CSCI 445 Lab 6 & 7 — Midterm Project

Prof. Culbertson, University of Southern California Fall 2022

In the next two labs you will enable your robot to follow a line while avoiding obstacles at the same time.

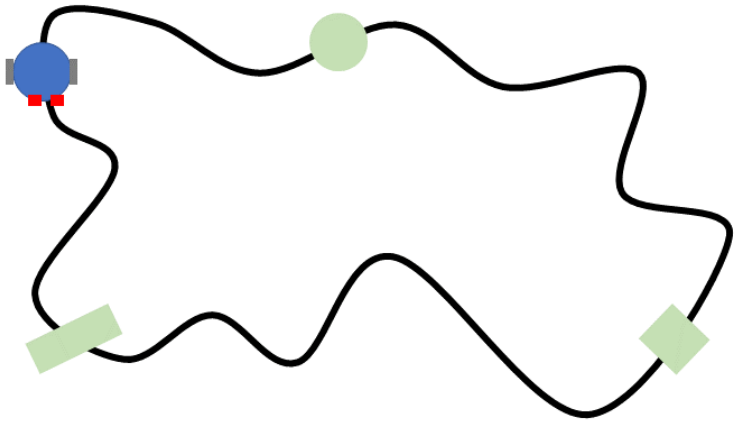
1 Prerequisites

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

2 Goal

Your robot will be asked to follow a line that will be occasionally blocked by obstacles. The robot should be able to avoid the obstacles and then go back to following the line.

The images below shows an example of the setup. You will test with one line map, but can freely move the obstacle and change the number of obstacles. For the competition, we will change the line map and use the same obstacle placement for all.



2.1 Line Following Without Obstacles

You will make your robot follow a line by using the built-in line sensors to keep the robot centered on the black line. Your robot has 5 downward facing line sensors (read: reflectance sensors) on its front edge. These active sensors detect the amount of infrared light that is reflected back from the ground surface. The documentation for the line sensors is here: https://pololu.github.io/pololu-3pi-plus-32u4-arduino-library/class_pololu3pi_plus32_u4_1_1_line_sensors.html

Hint: Since lighting conditions change, you must make sure to calibrate your sensors so that they correctly recognize "black" and "white". There is a function `calibrate()` for the line sensors, which will store the minimum (black) and maximum (white) values that the sensors read.

Implement a PD controller and tune your gains such that your robot is able to follow the line from start to finish without getting lost. The faster your robot traverses the line, the higher your chances for winning the first competition. However, make sure that the robot does not move so fast that it gets lost. Keep a copy of your code for the first competition.

Hint: Think about what value you are trying to control for. What is your controller's setpoint and how do you calculate error?

Hint: Similar to wall following, you can set a base speed and control just the robot's angular velocity to keep the line centered in the middle of the robot.

2.2 Line Following With Obstacles

Next, implement a control architecture for the robot to navigate the line that is occasionally blocked by obstacles. Your robot should traverse the line from start to finish without getting lost and without bumping into any obstacles. We guarantee that no obstacles block the line in more that one location and no point of any obstacle lies within within a radius of $10\,\mathrm{cm}$ of another part of the line. 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 traverses the line while avoiding obstacles, the better you will do in the competition.

Hint: You can adapt the Wall-Following controller from Lab 4 to work as obstacle avoidance.

Hint: Your robot will need to use the Obstacle Avoidance controller and the Line Following controller from above at different times. You'll need to write a control architecture to decide when to use each one.

Hint: The sonar has limited range. 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 line maps to test your implementations for each competition. You will also be given a variety of different obstacles, which you can use to test to robustness of your controller by changing the number and placement of the obstacles. You will have two attempts for each competition. An attempt is counted if the robot traverses the line from start to finish and did not hit an obstacle on the way.

3.1 Competition 1

Your robot must follow a line from start to finish with no obstacles as fast as possible.

3.2 Competition 2

Your robot must follow a line from start to finish with obstacles as fast as possible. Each obstacle will only intersect the line once.

4 Grading

200 Points in total for labs 6 and 7

- (10 points) Pre-Lab
- (170 points) Implementation
  - (50 points) Line Following
  - (120 points) Line Following with Obstacles

- (20 points) Competition
  - (5 points) Line Following
  - (15 points) Line Following with Obstacles

5 Timeline

You will have all of Lab 6 and the first 2 hours of Lab 7 to finish the regular lab assignment and show all your results to the TAs. The last 1 hour of Lab 7 are reserved for the two competitions. We recommend that you finish the line following in Lab 6 (and get further if you can!). You should spend Lab 7 the obstacle avoidance controller, bringing the two parts of the controllers together, dealing with arbitration between the controllers.