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The development of a service robot for restaurant serving and guidance

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Abstract: A serving robot has been developed for use in a restaurant environment. Various conventional technologies were drawn from the fields of control, navigation, software interface design and artificial intelligence and adapted for commercialization in its development. This paper introduces the developmental process towards commercialization of such a product. As a result, we successfully developed various technologies for commercialization by implementing a system that abstracts the interface between the robot mainframe and the external systems.

1. INTRODUCTION

The serving robot recently developed builds on a layer of commercially adapted technologies already featuring in both a cleaning and a security robot. However, the serving robot requires additional peripherals and higher level functions that enable complex interaction with its environment and its users. This includes being able to navigate in a dynamic environment, manipulation of specific objects within that environment and unstructured interactions with its users.

The technical issues required to satisfy the afore-mentioned needs above are as follows: (a) Recognition and identification of features and users in the external environment (b) The ability to follow a user (c) A convenient interface for human-robot aural communication (d) Navigation algorithms for path planning in a dynamic and cluttered environment. (e) Internet connectivity for quietly and promptly addressing a user's needs. (f) Automatic re-charging of its power supply given utilizing specialized localization techniques (g) Technology that reorganize the contents using CRM(Customer Relation Management) database (h) Inter-robot communication technologies (i) Mobile phone connectivity for robot control.

This paper describes the method of integrating and adapting these technologies in a commercial product.

2. System Configuration

Fig.1 illustrates the developed robot for serving in a restaurant environment. It is named Galaxy. The design concept of this robot is intended to provide a feeling of familiarity and comfort for the customer. The primary distinguishing features for the robot includes: 6 DOF arms to deliver beverages, two microphones to recognize and localize the direction of a user's voice, a camera equipped to enable user recognition and implement a user following ability and finally, a wheel driven platform adapted for movement around a cluttered restaurant or store.

The wheel driven platform integrates a single IR scanner and ultrasonic sensors that are attached to the front and the side to rapidly detect a variety of obstacles and people in wide area. Bumper sensors are also utilized to minimize the effects of impacts if they should occur. Nevertheless, navigation in a large and possibly complicated environment, with a minimal array of sensors remains a complex problem. Additionally, we attached an IR localizer on the top of this robot to assist in solving this problem.

Currently, many robots use multiple CPUs to increase the computing performance. However, to remain a cost-effective implementation, this robot utilizes a single CPU to drive the various hardware and software components.

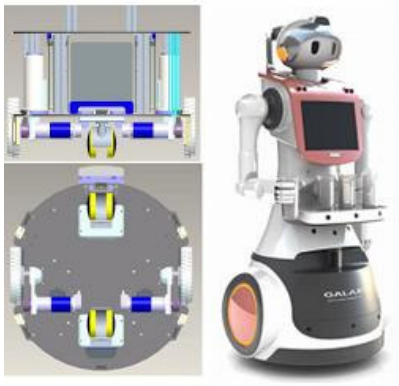

Fig. 1 The appearance of serving robot

These components are abstracted and implemented as individual engines that are all managed by a central

application. To conveniently co-ordinate the control of each of these interfaces, the RSSP (Robot Software Service Protocol) was developed.

2. Main Technology

2.1 Navigation

Conventional localization technologies have several weak points that limit their capabilities in real environments. They are often very sensitive to changes in the environment, require a high processing load (particularly with a camera) and often quite low performance even with information fusion techniques.

This robot can get the distance, the direction and the heading angle to each landmark through the IR cameras (Fig.2). Each landmark has a specific pattern and is placed on the ceiling. This landmark information is used in conjunction with wheel encoder information to update robot and landmark positions. This enables a grid map of the environment to be generated in real time. If user commands the robot to move, the robot subsequently plans an appropriate path and moves to the target using this grid map.

Fig. 2 Sensor and method for localization

Whenever the robot is idle, the robot attempts to recharge and wait for customer at the charging station (Fig.3).

Fig. 3 Recharge attempt for idle time

2.2 Robot Service Platform

The RSP (Robot Service Platform) is a server system that interfaces the robot wirelessly with a POS(Point of Sale) system. RSP enables the robot to communicate quickly and quietly with the POS database, service contents and middleware in real time(Fig.4).

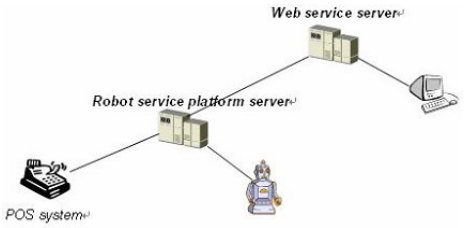

Fig. 4 Robot Service Architecture

The robot middleware is the core module for interaction between applications and service engines. The middleware manages the service engines in the robot, that is, it receives a request from the various applications and passes along the specific tasks required to fulfil the request to the various service engines (Fig.5).

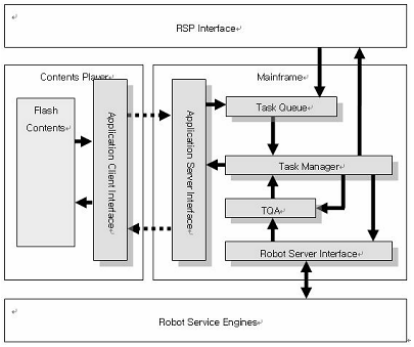

Fig. 5 Robot middle structure

2.3 Arm Architecture

This robot possesses 2 arms of 5 axes and 1 gripper. The robot uses each arm to interact with user and to deliver beverages.

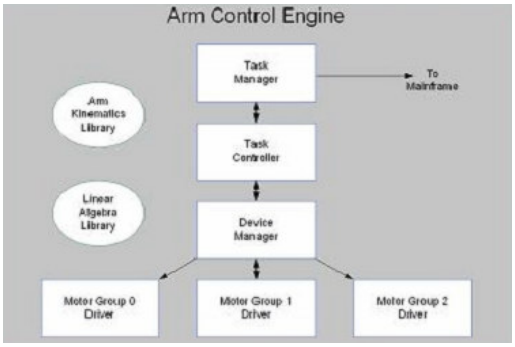

Fig. 6 Arm control engine

The ACE (Arm Control Engine) defines such motions as waving, pointing, picking up the cup as tasks through the use of task templates. These tasks can be requested by the RSP and ACE manages the processes and controllers required to carry out the task (Fig.6).

6. CONCLUSIONS

This serving robot platform enables restaurant serving functionalities and also develops technologies that provide and enhance navigation techniques in complex environments. In doing so, we have adopted various technologies for commercialisation by implementing a system that abstracts the interface between the robot mainframe and the external systems.

In the future, this robot will feature additional functionalities that will assist it in providing services in a wider range of service-style environments. It is predicted that this will encourage and diversify the demand for such a robot.