Team-EME 2016 Team Description Paper

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Abstract. This aims at reporting the recent progress of autonomous robot - IDRIS (Intelligent Driving System) in acquiring the benchmarks associated with RoboCup@Home competition 2016. The effort covers enabling IDRIS to work efficiently in a domestic, dynamic and uncertain environment; implementing successful Human-Robot Interaction; and fluent navigation through an unknown environment. The paper also covers the new gripper research, simulations and its integration with the robot.

1 Introduction

The outcome of our project was to establish a fully functional prototype structure for a domestic robot to work in an indoor environment.The basic tasks that we aimed to accomplish were:

a Design, simulation and fabrication of mechanical structure of the robot
b Simultaneous Localization And Mapping (SLAM)
c Object Detection & Recognition
d Object manipulation via a Robotic Manipulator
e Facial Recognition & Registration
f Skeleton Tracking and Human follower
g Autonomous Navigation in known indoor environments
h Speech recognition and synthesis

We intend to cover the components of a domestic robot working in an indoor environment and design such that it would be easier to integrate and improve above listed modules in the future.

2 Background

The project started in 2014. The team that worked on it during the 2014-2015 session setup an iRobot Roomba 4400 with an XBOX 360 Kinect as the basic structure of the robot. They also worked on the electrical circuitry involved, follower module, skeleton tracking, android app for teleoperation (controlling movement of the robot via keyboard commands) and made some progress on SLAM.

3 Team Description

In 2015-2016 session, our team worked further on developing the modules of the robot. Our team consists of six students in final year of BS in Mechatronics Engineering from College of EME, NUST.
TEAM MEMBERS:
1. Ali Ahmad
2. Assad Irfan
3. Fajar Javed
4. Hammad Asif
5. Muhammad Hassaan
6. Zarqash Ahmed

We have not yet participated in any of the previous iterations of RoboCup league but are hoping confidently to participate in the future ones.

Our objective pertains with acquiring a challenging position in an environment where we can best utilize our skills and education and participate as a team in a dynamic, competitive environment in promoting growth of ourselves and our country.

4 Hardware

The hardware consists of a platform supported on iCreate Roomba base.This platform is responsible for upholding and firmly carrying the remaining components of the robot. The design of platform is quite similar to that of a conventional turtlebot as shown below:

Fig. 1. Conventional TurtleBot mounted on Roomba 4400

For the sake of greater stability we added a fifth supporting rod from behind.

The structure consists of 5 aluminum rods, three black acrylic sheets as three floors and one aluminum sheet that is attached to the base and serves as the ground floor.

A robotic arm is mounted on the top of the highest acrylic. Four aluminum rods go through the top plate as 4-single identities passing through the 2-lower plates. There are a total of 18 clamps (number of usage depends upon the requirements) for making that happen. These clamps are responsible for holding the lower plates and will also be helpful in making these plates adjustable in term of their heights. Laptop is placed in one of the lower plates and the Kinect will be mounted according to its most feasible monitoring position.

Fig. 2. Robot structure

4.1 Robotic Arm

Turtlebot arm is a 5 degree-of-freedom robotic arm and an easy addition to the Turtlebot ROS robotic platform. The hardware consist of five Dynamixel AX-12a Actuators (half duplex) and several brackets of different sizes each 3D printed. Turtlebot arm weighs about 550g, has a vertical reach of 35cm and a horizontal reach of 31cm. Gripper has holding strength of 500g. Wrist lift strength is 250gram. The Turtlebot arm is controlled by ArbotiX-Robocontroller and FTDI board is used for Serial to USB communication. A power supply of 12V and 5A is provided to the servo motors. The Dynamixel actuators gives Turtlebot arm the ability to track its speed, temperature, shaft position, voltage, and load.The control algorithm used to maintain shaft position on the ax-12 actuator can be adjusted individually for each servo, allowing us to control the speed and strength of the motor's response. All of the sensor management and position control is handled by the servo's built-in microcontroller. This distributed approach leaves main controller free to perform other functions. Operating voltage of motor is 12V. Stall torque of each servo is 15.3kg.cm. Communication protocol is TTL half duplex asynchronized serial.

5 Software

5.1 Object Detection & Recognition

This project was aimed at successfully competing in the RoboCup@Home League 2016. In order to complete all tasks assigned to the teams for this league, the robot must be able to detect different objects and identify i.e recognize them as individual objects correctly. There are 3 steps required for object detection & recognition:

1. Object Capture: The robot captures a number of views of an object from various angles and stores them in a database or memory unit for further use. The robot detects any object inside the "capture workspace" and captures its views from various angles.

2. Object training: The robot then "reads" these views and "learns" to consider them as the different views of the same object rather than discrete pictures of different objects.

3. Object recognition: Once the robot has learnt to view the different views as the different poses of the same object, it remembers the name and other necessary properties (if any) of the object so that it can recognize the objects of the same type in the future without any further instruction.

The robot is using an integrated Xbox Kinect 360 as the camera & a set of object recognition packages, collectively called the "Object Recognition Kitchen" in order to achieve the following tasks.

5.2 Tabletop detection

The robot should be able to detect & recognize a table in its field of view.

Preparation/Configuration of a database of common objects Different objects of interest are to be detected and recognized by the robot to successfully complete the required tasks. A database of objects ensures that the robot can detect and recognize any of the objects in its database without the need of any further training.

Single Object Detection and Recognition Once the database is properly configured, the robot must recognize the objects already present in its database whenever the object is brought in its field of view.

5.3 Facial Recognition & Human Follower Module

The robot must have the ability to recognize faces, navigate its way while following a person and observe the real face images. It must also differentiate between different faces. The recognition is able to integrate new identities to its database. The person can also change their pose in order to improve the recognition results.

Facial Recognition Given the depth of a pixel, the plausible size of a face centered at that pixel can be calculated and the face detector can be restricted to look for faces only of that size.

The algorithm used for face recognition is Eigenface. We wish to find the principal component of the distribution or the eigenvectors of the covariance matrix of the set of images treating an image as a vector in a very high dimensional space. The background could significantly affect the results so we need to eliminate the background. De-emphasizing the outside of the face is important. Changing hair style could affect the recognition.

Human-follower The robot must follow the target and continue to do so even if another person crosses paths or comes in between. The approach used for this uses pointcloud, a combination of data points for simulating 3D objects. The size and shape of the person's head to shoulder is analyzed via 3D point clouds. This way it can consistently verify that it is following the right target. Also the robot does not need to request the target to face it for re-verification after the robot has lost sight of the target person.

5.4 SLAM

For the module of simulataneous localization and mapping we used the rgbd-slam algorithm which uses the Kinect's depth image. It uses SURF and SWIFT to match pairs of acquired images and uses RANSAC to estimate the 3D transformation between them.The pose graph is then optimized using HOG-Man to reduce the pose errors.

6 Conclusion and Future Work

The robot is capable of implementing the basic modules required as explained above. We aim at creating a fast and robust system without errors and bugs which can compete successfully in RoboCup@ Home 2016.

The system is easy to understand and build and hence can be utilized by other research groups to use it as it is or to mold the system according to their needs.

The robot is along with its circuitry is easy to make and can be commercialized with a little effort. Hence this can be used to take part in jobs such as a restaurant to welcome guests or in events. It can be profitably oriented.

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