SI475: Robotics Problem Set

Due: 30 April, 2007

Name:

Problem	Points	Score
1.	19	
2.	16	
3.	20	
4.	15	
5.	14	
6.	18	
7.	30	
total	132	

1. **Mobile Robot Kinematics** A mobile robot with differential drive and a wheelbase of 10cm starts out with the left wheel velocity of 5 cm/s and a right wheel velocity of 6 cm/s, for 15 seconds. Then both wheels increase in speed to 8 cm/s, for 10 seconds. Finally, the left wheel runs at 10 cm/s and the right wheel runs at 3 cm/s for 7 seconds.

   (a) What is the initial pose?

   (b) How many time periods are there?

   (c) For each time period, give:

      i. the pose at the end of the time period, relative to the start of the time period.

      ii. the pose at the end of the time period, relative to the initial pose.

2. **Detection**

   (a) What is the purpose of the detection module in robot control? That is, what does it do?

   (b) If we want to find the probability that the robot is in font of its recharging station, given its 2 sonars and 3 IR sensors, $P(R|s_1, s_2, i_1, i_2, i_3)$, what is the formula with out the naive assumption?

   (c) What is the formula for this **with** the naive assumption?

   (d) Assuming the Naive Bayes Assumption and given the following tables:

$\mathbf{P}(S_1\|T)$	$T \leftarrow$ true	$T \leftarrow$ false
$S_1 \leftarrow$ true	0.8	0.3
$S_1 \leftarrow$ false	0.2	0.7

$\mathbf{P}(S_2\|T)$	$T \leftarrow$ true	$T \leftarrow$ false
$S_2 \leftarrow$ true	0.5	0.6
$S_2 \leftarrow$ false	0.5	0.4

$\mathbf{P}(S_3\|T)$	$T \leftarrow$ true	$T \leftarrow$ false
$S_3 \leftarrow$ true	0.1	0.9
$S_3 \leftarrow$ false	0.9	0.1

   $\mathbf{P}(T) = 0.5, S_1 \leftarrow \text{false}, S_2 \leftarrow \text{true}, S_3 \leftarrow \text{false}$,
   what is $\mathbf{P}(T|S_1, S_2, S_3)$?

3. **Potential Fields**

   (a) Imagine a scenario where there is a robot at position (10,0), a point obstacle at (4,0) and a target at (0,0). The robot is using potential field to navigate. The magnitude of the attraction field around the target is given in terms of the distance to the target by:

$$m = \min(10, \frac{100}{d^2}).$$

The magnitude of the repulsion field around the obstacle in terms of the distance to the obstacle is given by:

$$-\frac{1}{4}x + 3.$$

Where is the equilibrium?

(b) Describe two techniques that would solve the problem of the equilibrium. That is, either prevent the equilibrium from occurring or get the robot out of it.

4. **Subsumption**

   (a) In subsumption architectures, modules at higher layers are more complex than those at lower layers. Describe why.

   (b) Illustrate your answer to part a) by describing a robot task of sufficient complexity, and designing a subsumption based system to solve it. Your answer must elucidate precisely why a subsumption architecture is a good idea, and make clear how it might solve it.

5. **Map-making**

   (a) Given a map-making situation with a robot in a grid, **calculate the probabilities for cell grid [3,6]** (where [0,0] is the lower left corner of the area), at times 0 and 1.
   general assumptions:

      i. Initially, $P(O) = .5$

      ii. The sensor model is approximated by:

         A. If the sensor reads a distance d that is within two units of the cell we're updating, then $P(s|O) = (20-d)/20$. For example, if the robot is at [0,0] and is updating the cell at [0,10], and the sensor reading s is 9, then $P(s \leftarrow 9|[0,10] isOccupied) = 0.55$

         B. If the sensor reads a distance d that is more than two units beyond the cell we're updating, then $P(s|\neg O) = (20-d)/20$.

   At time 0:

      i. The robot is located at grid location [3,5].

      ii. The north facing sonar returns a reading of 4 units.

