Spring 2012 Midterm

Introduction To Robotics (16-311)
3/5/2012

Name: _____

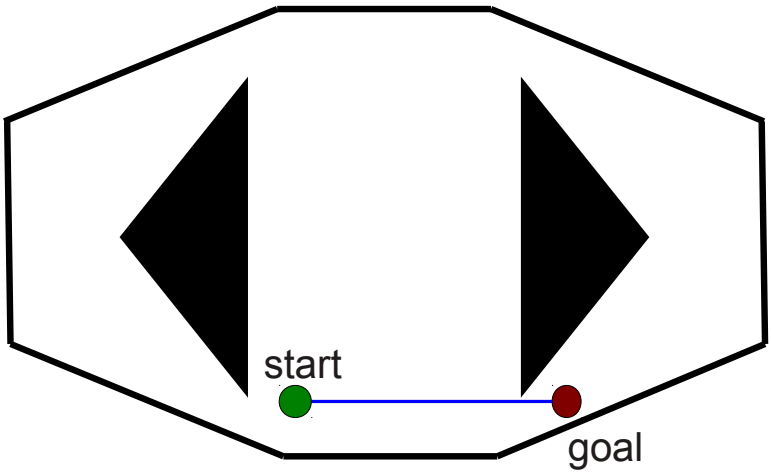
Group Number: _____

Read all of the following information before starting the exam:

- You have 1hr and 15 minutes to complete this exam.
- When drawing paths, be sure to clearly indicate rounded edges vs sharp edges.
- When in doubt, explain your answer as you might get partial credit.
- Justify your answers algebraically whenever possible to ensure full credit.
- Circle or otherwise indicate your final answers.
- Please keep your written answers brief; be clear and to the point.
- This test has 6 problems and is worth 100 points. It is your responsibility to make sure that you have all of the 11 pages!
- Good luck!

1. (*10 points*) Optimal Planning

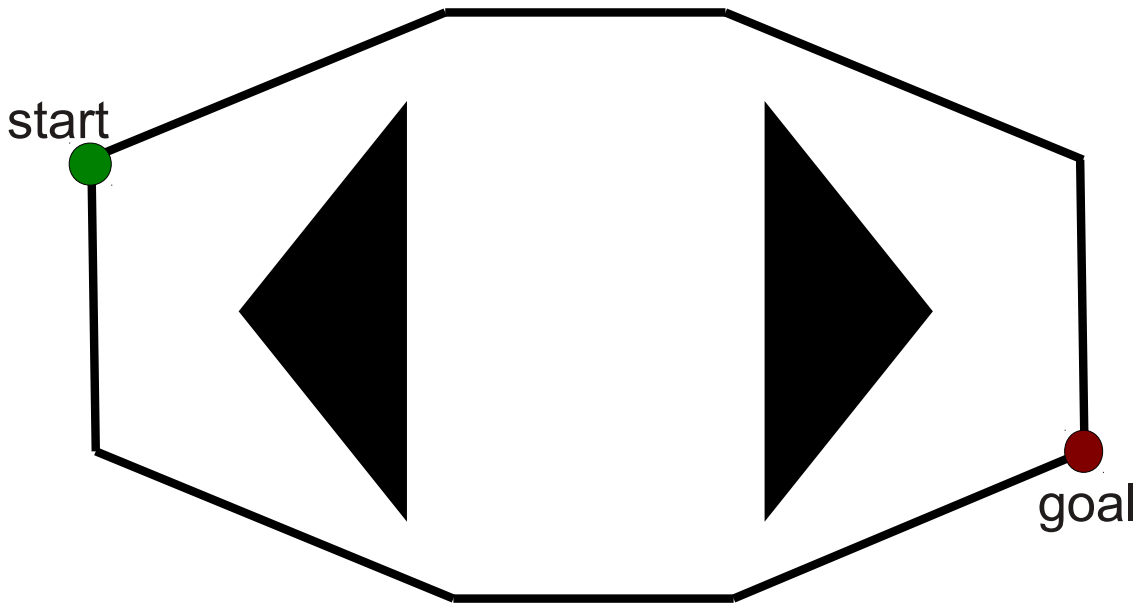
Consider the figure below with the shown obstacles, start, goal, and path.



