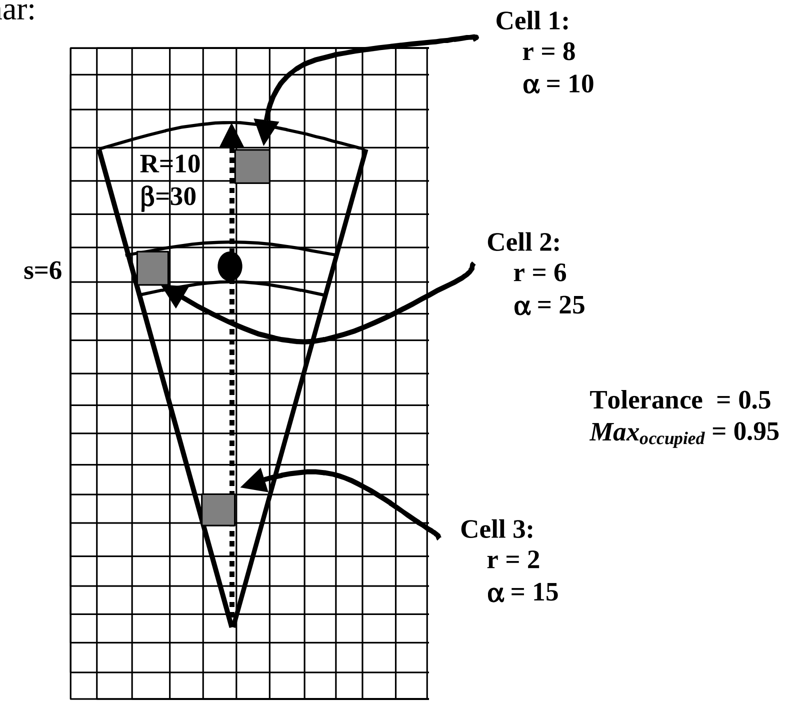
Homework 5 (Undergraduates only):

Sensor Models, Potential Fields, Vector Field Histogram, Combining behaviors

Assigned: Thursday, October 30, 2008
Due: Thursday, November 7, 2008, at the beginning of class (no later than 5:10 PM)
(Hard copy is acceptable.)

1. Bayesian Updates of Occupancy Grids -- Unconditional Probabilities.

Consider the situation in the following diagram, which shows the sensing model for a single sonar:



For the situation in the above diagram, supply the unconditional probability values for Cells 1, 2, and 3 below. If the value is unknown according to the sonar model update rules, then enter "Unknown".

Cell 1: $P(Occupied)$ = _______________

$P(Empty)$ = _______________

Cell 2: $P(Occupied)$ = _______________

$P(Empty)$ = _______________

Cell 3: $P(Occupied)$ = _________________

Cell 3: $P(Empty)$ = _________________

Conditional Probabilities.

Given that $P(H) = 0.80$, provide the following conditional probability values. If the value is unknown according to the update rules, then enter "Unknown".

