Plasma-MK
Team Description for RoboCup@Home 2010

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Abstract. Our robotics group has been participating in RoboCup for many years, mainly in two leagues: RoboCup Soccer Small Size League and Robocup Rescue Robot League. We won the first place in both leagues in 2008 and we have a strong interest in participating in the RoboCup 2010 @Home League Competition. As a team with experiences in robot vision, motion control, artificial intelligent, we believe that we can integrate human-machine interface to follow the objectives of RoboCup @Home League and provide interesting housekeeper robot issues to the league. This paper describes the currently developed and our approach of Plasma-MK robot maid team. We present an overview for the entire system: hardware and software.

1. Introduction

Plasma-MK is a new robot maid team from Engineering Innovator Club, Faculty of Engineering, Chulalongkorn University[1], Thailand. Plasma-MK was formed in August 2008. Our main goal is to develop a housekeeper robot to participate in international robotics competition and to be a motivation for youth in Thailand. Through the participation in this competition, the team can share knowledge with other research groups, and test the ability of developed technologies. We first present our robot in our university's exhibition. We have been experimenting and developing many parts of our system for better performance to join the World RoboCup 2010.

This will be the first time for Plasma-MK team on participating in RoboCup@Home League. Even though we are new to this competition, we believe that our knowledge from previous competitions can significantly help us.

2. Team's Areas of Interest and Experience

Our participation in previous RoboCup (both Small Size League and Rescue League) gives us lots of experience in mobile robot and robot vision. From the previous year, we have joined force with graduate level robotic research laboratory, Intelligent System Laboratory 2 [2]. By this, we have gained access to extensive knowledge and resource in localization and mapping, path planning, computer vision, grasping and manipulation. We are especially interested in SLAM and grasping.

3. Robot Design

The overall design concept focuses on ease of control, neat appearance and flexibility of adjusting to surrounding environment. This design consists of Hardware Architecture and Software Architecture. Hardware Architecture describes the robot's specification and all peripheral devices attached to the robot. This includes a robot base, cameras, robotics arm, etc. Software Architecture describes our design of software component and communication channel between components. The software are responsible for several tasks such as map generation, navigation, human detection and recognition, voice recognition, speech synthesis, manipulation and robot's strategy.

3.1 Hardware Architecture

The robot's is built upon commercial mobile robotic platform. Main design concept emphasize on minimal overall weight and on-the-field adjustable of components.

3.1.1 Specification

The robot's dimension is fit to work in general scenery. Its height can be varied to be approximately 1 to 2 feet from standard table height. The height can be manually adjusted on the field. We use PIONEER P3-DX as the robot's base with its 44cm x 38cm top workspace. The robot is extended vertically by aluminum profile. Peripheral devices are attached to the aluminum profile. We also include adjustable height horizontal platform for arm and laser scanner placement.

Total weight, including all devices and battery, is 40 kg with 16.5cm diameter drive wheels. Each wheel is driven by motor using 38.3:1 gear ratios containing 500-tick encoders. This differential drive platform is highly holonomic and can rotate in place by moving both wheels, or it can swing around a stationery wheel in a circle of 32cm radius. A rear caster balances the robot. The robot can move at speeds of 1.6 mps. We increase the stability of P3-DX attaching additional casters to the base.

Figure 1: Robot with prototype structure which will be replaced by aluminum profile.

3.1.2 Device

Robot moves with P3-DX base attach with devices. All devices are connected to notebooks on the robot to sense environment and response back to scene. There are 6 devices listed below:

Computer

P3-DX includes on-board PC104, we also include additional laptop PCs for faster processing of input from devices and also navigation and top level control. The additional laptop also serves as display and sound output.

Laser ranger finder

HOKUYO URG-04LX, with 20 to 4000 mm range and 240 degree of scanning area. The laser, which located near the wheel and the floor, provides information of room's obstacles such as walls, tables, chairs. This information is used by the navigator module.

Pan-Tilt-Zoom Camera

We use Pan-Tilt-Zoom canon VC-C4 communication camera, with its 16x zoom , center mounted for a smoother pan/tilt and reduced vibration; 460TVL of resolution; height of 3.5", and weight of 1 lb. range of 340 degrees and a tilt range of +10 degrees/-90 degrees. The camera is located at the head of the robot as the eyes to see the environment around. Images from PTZ camera is used by human and object tracker.

Robotic arm

We plan to incorporate Neuronics AG Katana Arm with 5-6 degrees of freedom and 517 mm operation space. Currently, this arm is under procurement process.

Figure 2: Katana Arm

Microphone & Speaker

The robot uses a wireless microphone in order to receive command from user's voice. Voice response from the robot is done via external speaker attached to the aluminum profile.

3.2 Software Architecture

Our software is divided into 3 layers: Input layer, Strategic layer, and Output layer. Each layer consists of several modules as shown in figure 3. The input and strategic layer is placed inside one laptop PC. Additional PC are used for rendering output. Each module in Input layer is separated into their own thread because of their blocking nature and high query time. Our software also includes GUI which provides us easier ways to test our robot. We implement our GUI with OpenGL and Win32 base application.