Is the path optimal?

2. (*15 points*) Visibility Graphs

a. (*10 pts*) For the environment below, draw the visibility graph. Note that the start and goal nodes are already on vertices, so no extra vertices need to be added.



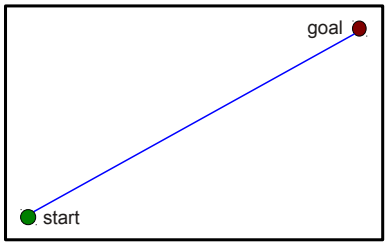
b. (*5 pts*) Using heavy, obvious lines, draw the shortest path in the above figure.

3. (*10 points*) True or False?

Circle the correct response in each part below. 1 point each.

TRUE FALSE A square is a rhombus.

TRUE FALSE The following path is optimal with respect to both the L1 and L2 metric



TRUE FALSE The distance between two points in the 8-connected metric is always less than (or equal to) the L1 distance.

TRUE FALSE The Bug 2 algorithm always produces shorter paths than Bug 1

TRUE FALSE Convolving an image with the following mask would detect diagonal edges (from bottom left to top right)

$$\begin{bmatrix} 1 & 1 & 1 & 1 & 0 \\ 1 & 1 & 1 & 0 & 1 \\ 1 & 1 & 0 & 1 & 1 \\ 1 & 0 & 1 & 1 & 1 \\ 0 & 1 & 1 & 1 & 1 \end{bmatrix}$$

TRUE FALSE A differential drive robot can drive in any direction, regardless of which way it is facing

TRUE FALSE Voronoi diagrams are examples of roadmaps

TRUE FALSE Consider a two link manipulator with no joint limits in a work space free of obstacles. The distance between $(10, 10)$ and $(350, 350)$ is 680 in the L1 metric

TRUE FALSE When we model the response from an ultrasound sensor as coming from anywhere on the arc, we are using a Gaussian distribution

TRUE FALSE It is possible to fly more than 10 micro aerial vehicles through a small opening and then in a figure 8 pattern

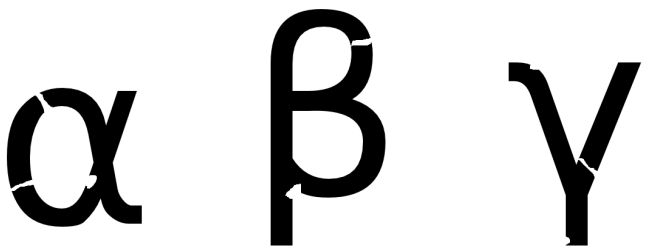
4. (*25 points*) Its all Greek to me

In this problem, you will outline an approach for detecting Greek letters. Assume you have a fill function as described below, as well as any other function we learned about in class or implemented for homework. Be sure to specify what the arguments and return value (if any) of these functions are. The fill function psuedocode prototype is:

```
fill(image, x, y, replace_value, color)
```

This function takes an image and an (x, y) location in that image and replaces all pixels within the blob of value `replace_value` with the value `color`. The function returns true if any pixels were updated (it doesn't update any pixels if it doesn't find `replace_value` at (x, y)).

a. (*15 pts*) For this part we only have the first three letters of the Greek alphabet all in lower case. However, the letters are not perfect and have broken patches as shown in the examples below. They will be in a similar font as shown below, so you don't need to worry about other ways of writing the letters.



Write psuedocode that could differentiate between the three letters above. Note that the letters you see will be similar to those above but not identical (they may have different places with small gaps, for example).