   At time 1:

      i. The robot is located at grid location [3,2].

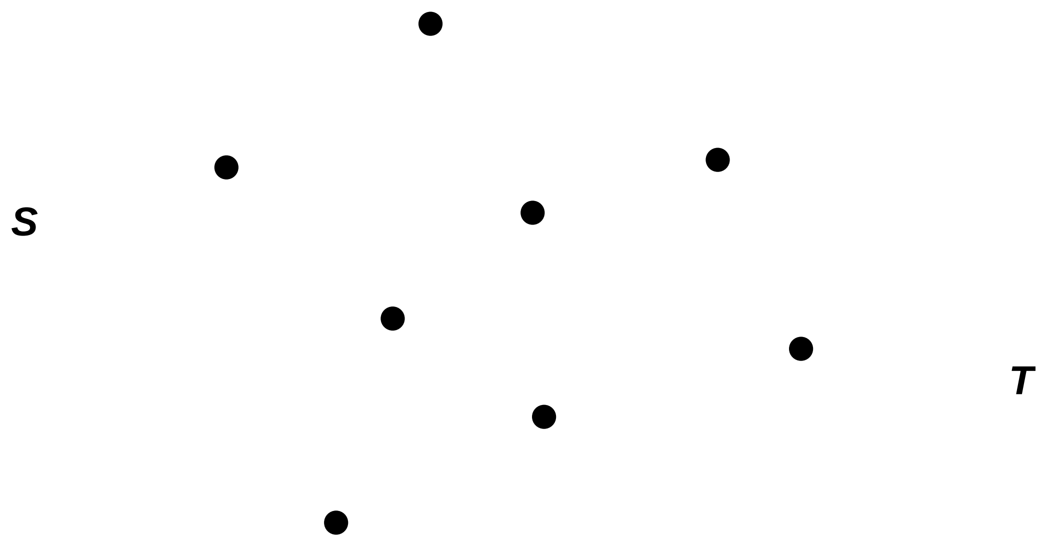
      ii. The north facing sonar returns a reading of 4 units.

6. **Navigation**

(a) Given the set of points below, construct the Voronoi Diagram. Label all of the vertices. Do not use S and T as points in your diagram.

(b) If the robot is at position S, and is instructed to plan a path to position T, what algorithm would you use to find it? What are the vertices of the path according to this algorithm? Why? If you need to use distances, estimate them with a ruler.

(c) What is a Generalized Voronoi Diagram? How does using the GVD change the algorithm for finding a path?



7. **Planning**

Sir Gawire was an ancient "Robot of the Round Table" who performed many important tasks for King Arthur. In particular, there was this one time when Arthur needed to borrow the Holy Wii from his cousin Mordred in the blue castle, but Mordred wasn't home. Sir Jiprotector had a key to the blue castle, but it taken by the Green Dragon Andon, who guarded it in the green castle. Sir Mineallmine had a green dragon slaying sword at the orange castle, but demanded payment of gummy candy to rent it. So Arthur sent Gawire off with a bag of Haribo Gummy Peaches.

If the start state has: Gawire at Camelot, Gawire has gummy peaches, Mineallmine at orange castle, Mineallmine has sword, Jiprotector at blue castle, Dragon Andon has key, Dragon Andon at green castle, Wii at blue Castle, blue castle locked,
and the actions are: goto, rent, slay, unlock, take, and return-rental
and the goal should include: Gawire at Camelot; Gawire has Wii; Gawire does not have sword then...

(a) Describe the start state in logic.

(b) Describe the actions, including the preconditions, the adds and the deletes.

(c) What was Gawire's plan?

(d) Demonstrate how Gawire came up with this plan. That is, show how the algorithm discovers the graph to find the plan by drawing the portion of the graph examined by the algorithm at each step. You might want to give the vertices letter names, and provide a table describing the world state corresponding to each vertex.

This is tricky in that it requires a great attention to detail. For instance, you need to include in the preconditions for *take* that you can't take if the castle is locked, otherwise, Gawire wouldn't need the key.