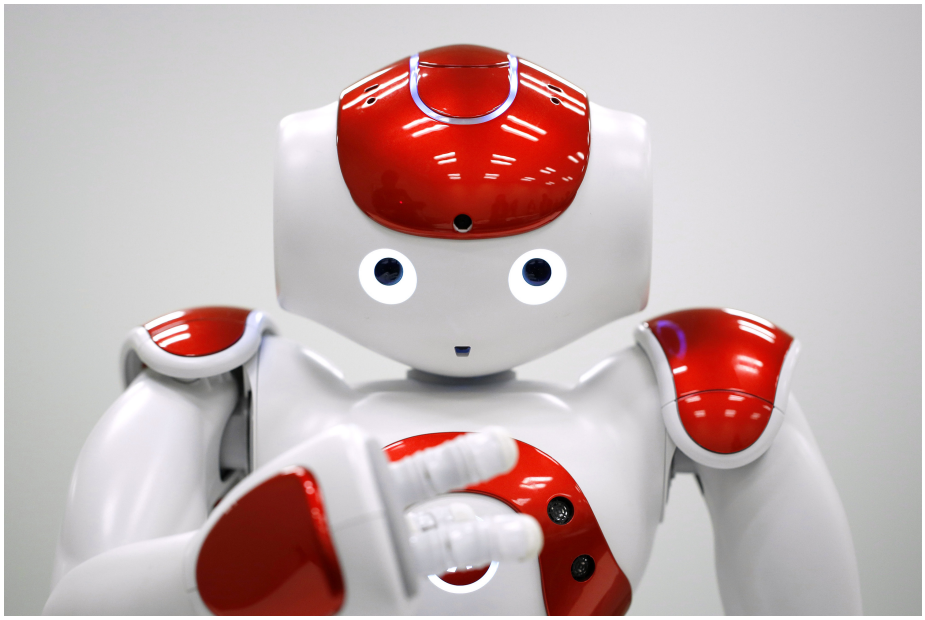

Robotic Project Survey

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1 Introduction

The robotics community has made impressive progress in recent years. Reliable and inexpensive robot hardware from land-based mobile robots, to quadrature helicopters, to humanoids is more widely available than ever before. Perhaps even more impressively, the community has also developed algorithms that help those robots run with increasing levels of autonomy.

In spite of (or, some might argue, because of) this rapid progress, robots do still present some significant challenges for software developers. This book introduces a software platform called Robot Operating System, or ROS,that is intended to ease some of these difficulties.

The aim of this survey is to introduce some ideas for projects which will allow us to understand the inner working of ROS and to gain an in depth knowledge of 3D computer vision for mobile robotics, robot navigation and control using ROS. Also to understand the power usage of ROS and its practical implementation on a turtlebot.

In this survey, we will introduce techniques of 3D Computer Vision for Mobile Robotics implemented in ROS. and in this survey, we will introduce two projects which we will choose one to implement as our robotic project in this semester. The first idea is a cleaning robot, this project is focused on the believe that between 25 and 50 years every home will have a cleaning robot. The second idea is Assistant Robot For Book Manipulation in a Library, which assist users in a library. With this aim, the system must be capable to looking for a specific book in a shelf, asked by any user, and whether it is found and guide the user. In these projects we will use ROS and image processing techniques for mapping, objects recognition and visual servoing.

Figure 1: Cleaning robot and Library assistant robot

2 3D Computer Vision for Mobile Robotics techniques implemented in ROS

Vision is a very important sense for humans. Robots also need to be aware of their environment for working in it. This is even more important for mobile robots that operate in unknown environments that are not prepared for robots. In this section, we focus on 3D Computer Vision for Mobile Robotics techniques implemented in ROS.

Components for detection and recognition of objects and their features enable robot to perceive and interact with the environments.

For 3D reconstruction, there are many techniques to do that, one of these techniques is the localization and mapping using the LIDAR sensor and the creation of the decided map using the gmapping commands. Another technique is SLAM using ROS with the help of the gmapping package which is a third party package by OpenSlam. This provides a depth based SLAM using Rao-Blackwellized particle filter.SLAM gives autonomous system for efficient creation of photo realistic 3D models of indoor and outdoor environments.

Most modern high definition 3D scans are done using RGB-D cameras. In recent years, with the introduction of the Microsoft Kinect, 3D point clouds became a hot topic of research. A multitude of projects have been under development, such as those from the Microsoft Kinect Fusion and MIT. 3D point clouds are also at the core of many robotics applications, ranging from Simultaneous Localization and Mapping (SLAM) and artificial intelligence to augmented reality.