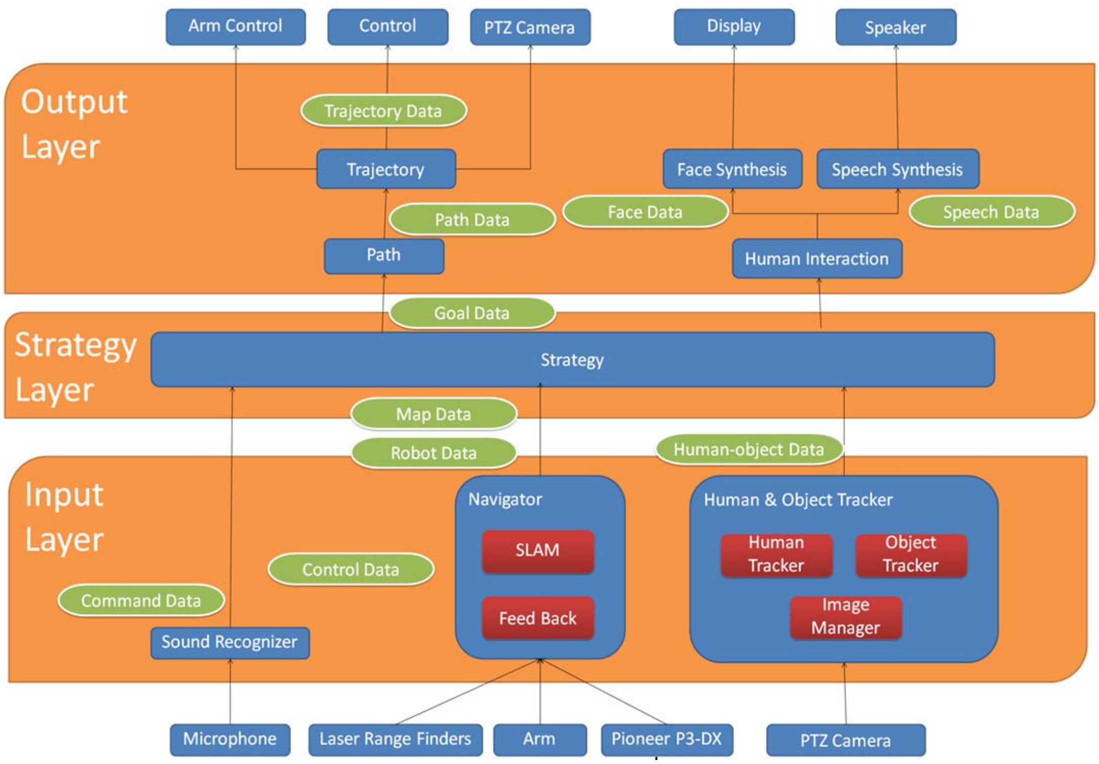

Figure 3 Software Architecture

Input layer

Our robot has the following sensors: a microphone, laser range finders, motor encoders (Pioneer P3-DX), and a PTZ camera. In each module in Input layer, raw data is read from each sensor, and then trigger a new loop of execution, and outputs are stored in their own module for the Strategic layer. The frame rates of the other two layers depend on the Navigator module which has slowest frame rate at 10 fps.

Input layer consists of three modules: Speech Recognizer, Navigator, and Human and Object Tracker. Speech recognizer module is divided in two parts, speech recognition and voice recognition. Speech recognition recognizes what is the meaning of the voice and voice recognition identifies the speaker. Speech recognition provides speech command id. Navigator module is implemented using polar matching and laser base EKF SLAM approach. The navigator module provides mapping, position and direction of the robot. Human and Object Tracker module is implemented using SIFT and Optical Flow algorithm to track and several techniques to recognize humans and objects. We mainly use OpenCV as a tool in this module because using implemented image processing algorithms in OpenCV help us implementing our algorithm faster. Human and Object Tracker module provides human id and object id.

Strategic layer

There are three modules in this layer: manager module, task module, and skill module. All modules work together. Manager, which is the top level of strategy, manages a task queue. Task is implemented as state machine to control behavior of our robot. Skill generates the appropriate commands for our robot via Output layer.

Output layer

Output layer consists of two modules: Robot Controller module and Emotion module (Display and Speak). All constrains are applied to control data from each module. Robot Controller module controls the mobility of the arm, the robot and the PTZ camera. This module generates paths, trajectory, and control of robot by analyzing the map data. Emotion module generates and synchronizes the friendly face and speeches for our robot.

4. Reusability and application in the real-world

For this year, our robotic group has secured funding from Thailand's leading restaurant group. The funding is for development of restaurant servicing robot that moves around the perimeter greeting and interact with customers. Plasma-MK will be used as a proof of concept for localization and navigation. Plasma-MK SLAM and top level navigation will be used in the funded project. After the competition, our robot will be a showcase in our university tri-annual exhibition and also several other occasional exhibition.

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References

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