HOMEWORK ASSIGNMENT 2

(Due: Friday, April 1, 2016; 8pm)

Review the paper Hellström paper, “Kinematics Equations for Differential Drive and Articulated Steering.”

1. You are given a differential drive robot with a 30cm wheelbase and 15cm diameter wheels. Determine the right and left wheel velocities (V_r and V_l) needed for the robot to drive around the circumference of a 2 meter diameter circle and complete one full rotation in 30 seconds. Assume that the global reference frame has an origin of (0.0m, 0.0m) and that the robot starts at the pose (1.0m, 0.0m, $\pi/2$) in this reference frame.

2. For the robot of problem 1, plot the trajectory for completing the circle for time steps of 5, 1 and 0.1 seconds. Comment on the results.

3. You are given a differential drive robot with a 30cm wheelbase and that you command the robot to adopt wheel velocities of V_R = 0.5184 m/s and V_L = 0.4243 m/s. Assume dt = 0.1 seconds.
   a. What is the ICC for these velocities?
   b. Suppose that due to a calibration error, the actual left wheel velocity is V_L = 0.4343 m/s. What is the resultant pose of the robot assuming it started at (1.5m, 0.0m, $\pi/2$)?
   c. Plot the actual trajectory of the robot given V_R = 0.5184 m/s and V_L = 0.4343 m/s.

4. You are given a differential drive robot with a 30cm wheelbase and that you command the robot to adopt wheel velocities of $V_R = V_L$ = 0.5184 m/s. Relative to the global coordinate frame, the robot pose is (1.0m, 1.0m, $\pi/6$). After 20 seconds, what is the robot pose in the global coordinate frame?

5. For the robot described in problem 1, assume the robot begins at a pose of (1.0m, 1.0m, $\pi/6$). The commanded wheel velocity was 0.5 m/s, however due to a variety of error sources, the velocity is not exact. The file RBE3002_D16_Homework_2_Data.xlsx contains the actual wheel velocities measured for the right and left wheels for 10 different runs of the same robot, each run starting from the same beginning pose. The data are measured every 100mS.
   a. For each of the 10 runs, what is the robot pose after 20 seconds?
   b. Plot the cluster of resultant positions of the robot with the origin, all of the resultant positions, and the “true” position (based on a perfect model) on the same graph.
   c. What is the magnitude of the maximum error (“true” – actual) for this robot after 20 seconds?

6. Your robot must travel from the origin of your global coordinate system, at beginning pose P(start) = (0.0m, 0.0m, 0) to post P(end) = (10.0m, 10.0m, $\pi/2$). The robot <u>must</u> travel through the waypoints W1 = (5.0m, 3.0m) and W2 = (7.0m, 8.0m) on its way from P(start) to P(end). The rotation of the

robot at any intermediate waypoint is arbitrary). Assume that the forward velocity between any two waypoints is exactly 1 m/s and assume any rotation requires 500 mS.

a. What is the minimum distance the robot must travel to get from P(start) to P(end)?
b. What is the Manhattan distance the robot must travel to get from P(start) to P(end)?
c. What is the motion plan (rotations and translations) needed to move the robot from P(start) to P(end) along the shortest path (remember, the shortest path must include the intermediate waypoints)?
d. What is the motion plan (rotations and translations) needed to move the robot from P(start) to P(end) along the Manhattan path (remember, the path must include the intermediate waypoints)?
e. How long does it take to get between W1 and W2 for both the shortest path and the Manhattan path?