For 3D recognition, we choose feature as they would be unique from on object to another which will allow us to recognize objects easily. In ROS there are several recognition methods:a textured object detection (TOD) pipeline using a bag of feature approach, a transparent object pipeline and a method based on LINE-MOD the old tabletop method. It also has several tools to ease object recognition, model capture 3d reconstruction of an object, random view rendering and ROS wrappers.

In the following section we will propose two ideas for our project, in each project we will go further in every step.

Figure 2: Turtlebot 2 and ROS

3 The proposed robotic projects

3.1 3D localization and classification of trash object for mobile cleaning robot

The research and development of an autonomous mobile robot prototype able to vacuum cleaning a room or even an entire house is not a trivial challenge. In order to tackle such a task, so that it could be completed in six weeks (the duration of the course), some simplifications and assumptions will be made to the designers initial idea of an "ideal" autonomous mobile cleaner robot. Probably the decision that the most affects the robot complexity is the ability of mapping the environment and recognize objects.

With the aim of keeping our robot as simple as possible, while able to perform the initial goals, i.e. an autonomous mobile cleaner robot able to randomly navigate through a room or a house with the minimum human assistance, the following specifications were found, obstacle avoidance, floor detection,collision detection, and object recognition.

The main objective of the project is to separate the trash from a road side environment or an after party site. The process is designed that the robot is programmed to navigate and search the area for path and detecting object. Later, after detecting trash they are classified into three sections like paper cup, can or thin and the organic like leaf.

Figure 3: Cleaning Robot

3.1.1 Mapping and Navigation

The Navigation of the robot is designed to work with two environments. The first part is designed with the known area mapping environment where a saved map for a particular boundary of area is used. The second is done with unknown area done by RPS algorithm. This process is a collecting of mapping data with the surveillance of area with the increase of radius. The package (rtabmap ros) is used as a reference to design the process.

Figure 4: Mapping and Navigation

3.1.2 Object Detection and classification

The process is designed with scanning of the 3D data from the object and later if the object is detected, the movement of the robot is stopped and the classification of the process is done. The feature of sound and led indication is included for the detection process. The package (object recognition) is used as a reference to design the process.

Figure 5: Objects to detect

3.1.3 Real-time 3D visual SLAM with a Kinect camera

In the previous two sections, we propose the ROS packages that we will use. In this section, we will propose an approach in detail for using SLAM with Kinect camera for map reconstruction and objects recognition.

the practical applications of 3D model acquisition are manifold. In this section, we present our RGB-D SLAM system, i.e., an approach to generate colored 3D models of objects and indoor scenes using the hand-held Microsoft Kinect sensor.

Our approach consists of four processing steps as illustrated in next Figure. First, we extract SURF features from the incoming color images. Then we match these features against features from the previous images. By evaluating the depth images at the locations of these feature points, we obtain a set of point-wise 3D correspondences between any two frames.Based on these correspondences, we estimate the relative transformation between the frames using RANSAC.

The third step is to improve this initial estimate using a variant of the ICP algorithm. As the pair-wise pose estimates between frames are not necessarily globally consistent, we optimize the resulting pose graph in the fourth step using a pose graph solver.

The output of our algorithm is a globally consistent 3D model of the perceived environment, represented as a colored point cloud. Further, we plan to evaluate our system using ground truth information. Our approach enables a robot to generate 3D models of the objects in the scene.

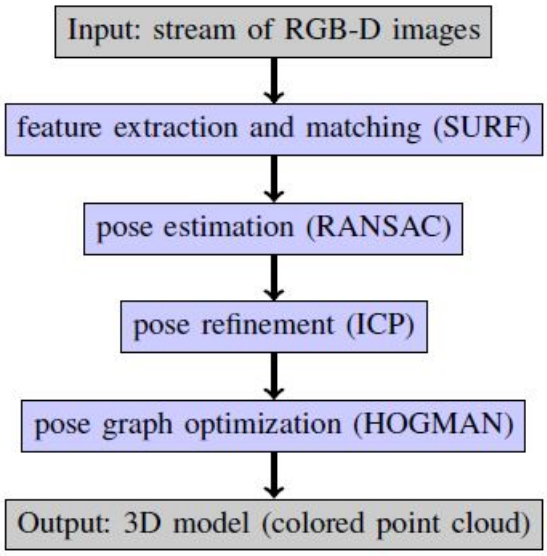

Figure 6: The four processing steps.