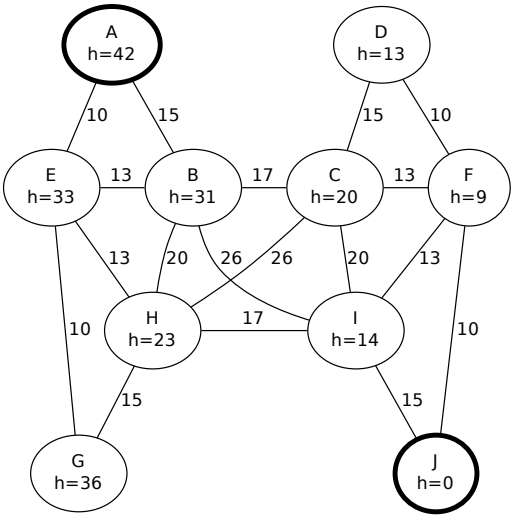
b. (*10 pts*) Now we introduce one more possible letter, a capital gamma, again corrupted by holes as shown in the example below:

Write psuedocode which can differentiate between the three letters above and this capital gamma. You can call your answer from part a as a sub-routine if you like.

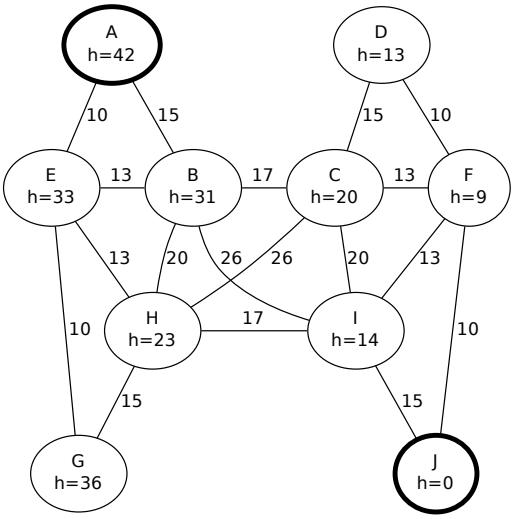
5. (*20 points*) Fun with A*

In this problem you will explore two different tie-breaking methods for A*. You will be asked to list the nodes in the order they are expanded, as well as list the final path returned. While the search is running, if you find a new path to a node which has the same f-value as a node already in the `open` list, do not update the path to that node.

For example, if your `open` list had node D with an f value of 5 and a backpointer to E (the path to D comes from E) and then you saw a new path to D from node K also with f value 5, you would **not** update the backpointer associated with D and the path would still go through E instead of K.



a. (*8 pts*) Run A* starting from node A to goal J. Break ties in alphabetical order. List the order of nodes expanded and the final path returned.



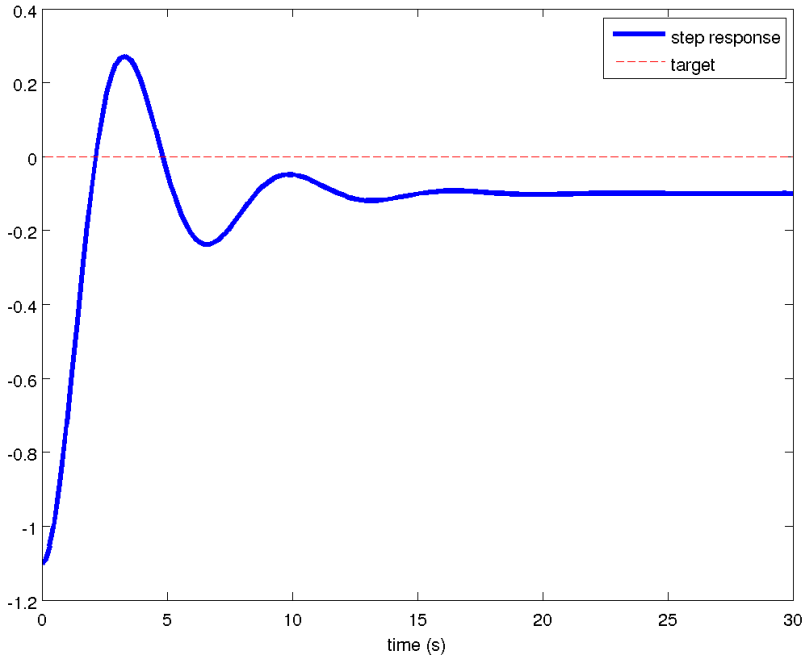
[This is the same figure, reproduced here to avoid excessive page flipping]

