Pathfinding and Object Detection using PR2

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Project Group 05

Problem Statement

The PR2 robot will identify objects of particular types utilizing a machine learning approach for computer vision, differentiating multiple object types and gathering correct objects. Once objects are picked up and the robot's carrying capacity is met, the robot will return to a goal position, such as a stockpile for the resources, and then robot will return to its last picked object location. From there, the robot will repeat the same process until all the objects of that type are moved to goal state.

Motivation

The collection and transportation of materials by an autonomous robot has many practical purposes. The PR2 robot's program can for example be utilized in general for cleaning tasks or in construction, both of which involve materials which may not be found in fully predictable locations. Additionally, any acquisition of materials carried in an environment hostile to humans would benefit from efficient search, classification, and transportation protocols.

Approach

To approach this problem we will be building on the PR2 robot simulation libraries for ROS to be simulated in Gazebo, (`http://wiki.ros.org/Robots/PR2`). This will allow us to simulate a robot that can explore an environment, as well as physically pick up various objects. We will build on this framework by implementing path finding via search algorithms as well as object recognition for identifying the correct objects to gather using OpenCV plugins with ROS.

Our first pass of this problem will be partially observable and deterministic. The robot will only be able to apply object recognition to objects within its local view, however we will not initially model transitions failing to go to the appropriate state or having some chance of going to multiple states. If our deterministic approach is successful, we will extend this to a more realistic scenario with stochastic state transitions.

We will design interesting scenarios for our robot simulation to complete. First we will require the robot to differentiate between two object classes, one that is the goal to be returned to the stockpile and another representing objects that we do not want returned to the stockpile. We will additionally design environmental layouts that require the robot to find paths from the starting point to resources, and then back to the stockpile. Finally, we will require that the robot has a limited carrying capacity (for instance one object per arm), requiring the agent to decide to return to the stockpile when it can carry no more objects, and then continue searching from where it left off.

Task Assignment

The project is primarily divided into 4 tasks equally amongst 4 members. Namely,
- OpenCV Integration (Steve)
- Path-finding Algorithms (Tejaswi)
- Environment Design and Arm Navigation (Karl)
- PR2 Robot Simulation using ROS (Kirtus)

The first task is all about infusing vision and perception into the robot by using OpenCV. Computer Vision is required here in order to discern between the objects and to correctly classify the desired objects that should go on the stockpile. Accomplishing this task will require to understand how computer vision libraries work, and the necessary images to be collected in order to train the desired model.

The second task involves all the path-finding algorithm design that would assist the robot in reaching to the stockpile from a point and back.

The third task involves the design of a simulation environment for the robot to perform. Currently, we are planning to use an environment that involves multiple rooms separated by walls. The walls in this case will be the obstructions the robot will have to avoid while finding a path to the stockpile. Arm navigation is an important part of this project as it allows the robot to pick up objects. The pr2_arm_navigation package will be used to implement the actions involving arm movements.

The PR2 Robot simulation task includes ways to simulate the PR2 robot into the gazebo environment. Once that part is done, further work will involve learning about PR2 teleop and kinematics.

Each of the team members are expected to work on this in equal synergy. After each individual task is accomplished, we will proceed further with the necessary integration to get the desired results.

Changes

We made the following changes due to comments on our proposal and ongoing development:

1. Karl unfortunately left our group.
2. As per the suggestion to use libraries to simplify our task we used the motion planning library Moveit! `https://moveit.ros.org/` for planning pick up actions.
3. Combining the multiple AI approaches in this project in combination turned out to be a daunting task. We did finish the implementation, but it is not perfect. We leave improvements to the combined task as future work and note that we also tackled each individual part of this project in separate demonstrations.
4. We maintained the API functionality given to us, but we changed the simulation framework so that we could work with PR2 instead of Turtlebot.