CS 547: Sensing and Planning in Robotics
Fall 2005
Quiz 2: November 2, 2005

Notes:

1. The quiz is open notes, not open book.
2. You may use a calculator.
3. You may not borrow notes or papers from others.
4. The quiz duration is 2.5 hours.
5. There are 10 pages in this enclosure.
6. Attempt all questions.
7. *Good Luck*

Name:____________________________

SS#/USC ID#:____________________

Problem	*Score*	*Out Of*
1		15
2		15
3		15
4		20
Total		65

1. [**15 points**] Explain the following terms briefly (no more than 3-4 sentences each).
   (a) Kalman filter

   (b) Action model

   (c) Probabilistic action model

   (d) Sensor model

   (e) Probabilistic sensor model

2. **[15 points]** Recall that a normal distribution is given by $\frac{1}{\sqrt{2\pi\sigma^2}}e^{-\frac{1}{2}\frac{x-\mu^2}{\sigma^2}}$

We would like to apply Bayes rule to Gaussians. Suppose a mobile robot is confined to a long straight road. Its location (position along the road) is denoted x. Suppose that the initial estimate of the robot's location is $x_{init} = 1000$, but we happen to know that this estimate is uncertain. Based on this uncertainty we model our initial belief by a Gaussian with variance $\sigma^2_{init} = 900$.

To find out more about the robot's location, we query a GPS receiver mounted on the robot. The GPS receiver measures a location of $z_{GPS} = 1100$. The GPS is known to have an error variance of $\sigma^2_{init} = 100$.

a. **[7 points]** Write the probability density functions of the prior $p(x)$ and the measurement $p(z|x)$. Draws graphs showing each.

b. [**8 points**] Using Bayes rule compute the posterior $p(z|x)$. Is the posterior Gaussian ? Justify your answer, and draw a graph of the posterior.

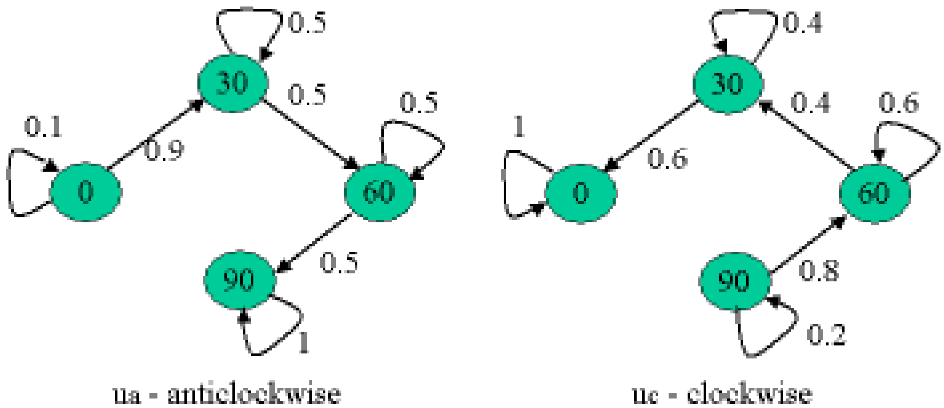
3. [**15 points**] Imagine a robot that can move back and forth along a narrow road (i.e. along a line) and can turn in place. Denote the robot's position along the road by x and its angular orientation by θ. The robot is equipped with two controls v and ω, for linear and angular velocity respectively. We wish to derive a velocity-based probabilistic action model for this robot following the treatment discussed in class.

   a. [**3 points**] Clearly state the inputs and the output for such a model.

   b. [**3 points**] Enumerate three assumptions one might make in such a model.

c. [**9 points**] Under the assumptions enumerated in the previous part, write a procedure which implements a velocity-based probabilistic action model for this robot. Like the treatment in class, you may assume that you are given a function $\mathbf{prob}(a, b)$ which computes the probability of its argument a under a zero-centered distribution with standard deviation b.

4. [**20 points**] A monitoring camera is installed such that it can be rotated clockwise (u_c) or anticlockwise (u_a). The actuator responsible for camera rotation is unreliable. The camera can exist at one of four angular positions $\theta = 0^o, 30^o, 60^o, 90^o$. The state transition diagram showing the effect of action u_a and u_c on the angular position of the camera is shown in the figure below.



a. [**5 points**] Draw an unbiased prior over the variable θ.

b. [**6 points**] Starting with an unbiased prior the camera is subjected to the following action sequence (u_c, u_c, u_c). Compute and graph each succeeding posterior over θ on the graphs below.

c. [**6 points**] Starting with an unbiased prior the camera is subjected to the following action sequence (u_a, u_c, u_a). Compute and graph each succeeding posterior over θ on the graphs below.

d. [**3 points**] Starting with an unbiased prior, which of these two action sequences leads to a better estimate of the actual camera angle ? Briefly justify your answer.