3.1.4 Conclusion and future work

The project is designed to detect and classify the trash. The process is designed that the robot is programmed to navigate and search the area for path and detecting object. Later, after detecting trash they are classified into three sections like paper cup, can or thin and the organic like leaf.

The future extension could be by robot control and picking objects using grasping hand, the control of the robot is switched between autonomous or manual remote control using a QR code and the remote control is much easy to navigate and start from the particular location. The picking or collection of the trash is implemented on the robot with the robotic arm.

Another future idea is probability mapping, which is to enhance and clean the search area efficiently. It is an advance option of determining the location where more of the trash is detected. By calculating the map, the next time the area can be searched as a first priority.

Another future idea is going for cleaning more complicated objects, such as dust using a brush and windows using a rage.

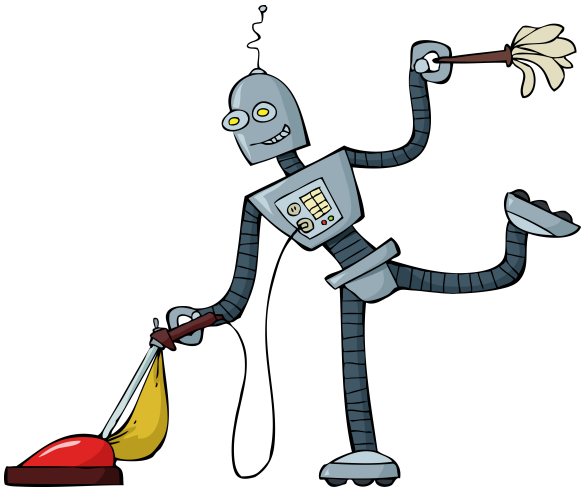

Figure 7: Future cleaning robot

3.2 Assistant Robot For Book Manipulation in a Library

Assistant Robot For Book Manipulation in a Library to assist users in a library. With this aim, the system must be capable to looking for a specific book in a shelf, asked by any user, and whether it is found and guide the user.

We can distinguish two main components in such robot, a mobile platform, including navigation capabilities; and a user interface, letting a very high level of interaction with the system.

3.2.1 Mapping and Navigation

There are two ways to build the map, using SLAM or using LIDAR sensor.

SLAM by using ROS with the help of the gmapping package which is a third party package by OpenSlam. This provides a depth based SLAM using Rao-Blackwellized particle filter. As some turtle bot is not equipped with a laser scan, the point cloud data obtained from kinect is transformed into the laser scan data for this purpose. The constructed map can be saved in yaml format and then later used for other purpose such as Autonomous Navigation. The navigation of the turtlebot was achieved using the turtlebot navigation package. This package is developed by OSRF specifically for the use with the turtlebot.

LIDAR sensor mounted on the turtlebot which make a great contribution to the development of the map building and aid in the navigation. 360° laser scanner development kit with omnidirectional laser scan. we can change the scan rate and other parameter. Navigation and localization should be done by the package provided by OSRF which is Adaptive Monte Carlo Localization AMCL. Using odometery as it is motion standard and LIDAR scan data as the measurement standard. It is probabilistic approach. The particles of the filter may converge, leading to localization. Upon motion the particles convergence while getting laser scan data.

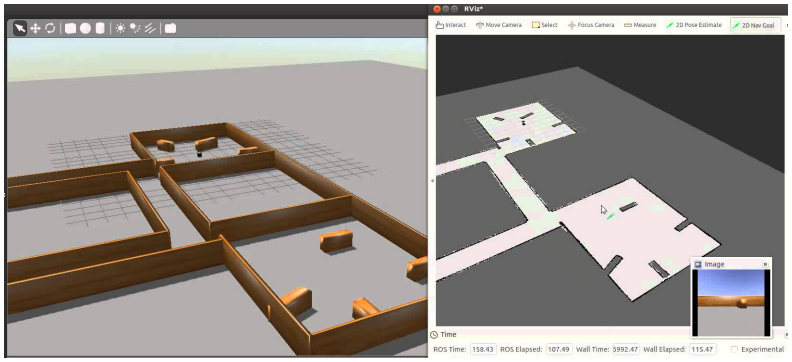

Figure 8: Mapping and Navigation

3.2.2 Robot Tasks

we would be discussing the 3 tasks namely, visual servoing, voice control and object recognition.