b. (*8 pts*) Run A* starting from node A to goal J. Break ties in reverse alphabetical order. List the order of nodes expanded and the final path returned.

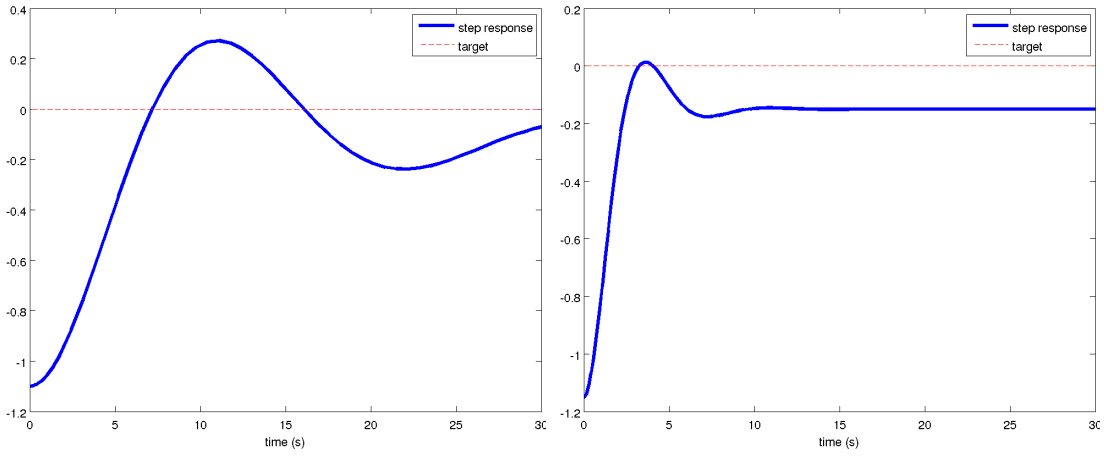
c. (*4 pts*) Did you get the same path for both parts above? If so, will you always get the same path, regardless of tie breaking order? If not, which path was shorter and how is it possible that two different paths are returned?

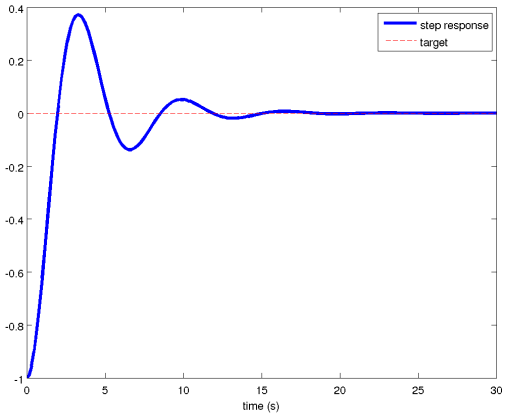
6. (*20 points*) Out of Control

In this problem you have a system and a PID controller. With the current gains, the step response is as shown below:



a. (*15 pts*) For each of the 3 pictures below, one of the PID gains has changed. Write on each picture which gain has changed and which way it went. Each gain is only changed once, so you should have one plot where P changes, one where I changes, and one where D changes. (5 points each)





b. (*5 pts*) You are so excited to have your new controller working that you put it on a robot arm and bring it to a demo showcasing 16-311 students. You test out the controller and it seems to be working great! Howie is introducing your project and your arm is noisy, so he asks you to turn off the motor while he is talking. 15 seconds later he asks you to turn the motors back on so everyone can see your great controller and you get the response below. What happened? How could you fix this?