EE183DA (Winter 2017)

Design of Robotic Systems I

Prof. Ankur Mehta
mehtank@ucla.edu

Lab assignment 4
Due 2pm Tues Feb. 28, 2017

1 Lab Overview

1.1 Objectives

In this lab, you will implement the computational infrastructure necessary to command a simple 2 wheeled robot. You will derive a mathematical input-output model of the system dynamics, and build on to it sensor and actuator responses. You will then implement this model within a computational environment, and use it to build a state estimator.

You will be working in your project teams. You will be responsible as a team for dividing the various tasks of this project between all members. Your grade will be based both on team and individual performance.

1.2 Deliverables

As a team, you will submit a documented git repository of your code, along with further documentation describing your mathematical formulation, algorithms, experimental setup, experimental results, and final performance. This additional documentation can take the form of either a lab report as in lab 1, web site as in lab 2, or academic poster as in lab 3. You will be assessed on both the clarity and completeness of your content. Upload a link to your code repository / website along with a pdf of your report / poster (if applicable) on CCLE by 2pm Tues Feb. 28, 2017.

As an individual, you will submit a participation questionnaire indicating the contributions of each team member to the team results.

Submissions that are up to 24 hours late will be accepted for a 10 percentage point reduction in final grade. No submissions will be accepted more than 24 hours late.

2 Lab specification

2.1 Robot model

You will consider a 2 wheeled robot similar to the one shown in Fig. 1. It has two wheels of radius $r = 50mm$, separated by a distance $w = 90mm$. It drags a tail for stability, at a distance $l = 70mm$ behind the centerpoint of the wheels.

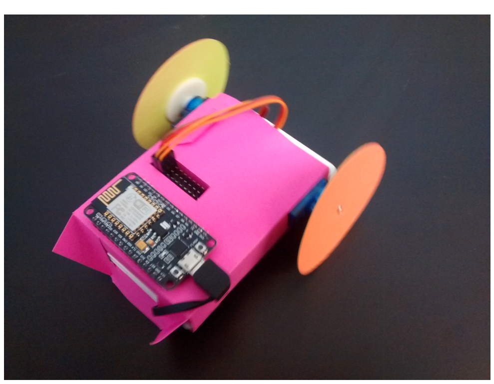

Figure 1: Two wheeled tank-drive robot

Each wheel is powered independently by a continuous rotation servo, with the angular velocity of the wheel controlled by a PWM signal from the microcontroller. This allows the robot to drive forwards or backwards at variable speed, or turn with any turning radius.

You will be able to add onto the robot reflectance sensors for wheel odometry and/or a gyro sensor for angular rate measurement. The gyro has some unknown potentially varying internal bias, resulting in an affine (linear plus bias offset) output as a function of angular rate. If you would like to use additional sensors, come talk to me.

2.2 Mathematical setup

The state of your robot will consist of the 3DOF pose of the robot in 2D space, along with their velocities. You may also want to include the gyro bias in your state if you use that sensor. Thus, your robot state will have at least 6 variables.

Your control input will be the PWM values you send to each wheel, for a total of 2 input variables.

Your sensor output can include odometry from the reflectance sensors measuring the angular rates of each wheel. It can also include the angular rate of the body as measured by a gyro sensor. This gives up to 3 output variables. If you use additional/alternate sensors, you may have more.

You will need to derive and present the mathematical equations describing this robot plant, including sensor and actuator models and system dynamics. Be sure to include noise terms as appropriate.

2.3 State estimation

You are free to choose any state estimation algorithm you'd like to compute a state estimate from a time series of sensor measurements. You may want to implement a model based state estimator, or perhaps implement an Extended Kalman Filter (EKF). Other options include an Unscented Kalman Filter (UKF) or a particle filter. Be sure to explain which algorithm you chose and why, and describe the mathematics behind it in your writeup. Identify any algorithm parameters that need to be set, and explain how you selected the values of those parameters.

2.4 Experimentation

You have the choice of doing experiments and analysis in simulation or with a real life robot.

If you choose to go the simulation route, you will need to implement realistic models of your sensor and actuator response (including noise) to generate simulated sensor measurement data given arbitrary control inputs. Generating these models will likely require some data collection from physical sensors and actuators.

If you would prefer physical experimentation, you will need to come up with a communication scheme to exchange control commands and sensor measurements between the robot and your state estimator.

Either way, run some examples that demonstrate the performance (in terms of accuracy and efficiency) of your computed state estimate over time as the robot is issued various commands. Clearly describe the experiments that were run, the data that was gathered, and the process by which you use that data to characterize the performance of your state estimator.

What can you conclude about the usability of your state estimator for potential tasks your robot may encounter?