Cell 1: $P(Occupied \mid s = 6)$ = _______________

$P(Empty \mid s = 6)$ = _______________

Cell 2: $P(Occupied \mid s = 6)$ = _______________

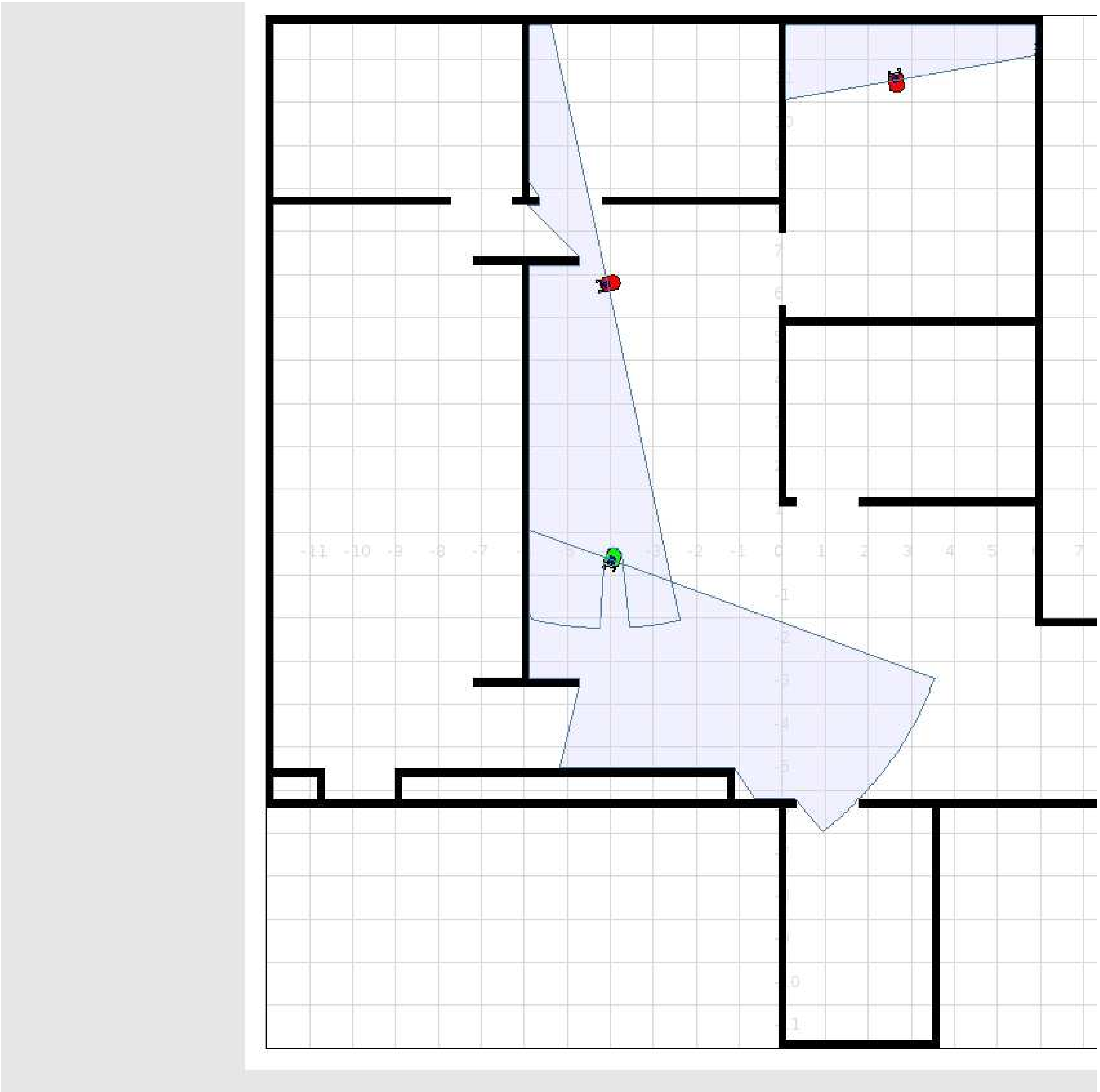
$P(Empty \mid s = 6)$ = _______________

Cell 3: $P(Occupied \mid s = 6)$ = _______________

$P(Empty \mid s = 6)$ = _______________

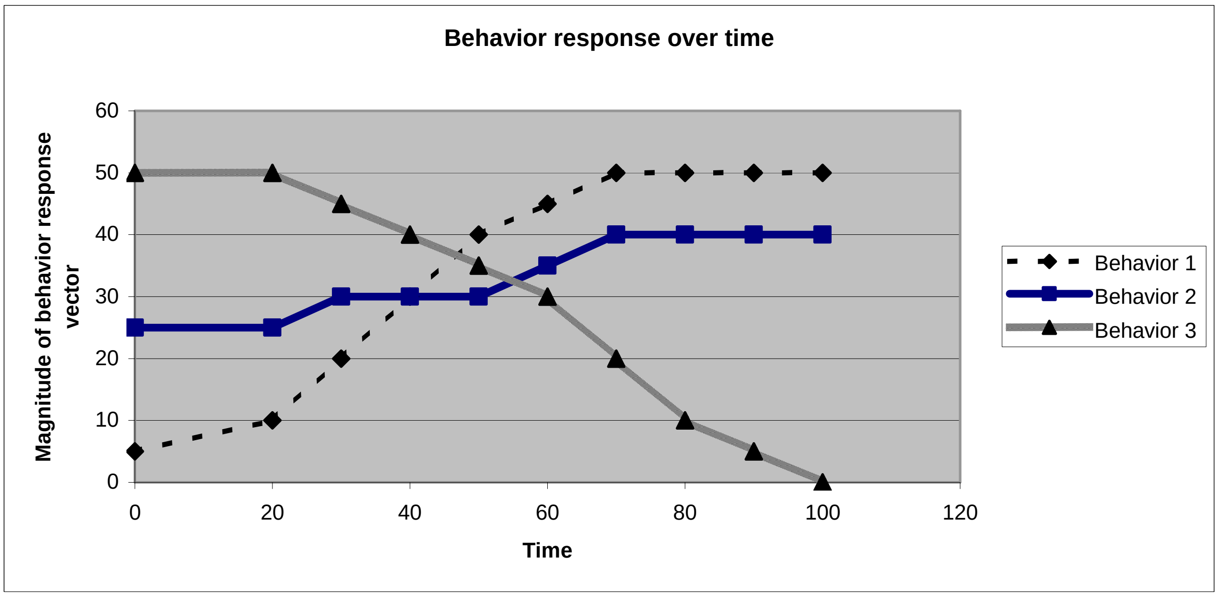
2. Potential Fields. Refer to the five primitive types of potential fields shown on slide 5 of the lectures slides on October 16th. Suppose you were to construct a library of potential fields of these five primitives. What parameters would you include as arguments to allow a user to customize the fields?

3. Vector Field Histogram. Draw the vector field histogram (VFH) for each of the following robots. (Be sure it is clear which VFH corresponds to each robot.)



4. Multiple Behavior Combinations

We have studied three methods for competitive behavior combination – priority-based coordination, action-selection coordination, and voting-based coordination. In the following questions, the table below gives the magnitude of the behavior response for each of three behaviors over time. (In this figure, all behavior response values are multiples of 5, so values located between the y grid lines are interpreted to be exactly half-way between the grids. For example, the starting values of the behavior responses at time t=0 are 5, 25, and 50.) Using this figure, answer the following questions (labeled subparts a through n).



<u>Priority-based (or fixed priority) coordination:</u>

Assume the gain vector, **G** = $\begin{bmatrix} g_{behavior_1} \\ g_{behavior_2} \\ g_{behavior_3} \end{bmatrix} = \begin{bmatrix} 2 \\ 1 \\ 0.6 \end{bmatrix}$ for all time values.

Also assume that the fixed priorities are Behavior 1 > Behavior 2 > Behavior 3, meaning that Behavior 1 has priority over Behavior 2, which has priority over Behavior 3.

At time t=20:

a. **What is the magnitude of the output response? ________________**

b. **Which behavior generates this output response? _______________**

At time t=60:

