ME597 Autonomous Mobile Robotics

Homework Assignment #1

Posted: January 19th, 2016

Due: February 5th, 2016

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1. Derive a motion model for an omni-directional wheeled robot with three wheels. Each wheel provides a speed in the direction of rotation of the wheel only, which contributes to both linear and angular velocity about the cg of the vehicle. If two wheels are rotated at the same speed in opposite directions and the third is held at zero, the vehicle moves straight forward in the direction that averages the two wheel orientations (see Figure 1, if $v_2 = -v_3$, motion is in x direction). When all three wheels rotate in the same direction, the robot spins in place. By decomposing each wheel input into x and y speed contributions, use the wheel rotation rates, ω_1, ω_2, ω_3 as the control inputs for the vehicle. Include additive Gaussian disturbances of standard deviation 0.05 m on x, y and 0.5 degree on Θ in the model. Assume a 10 Hz update rate for the model and set r = 25 cm, l = 30 cm.

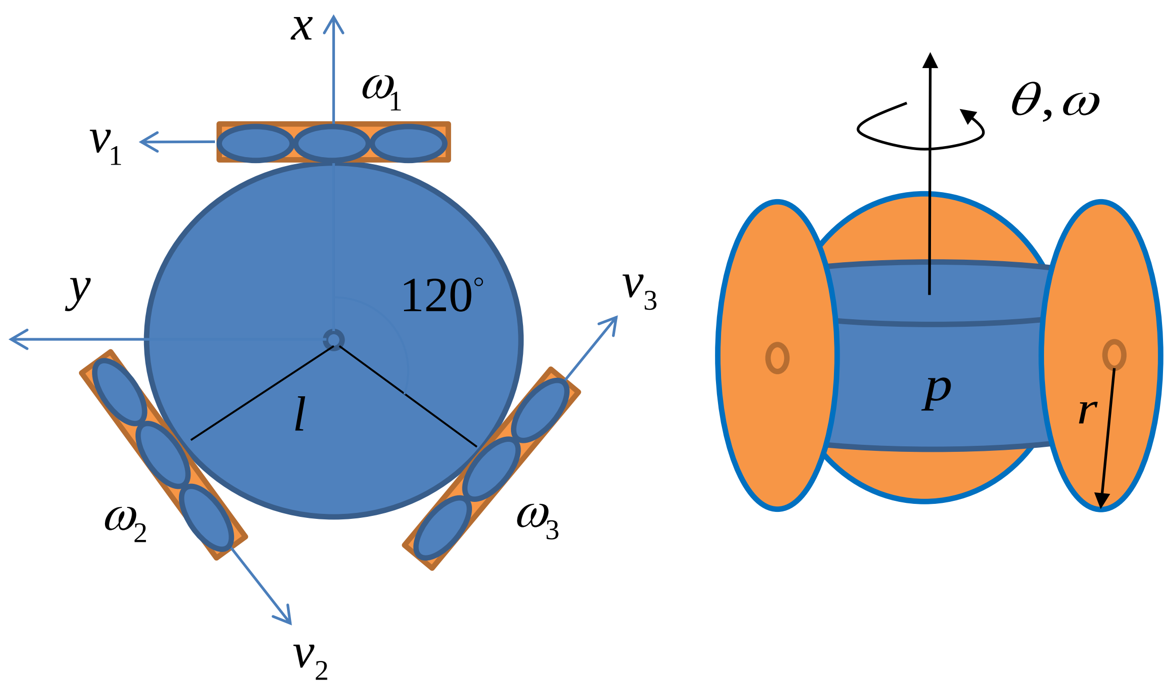

Figure 1: Swedish wheel vehicle

2. Create a simulation for the above robot. Apply rotation inputs of ω_1 = -15.5 rad/s, ω_2 = 10.5 rad/s, and ω_3 = 1.5 rad/s to the wheels and plot the true robot motion for a 15 second simulation. Identify those inputs that will allow the robot to move in a straight line, turn in a 2 meter diameter circle, and drive in an expanding spiral of any size. Confirm these inputs produce the expected results in your simulation.

3. Define a measurement model for the robot if it has both GPS and a magnetometer and operates on a 2D plane. The GPS output is in true North, East (and Down, not used here) and the magnetometer points to magnetic north (your declination is 9.7 ° West in Waterloo, ON). Define additive noise distributions, with standard deviations in North and East of 0.50 m, and in magnetic north of 10 degrees. Assume a 10 Hz update for all sensors.

4. Define an Extended Kalman filter that uses the two models from parts 1) and 2) to estimate the vehicle state.

5. Implement the EKF using the existing EKF sample code. Apply rotation inputs of ω_1 = -15.5 rad/s, ω_2 = 10.5 rad/s, and ω_3 = 1.5 rad/s to the wheels and plot the true robot motion, measurements, and EKF estimates for a 15 second simulation. Provide graphs in the x-y plane with error ellipses, and also plot each of the states and the related estimate on separate subgraphs.

6. Corrections are sent for the x,y position of the vehicle at an update rate of 1 Hz. These corrections improve the GPS measurements at that instant only, with an improved standard deviation of 0.01 m. Define a multi-rate Kalman filter that incorporates regular GPS, magnetometer and corrected GPS measurements, and modify your simulation to incorporate the new measurements. Provide the same plots as before for 15 seconds with the same inputs.