After building the map, the robot start to guide to the target place. This step includes avoiding obstacles and path planning. Once it reaches the target place, the Image processing and Optical Character Recognition (OCR), necessary to build the interface. This first step is in connection with the next one, because a scanner mechanism is needed to systematic process the different book labels until is found the one required by the user.

The next step has the double mission to looking for the desired label by the user and, whether it was found making the approaching towards this book.

Figure 9: Robot Tasks

3.2.3 Conclusion and future work

We think that Assistant Robot For Book Manipulation in a Library will be in each library, and to be capable to looking for a specific book in a shelf, asked by any user, and whether it is found and guide the user.

If we have a chance to add a grasping arm we can improve this robot to not just guide the users, also to get the book for them and return it when they finish.

4 The selected project and conclusions

It is really interesting to discuss and analyze lot of new ideas and features as a new applications. The ideas took us to a new level of imagination. But within the limited time give, the cleaning robot is decided as the final proposed project. We will be able to simulate and test this project in the provided turtlebot in the laboratory. The project is designed to work in the real time environment process and ROS is much robust. Thanks for giving the opportunity to work with the project, we as a team will be enjoying to work.

Overall we want to learn the strength of ROS especially navigation and vision. We also want to learn about the importance of using state machines to amalgamate all the task and goals of the robot to make it robust, easy to debug and scalable.

In this project, our robot tasks will be detecting the trashes, recognize the trashes and gathering each group alone.

The next figure shows our project story board.

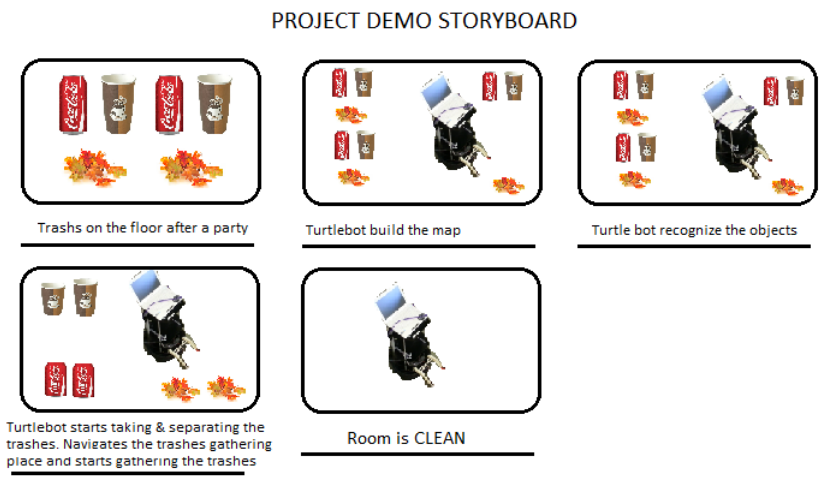

Figure 10: Project StoryBoard

5 Project Management

Project management is a critical component of every successful automation project which make ease the project implementation.
To ensure the least amount of disruption when new requirements and process changes arise, we will meet regularly to review status and identify changes. Design and develop a flexible solution that can be quickly adapted to meet new requirements.

What you can expect from us:
1. Real-time project scheduling.
2. Analyze and expand project definition,specific requirements that constrain the scope and approach.
3. Review layout and equipment.
4. Component and system time-line management.
5. Github update, documentation and codes.

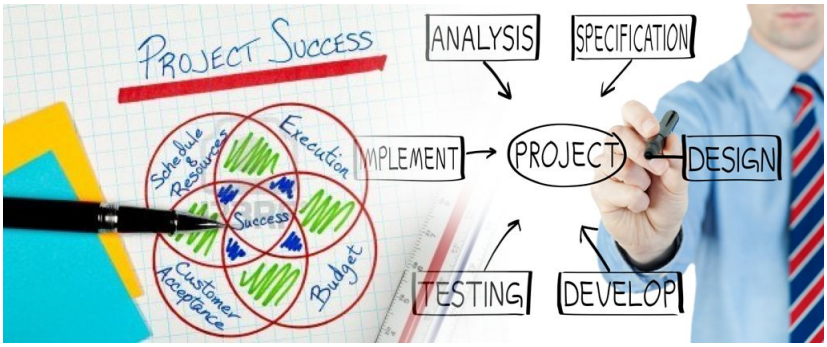

Figure 11: Project Management

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