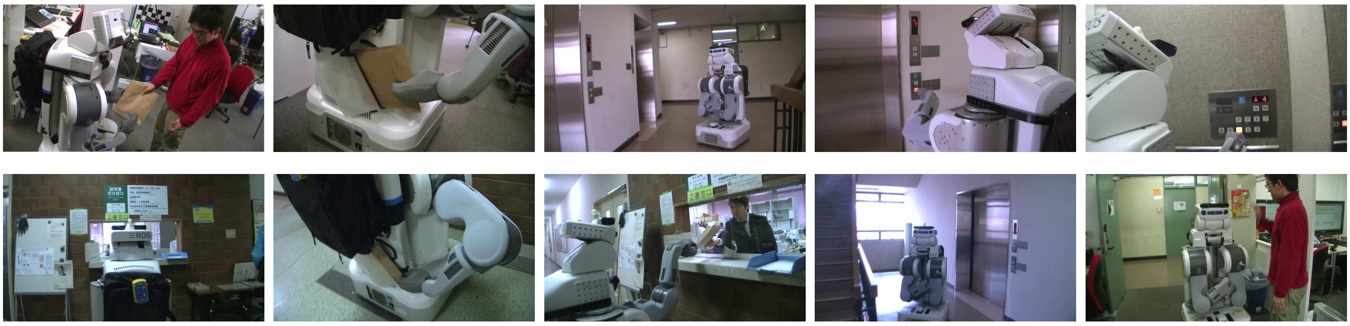

Fig. 4. Robot Service Application Experiment 2 : Deliver documents from 6F to 1F

Fig. 5. Robot Service Application Experiment 2 : Bying sandwiches at a local restaura

III. LARGE-SCALE KNOWLEDGE DATABASE

The robot works in large-scale environment for a long-time period requires both spatially and temporary large-scale knowledge database. Fig.6 shows our attempt to transfer JSK's static knowledge environment (`jsk_maps` of the top of the figure) of the whole building into TUM's semantic knowledge system (knowrob:`json_prolog` of the top right) and main task program (`Find-and-Pick-a-cup task` of the middle right) send query to the knowrob to determine the navigation goal or perception target through extending representations and reasoning method for multi-level building and object search strategies to prune the search space[2]. This experiment shows that both our system and knowrob system are able to cope with large-scale indoor environment.

The robot that works long-term periods is also able to utilize his/her experience as knowledge of future execution of the tasks. For example, the system described in the previous section stores all behavior results into the database and utilized for the learning.

IV. VIEW-TOUCH INTERFACE FOR ON-SITE TASK EXECUTION

User interaface becomes essentially important for a robot that works everyday. These interface must provide intuitive interface to uses as well as generate complex tasks while percepting dynamic environment. In this paper, we present our user interface that powered by 3d point cloud perception and motion planning functions. Bottom Left of Fig.6 shows overview of the interface. Users command on 2-D view image coordinates on the iPad interface is transferred to 3D point and normal information using point cloud data, and these information is passed to the motion planning package as a goal of the arm navigation. Resulting arm motion sequence is sent to the robot hardware through body controllers. This interface is also utilized for displaying knowledge databse to users.

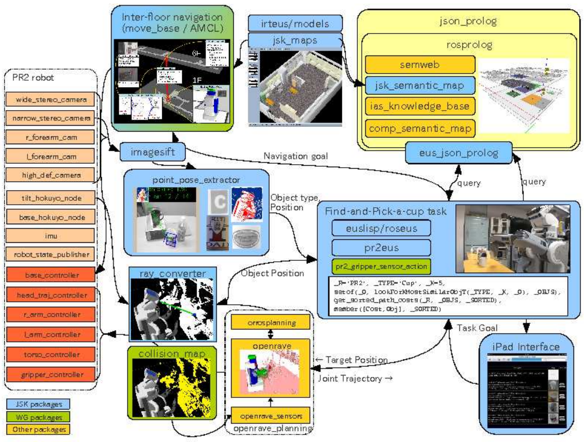

Fig. 6. Overview of the autonomous inter-floor navigation framework.

V. CONCLUSION AND OTHER WORKS

This paper presents our on-going projet with PR2 robot toward realizing robot service application that we ourselves would like to use everyday.

We have designed COLLADA basead standard robot file formats and developed importer/exporter for software tools such as ROS,OpenRAVE,OpanHRP and so on.

In our first semester starting April we started teaching a class on ROS, OpenRTM, OpenHRP, and OpenRAVE. In the second semester, we will tackle the difficulties in getting the PR2 and a humanoid robot to cooperate together.

REFERENCES

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[2] L. Kunze, M. Beetz, M. Saito, H. Chen, K. Okada, and M. Inaba, "Knowledge-based object search in large-scale indoor environments," in *IROS 2011 Workshop: Active Semantic Perception and Object Search in the Real World*, 2011, submitted.