COS 495 - Autonomous Robot Navigation

Midterm Exam - Practice

October 21, 2011

Name:

Signature:

Time Limit: **1 hour**

Closed Book
No Calculators

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. Issues that affect robot locomotion include
   a) The robot's stability.
   b) The robot's work environment.
   c) The robot's type of contact with the environment.
   d) All of the above

2. Proportional feedback control
   a) Produces very large control signals when the error is very small.
   b) Requires some measurement of the state being controlled.
   c) Always induces overshoot when tracking a step response.
   d) All of the above

3. A robot will have better localization capabilities if it uses encoder measurements instead of control inputs to predict is position because:
   a) Encoders have no errors.
   b) Encoders do not model slipping.
   c) The model that takes the control inputs and converts them to real wheel motion is not perfect.
   d) All of the above

4. If the VideoRay ROV was in an empty square tank, its differential drive configuration will allow it to

a) Follow any path through the workspace provided the path does not lead to collision with the walls.
b) Follow any trajectory through the workspace provided the trajectory does not lead to collision with the walls.
c) Follow any path and any trajectory through the workspace provided they don't lead to collision with the walls.
d) All of the above

5. The X80 is equipped with:

a) Exteroceptive sensors
b) Proprioceptive sensors
c) Active sensors
d) All of the above.

6. For a differential drive robot operating in a 2 degree of freedom workspace, how many degrees of freedom can be used to define the configuration space in a motion planning problem.

a) 2 degrees of freedom
b) 3 degrees of freedom
c) 4 degrees of freedom
d) Any of the above

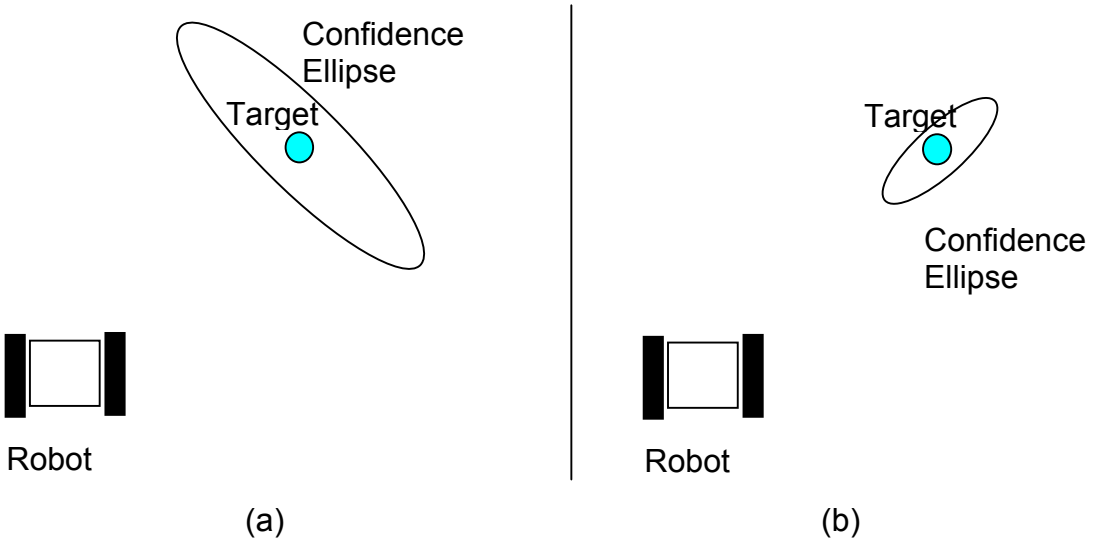
Question 7: 10 marks

a. Using a table, compare three different range sensors. Use four different characteristics to compare them. List these characteristics in the left column. List the sensor types along the top row. Within each cell of the table, provide a number between 1 and 10. Let 1 indicate the sensor does not have that particular characteristic, while 10 indicates the sensor is strongly believed to have that characteristic. For example:

Characteristic	Sensor type 1	Sensor Type 2	Sensor Type 3
1	1	10	1
2	5	2	2
3	7	4	1
4	1	1	2

b. The two figures below depict a robot, a target that is being sensed, and a confidence ellipse (aka error ellipse). The confidence ellipse provides an idea of how much confidence we have in the estimate of target position.

First, compare the two situations in terms of similarities and/or differences. Second, based on the confidence ellipse, guess what type of sensor is being used in each situation.


Confidence
Ellipse
Target
Robot
(a)
Target
Confidence
Ellipse
Robot
(b)

Question 8: 10 marks

A free flying blimp robot that has fixed roll, pitch and yaw orientations (i.e. they all equal zero), is flying over a target. The robot has a special GPS system that gives it PERFECT knowledge of its location in 3D space (i.e. $x\ y\ z$). The robot is also equipped with a downward facing camera of focal length f that it uses to track targets. At one instance in time, the robot is located at position $[\ x_1\ \ y_1\ \ z_1\ ]$ and detects the target at position $[\ x_{f1}\ \ y_{f1}\ ]$ on the camera's focal plane. At a later instance in time, the robot is located at position $[\ x_2\ \ y_2\ \ z_1\ ]$ and detects the target at position $[\ x_{f2}\ \ y_{f2}\ ]$ on the camera's focal plane. Given this set of measurements, determine the position of the target.

Question 9: (10 marks)
The IR range sensors used on the X80 must are useful sensors but must be used with care. Answer the following questions regarding these sensors

a) Explain the basic principles on how the sensor works in 4 sentences or less. Be sure to use a diagram. Give the equation used to calculate range, labeling variables on the diagram.
b) Draw the response curve (sensor output as a function of distance). Be sure to give real distance values on the x-axis.
c) Provide 2 issues that limit the sensors performance. For each issue, explain why the issue arises in 2 sentences or less.

Some Equations that might be useful:

$$d = c\ t / 2$$

$$\lambda = c/f$$

$$D = f\ l / x$$

$$p\ (A \wedge B\ ) = p\ (A \mid B\ )\ p\ (B\ )$$

$$E[X_1\ X_2] = E[X_1]\ E[X_2]$$

$$\Delta\theta = (\Delta s_{right} - \Delta s_{left}) / b$$

$$\Delta s = (\Delta s_{right} + \Delta s_{left}) /2$$

$$p\ (x_t \mid o_t) = \Sigma_{x'}\ p\ (\ x_t \mid x'_{t-1}\ ,\ o_t\ )\ p\ (x'_{t-1}\ )$$

$$p\ (x_t \mid z_t) = \frac{p\ (z_t \mid x_t\ )\ p\ (x_t\ )}{p\ (z_t\ )}$$

$$x = \frac{b(x_l + x_r)/2}{(x_l - x_r)} \qquad\qquad y = \frac{b(y_l + y_r)/2}{(x_l - x_r)}$$

$$z = bf/(\ x_l - x_r)$$

$$p(x'_{i,t}) = \Sigma\ p\ (\ x_{i,t} \mid x_{j,t-1}\ ,\ o_t\ )\ p\ (x_{j,t-1}\ )$$