CPE 482 - Autonomous Mobile Robots

Mid Term Assignment (Due Feb. 25th)

Multiple-Choice – 2 marks awarded for each correct answer, 1 mark deducted for each incorrect answer, 0 marks if no answer. Circle the answer that BEST completes the sentence.

1. In the robot's local coordinate frame:
   a) The magnitude of the robot's longitudinal velocity is always greater than or equal to the lateral velocity.
   b) The robot's rotational velocity is twice the rotational velocity in the global coordinate frame.
   c) The robot's lateral velocity is equal to the rotational velocity in the global coordinate frame.
   d) None of the above

2. Within a control architecture's temporal decomposition:
   a) Spatial locality increases with sampling rate.
   b) Context specificity increases with sampling rate.
   c) Temporal memory increases with sampling rate.
   d) None of the above

3. Coastal navigation:
   a) Uses walls to improve its state estimate.
   b) Dictates that the robot stay close to features to which relative measurements can be used to improve localization performance.
   c) Did not work for Minerva.
   d) None of the above

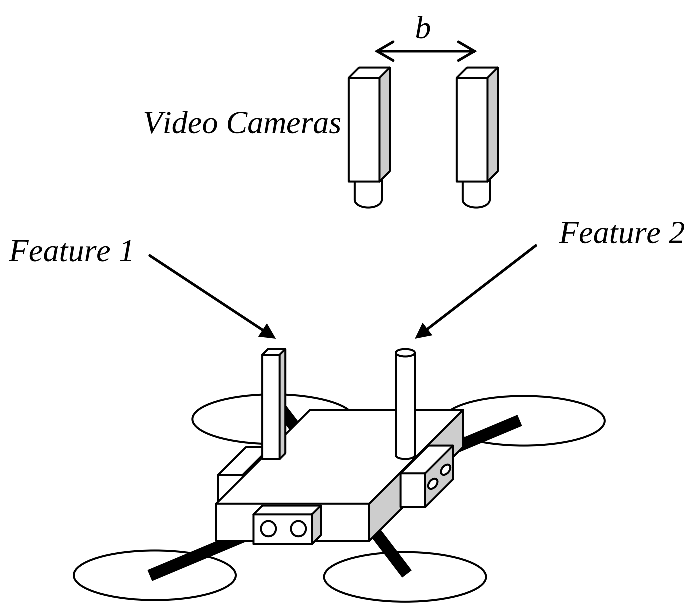
4. Particle Filter Localization
   a) Requires the use of range sensors.
   b) Always have problems running in real-time.
   c) Is more amenable to real-time implementation when compared with the traditional implementation of Markov Localization.
   d) None of the above.

5. Gray code:
   a) Is used when encoding tracks on absolute encoders.
   b) Has only one bit switched between numbers in the code.
   c) Is used to reduce the chance of measurement errors due to timing inconsistencies.
   d) All of the above.

Question 6: 10 marks
Consider using Markov Localization within room 14-302. Assume that the discretization results in grid cells of size 10cm x 10cm.

a) Describe how to make a motion model at time step for a differential drive robot given that the right and left wheel have moved Δs_r and Δs_l meters respectively.
b) Provide a diagram of an example probability distribution (similar to slide 10 of lecture 10), for a robot with θ=45 degrees and $\Delta s_r = \Delta s_l$ = 1m. Assume that each wheel measurement has an error that follows a normal distribution with standard deviation of 0.010 meter per meter travelled.

Question 7: 10 marks
Stereo Vision will be used to track the 3D position and yaw of a free-flying robot in the workspace provided in Figure 2. The robot will have two distinct features that the camera's can distinguish and identify. Assume the robot's pitch and roll remain equal to 0 at all times.



Develop equations that will determine the x, y, z, θ of the robot, given that (x_{li}, y_{li}) and (x_{ri}, y_{ri}) are measurements of the i^{th} feature in the focal plane from the left and right cameras respectively. Assume the focal length of each camera is f.

Question 8: Consider a robot that only drives forward or backward in the x direction. We want the robot to be able to move to any value of x. We control the robot by setting the rotational velocity of the wheel, $d\varphi/dt$. Assume the wheel has radius r.

To design a controller for the robot, we first define the error of the system

$$e = x_{desired} - x$$

Taking the derivative of this equation yields

$$de/dt = -dx/dt$$

a) Write a proportional control policy for this robot. That is, what is an expression for $d\varphi/dt$ that results in proportional control?
b) Substitute this control law into the differential equation above.
c) Your control policy should include a gain K. What values of K will guarantee this controller will work? Why?