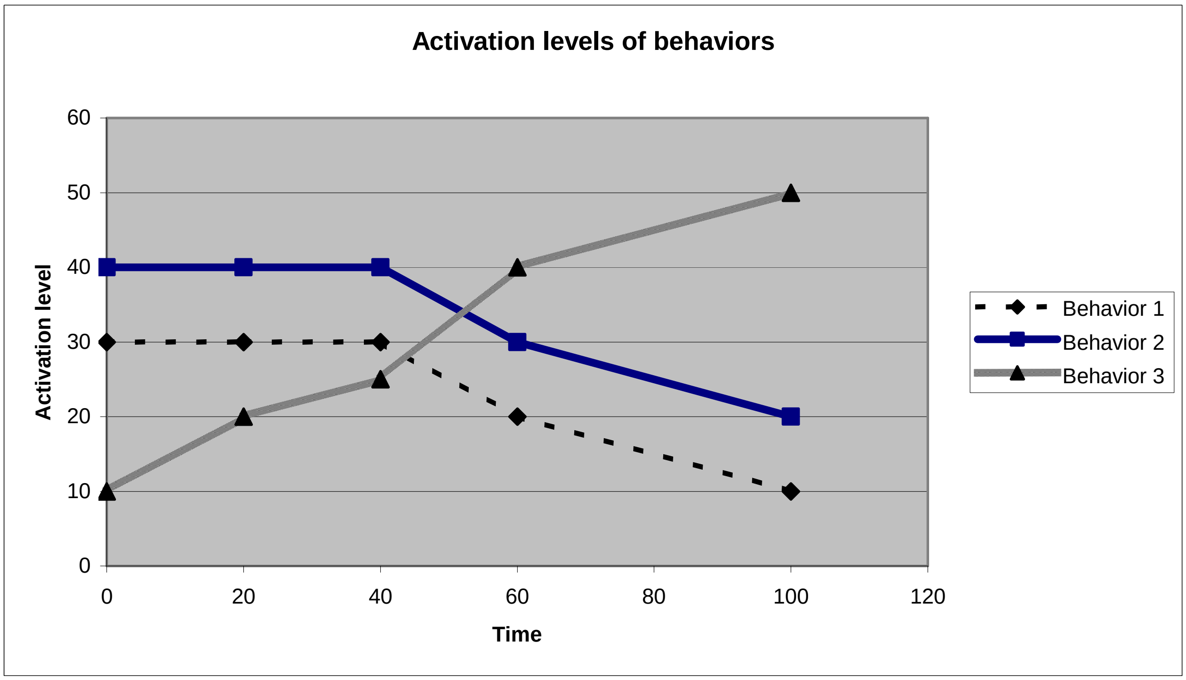
c. **What is the magnitude of the output response? ________________**

d. **Which behavior generates this output response? _______________**

Action-Selection coordination:

Assume the gain vector is still **G** = $\begin{bmatrix} g_{behavior_1} \\ g_{behavior_2} \\ g_{behavior_3} \end{bmatrix} = \begin{bmatrix} 2 \\ 1 \\ 0.6 \end{bmatrix}$ for all time values.

Also assume that the activation levels of each behavior are as shown in the following figure:



(As before, in this figure, all activation level values are multiples of 5, so values located between the y grid lines are interpreted to be exactly half-way between the grids.)

In this exercise, we are still using the behavior response diagram on the previous page.

At time t=20:

e. **What is the magnitude of the output response? ________________**

f. **Which behavior is generates this output response? _______________**

At time t=60:

g. **What is the magnitude of the output response? ________________**

h. **Which behavior is generates this output response? _______________**

Voting-based coordination:

Assume we now change the gain vector to be **G =** $\begin{bmatrix} g_{behavior_1} \\ g_{behavior_2} \\ g_{behavior_3} \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix}$ for all time values.

We are still using the behavior response values given previously.

We now have two predefined motor responses $\mathbf{M_1}$ and $\mathbf{M_2}$. Let $r^{B_i}_{magnitude}(t)$ equal the magnitude of the response vector of behavior B_i at time t. Then, the mappings of each behavior's output response to votes for the two motor responses is given by:

	Votes for M_1	**Votes for M_2**
Behavior 1:	0.1 x $r^{B_1}_{magnitude}(t)$	0.9 x $r^{B_1}_{magnitude}(t)$
Behavior 2:	1.0 x $r^{B_2}_{magnitude}(t)$	0.0 x $r^{B_2}_{magnitude}(t)$
Behavior 3:	0.4 x $r^{B_3}_{magnitude}(t)$	0.6 x $r^{B_3}_{magnitude}(t)$

At time t=20:

i. **What is the number of votes for M_1? ______________**

j. **What is the number of votes for M_2 ? ______________**

k. **Which motor response is activated? ____________**

At time t=60:

l. **What is the number of votes for M_1 ? ______________**

m. **What is the number of votes for M_2 ? ______________**

n. **Which motor response is activated ? ____________**