

## 16-869 Mid-term Exam

due November 7, 2000

This is a take-home exam. Please give your answers in readable handwriting, or prepare your answers on a computer and print them. Tests are to be returned in hardcopy only!

You are to complete this test on your own, without help from others. Print this cover page, sign it, and attach it as the front page of the test you sign in. By signing below, you certify you have completed this test by yourself.

Student name (please print):

Signature:

1. (10 points) What is the symbol system hypothesis? What is the grounded system hypothesis?
2. (10 points) In the motor schema approach (Arkin) how are the outputs of several motor schemas combined?
3. (10 points) Suppose we are combining the motor schemas MOVE-TO-GOAL and AVOID-OBSTACLE to enable a robot to navigate to a goal location. Give an example situation in which the robot will get stuck and be unable to reach the goal. You can draw a picture if you like.
4. (20 points) Suppose we are using Q-learning to program a robot. There are two possible states and two possible actions. The table of Q-values so far is:

	action <sub>1</sub>	action <sub>2</sub>
state <sub>1</sub>	0.1	0.4
state <sub>2</sub>	0.2	0.4

At time  $t - 1$  the robot was in state<sub>1</sub> and it selected action<sub>2</sub> and received a reward of 0.4. Now at time  $t$  the robot is in state<sub>2</sub>.

If  $\alpha = 0.2$  and  $\gamma = 0.8$  what are the new values of the four entries in the Q-table, using the standard update rule proposed by Watkins? Show your work.

5. (10 points) A robot team is composed of four types of robots: A, B, C and D. There are 2 robots of type A, 2 robots of type B, 2 robots of type C and 4 robots of type D. Using the information entropy-based metric proposed by Balch, what is the diversity of this system? Show your work.
6. (10 points) In Fox's approach to cooperative localization robots share information when they recognize each other to localize. Why must they move a certain minimum distance before sharing information again?
7. (30 points) Suppose your company has decided to develop an automated vacuuming system to clean single-floor department stores at night. You've been asked to spearhead the design. Describe the system you would propose, including the basic hardware and software. Would you use a multi-robot approach, or a single robot? How would the robots localize themselves? How would they divide up the work? Limit your answer to one page.