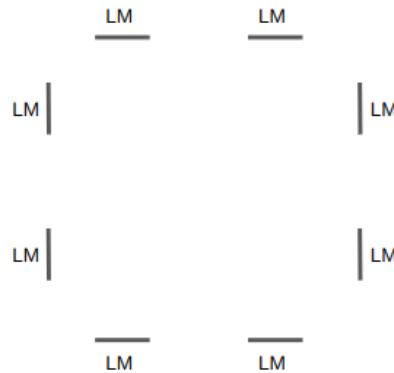


Homework 3 - CSE 276 - Introduction to Robotics

Due: Thursday, 10 November 2022, before midnight

The objective of homework 3 is to implement a version of the Simultaneous Localization and Mapping (SLAM) technique and evaluate its performance

1. Setup an environment in a $10\text{ft} \times 10\text{ft}$ area with landmarks (LM) as exemplified in the figure. There should be 2 landmarks on each side. The landmarks could be markers as used in HW2 or natural objects. If you are using markers, you can use a different ID for each landmark. Measure the position of your landmarks / walls



Provide a sketch of your ground-truth map in the top-down view layout as part of the report. If you want to scale down the square area, the minimum side should be 8 ft.

2. Implement the KALMAN filter based SLAM system as described in the lecture notes. Use the off-the-shelf software to detect the landmarks. You can drive slow enough to make the system matrices as simple as possible.
3. Start from a pose inside the square and drive through your environment to build up a map. The start pose is not known by the robot.
 - i) Initially drive the robot in a square path (say $n \times n$ ft in size).
 - ii) Drive through the environment using an 8-point octagon trajectory (side length m ft). Assume you know nothing about the location of the landmarks with respect to the robot. You thus have to estimate the position of the landmarks and the trajectory of the robot as part of the homework.
4. Compare the two maps, What are the main differences if any? Given that the robot start from an unknown pose and created the map, you

will need to measure the start pose and transform the map into the world frame to compare with the measured ground-truth map. If you drive multiple times around the trajectory is there a change in your results? Measure the average error of landmarks between the measured map from point 1 and the map estimated by the algorithm.

5. Provide a report that describes i) Your algorithm, ii) The results obtained with a square motion, iii) with the 8-point motion, iv) Comment on the results obtained. How did you select the size of the square n / 8-point m ? What trade-offs did you consider? v) A link to your unlisted YouTube video of the robot doing the SLAM.
6. For the algorithm part, the following should be included. i) What is the state x and measurement vector z ? ii) How did you get the system matrix F , control matrix G , and measurement matrix H ? iii) How did you initialize the state $x_{0|0}$ and state covariance $\Sigma_{0|0}$? iv) How did you determine the system noise and measurement noise? v) How do you handle a new landmark first time being detected, a landmark going out of field of view, and a previously detected landmark reappearing?
7. For the result part, i) provide a plot of the trajectory estimated by the algorithm (not your eyes) along with the map of landmarks you built. The landmark plot should include the position covariance for each landmark, ii) Measure the average error of landmarks between the measured ground-truth map from point 1 and the map estimated by the algorithm. iii) Describe if the map improves if you drive multiple times.
8. Provide a zip file with the code.