CSCI 445 Lab 6 & 7 — Midterm Project

Prof. Culbertson, University of Southern California   Spring 2020

In the next two labs you will enable your robot to follow a given set of waypoints while avoiding obstacles at the same time. You will stay with the same team for both labs and there will be an entrance quiz in Lab 6 and an exit quiz in Lab 7. Lab 7 will end with a competition and your grade will partially depend on the performance of your implementation in the competition.

1   Prerequisites

- Review the previous labs.
- Review control architectures.
- Review feedback control and odometry.
- Bring your laptop.

2   Goal

We will give you a start location for the robot and a list of waypoints as (x, y)-coordinates, for example:

```
waypoints = [
    [2,0],
    [2,1],
    [0,1],
    [0,0]
]
```

The waypoints can be hard-coded into your robot's code. For simulation, please demonstrate your implementation using the points we have given you in the file `waypointsLab6and7.txt`. For the competition, we will tell you the waypoints before the competition begins.

For all parts of this lab, in simulation and on the robot, please create plots of the robot's position and goal points like the ones you submitted in task 4 of Lab 5. This will help us to understand what your robot did and it may also be useful to you for debugging.

2.1   Waypoint Following Without Obstacles

First, configure the robot's code to follow a set of waypoints in an environment with no obstacles. The faster your robot completes the waypoints, the higher your chances for winning the first competition. However, make sure that the robot actually arrives at each goal location. Keep a copy of your code for the first competition.

2.2   Waypoint Following With Obstacles

Next, implement a control architecture for the robot to navigate through a set of waypoints in an environment with obstacles. Your robot should reach the desired waypoints accurately and without bumping into any obstacles. We guarantee that each waypoint is reachable and there are no obstacles within a radius of $0.5\,\mathrm{m}$ of each waypoint. You are not given a map, so your robot must dynamically detect and avoid the obstacles on the way. (The Wall-Following control module from Lab 4 might come in handy here.) The faster your robot reaches all the waypoints while avoiding obstacles, the better you will do in the competition.

Hint: Your robot will need to use the Wall-Following controller from Lab 4 and the Go-To-Goal controller from Lab 5 at different times. You'll need to write a control architecture to decide when to use each one.

Hint: The sonar has limited range and the odometry state estimate isn't very accurate, as you saw in Lab 3. You'll need to check for obstacles regularly in case the robot has drifted off course or a new obstacle has come into view.

Hint: As many groups observed in Lab 4, the sonar sometimes makes anomalous measurements. You may want to ignore single measurements that are very different from the ones immediately before and after, as these are likely to be wrong.

3   Competitions

In Lab 7, we will have two competitions. You should use the provided simulation scenes in V-REP for testing your implementations for each competition. Once you demonstrate the functionality of your implementations in simulation, we will give you a robot to tune your controllers for the competitions. You will have two attempts for each competition. An attempt is counted if the robot passed through all desired waypoints and did not hit an obstacle on the way.

3.1   Competition 1

Your robot must navigate through a set of waypoints in an environment with no obstacles as fast as possible.

3.2   Competition 2

Your robot must navigate through a set of waypoints in an environment with obstacles as fast as possible. The waypoints given will be reachable, and there will be no obstacles within 0.5 m of each waypoint.

4   Grading

200 Points in total for labs 6 and 7

- (100 points) Simulation
  - (30 points) Waypoint Following
  - (70 points) Waypoint Following in an environment with Obstacles

- (100 points) Robot
  - (80 points) Fully Working
    * (10 points) Waypoint Following
    * (70 points) Waypoint Following in an environment with Obstacles
  - (20 points) Competition
    * (5 points) Waypoint Following
    * (15 points) Waypoint Following in an environment with Obstacles

5   Timeline

You will have all of Lab 6 and the first $90\,\text{min}$ of Lab 7 to finish the regular lab assignment and show all your results to the TAs. The last $90\,\text{min}$ of Lab 7 are reserved for the two competitions. We recommend that you finish the waypoint following (simulation and robot) in Lab 6 and make good progress on the obstacle avoidance as well. If you do not complete obstacle avoidance during Lab 6, you should work on it during the week and bring a fully working simulation to Lab 7. This will ensure that you have enough time to deal with any robot-related issues during the first part of Lab 7.