Homework 3

16-311: Introduction to Robotics

Contents

1 Learning Objectives

1. Connect sensor and odometry skills from Lab 3.
2. Reinforce basic controls.
3. Think about controls for following a path.
4. Practice making block diagrams for open and closed loops.

2 Senors

1. If you have a light sensor designed to detect differences in the color of the ground under the robot, how would moving the sensor closer or further from the ground affect the readings?

2. Would it make a difference if the light sensor has a built in light or just relies on ambient light?

3. Would you want the sensor closer or further away from the body of the robot?

3 Odometry

Your robot is facing north. You measure the encoder tics from two very accurate motors. The motors have one tic for every degree. You measure at time t0=0sec and the number of ticks of the encoder is 180. You measure at time t1=0.1sec and get a reading of 250 ticks. Your encoder has precision of 1 tick per degree. Your robot has wheels 5 cm in diameter. How far did you travel in this time? (Assume no slip)

4 Controls

1. In the mass-spring-damper system, which characteristic is analogous to the proportional controller of a PID system?

2. In the mass-spring-damper system, which characteristic is analogous to the derivative controller of a PID system?

3. What is tangential velocity, v_{wheel}, in terms of angular velocity, ω_{wheel} (what an encoder would read) and wheel radius, r?

4. If you know the tangential velocity of your left and right wheel, v_l and v_r, respectively, what is the forward velocity, v, of your vehicle in the robot's frame?

5. If you know the tangential velocity of your left and right wheel, v_l and v_r, respectively, what is the angular velocity, ω, of your vehicle in the worlds frame?

6. The above steps document your actual speeds, but what about your desired speeds? Assume that you want to be moving at $v_{special}$ m/s. Pure pursuit is one method of determining desired angular speed given tangential. In this method, you draw a circle around the robot with a length of L, then you see where it intersects with a desired path that is given in terms of x and y coordinates from the robot frame. The curvature that the robot can take to get to this intersection point is $\kappa = \frac{2y}{L^2}$. The desired ω is found by multiplying that curvature by tangential velocity. Based on this method, what would be the $\omega_{desired}$ also incorperating a PD controller?

5 Block Diagrams

Draw a block diagram for the following control scenarios:

1. An open loop controller for controlling house temperature through a simple dial. Include labels for desired state, controller commands and output state. Include blocks for controller and plant and describe what those two things would be in our example house.

2. A basic closed loop controller for keeping a car at a desired cruising speed. Include labels for desired state, controller commands and output state. Include blocks for controller, sensor and plant and what those things would be in our car.

3. A controller with a feed forward term for keeping a segway at a constant 30 degree tilt. Include labels for desired state, controller commands and output state. Include blocks for controller, sensor and plant and what those things would be in our segway.

6 What To Submit

Submissions are due on Gradescope by the date/time specified in the Syllabus.

1. Create a .pdf file with the written answers ALL THE SECTIONS named hw3.pdf and submit to Gradescope.