Homework 8 - due 11/5/2003

15-491: CMRoboBits

1 Introduction

This week's homework contains only written questions to give you time to think about your project proposal and finish homework 7. It is due next Wednesday at the *start* of class.

2 Localization in a grid world

You have a robot operating in a 25 state grid world. The robot may move North (N), South (S), East (E), or West (W). It does not have an orientation. The effects of your actions are uncertain. Most of the time they have the intended effect, but there is a chance that they will move the robot to the wrong square. The robot cannot move through walls. Any action that would result in hitting a wall fails with certainty and leaves the robot in its original location. Here is the complete description of your actions:

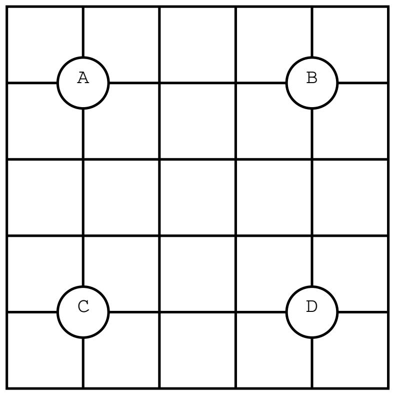
- North: p(N) = 0.8; p(NE) = 0.1; p(NW) = 0.1
- South: p(S) = 0.8; p(SE) = 0.1; p(SW) = 0.1
- East: p(E) = 0.6; p(NE) = 0.2; p(SE) = 0.2
- West: p(W) = 0.6; p(NW) = 0.2; p(SW) = 0.2

Note that North-South and East-West follow different patterns!

There are four beacons in the environment. These are labeled A, B, C, and D. If the robot is in one of the four squares adjacent to a beacon, it will see the beacon with certainty; there is no noise in the sensor signal. The robot cannot detect the orientation of the beacon, it can only detect its presence.

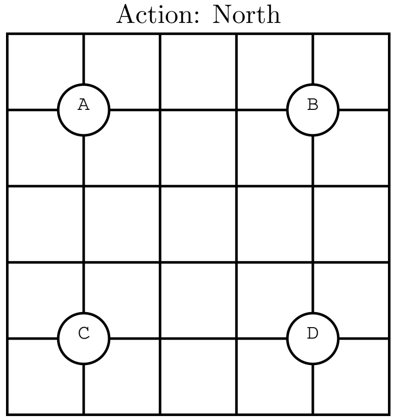
2.1

Consider the situation where the robot does not know where it is in the environment and has received no sensor updates yet. Fill in the values of the probability distribution function. Remember that they must sum to 1.0.

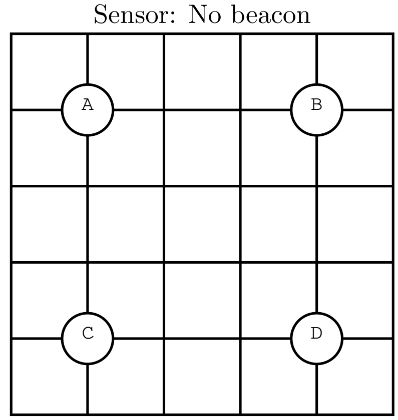


For each action, sensor update pair below, complete the probability distribution function after the action completes and then after the sensor reading. Start from the distribution above for the first pair only and use the distribution from after the previous sensor update for all subsequent pairs of distributions.

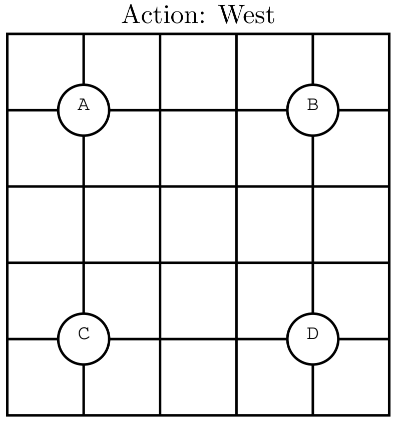
Action: North



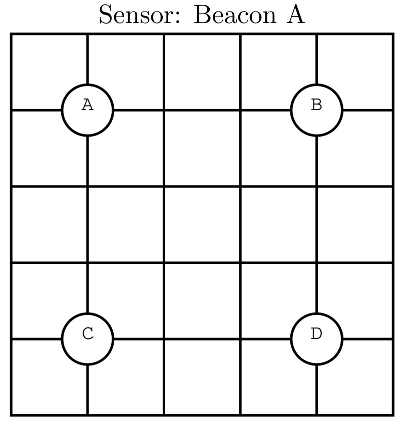
Sensor: No beacon

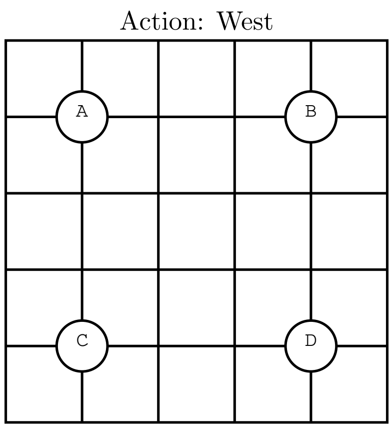


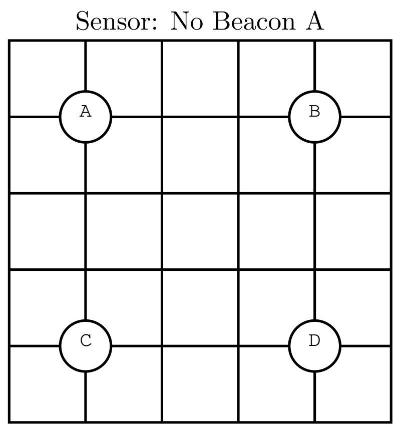
Action: West



Sensor: Beacon A







2.2

From an initial, known position at the center of the grid, is it possible to reach the lower left corner of the grid with certainty? Either provide a sequence of moves to do so or an informal proof that it is not possible.

3 Sensor models

Robots use a sensor model when they are localizing to estimate the likelyhood that objects' true positions take on certain values given sensor readings. For this question, assume that the robot sees a marker and *vision reports* that the marker is exactly 1500 millimeters from the robot.

3.1

Draw a sketch of the probability density function that represents the likelyhood of the marker truly being at a given distance from the robot. Your x-axis will be distance and your y-axis will be p(x). Assume that sensor noise is Gaussian with a standard deviation of 10% of the reported distance. Make sure to mark the distances that are 1 standard deviation away from the most likely point.

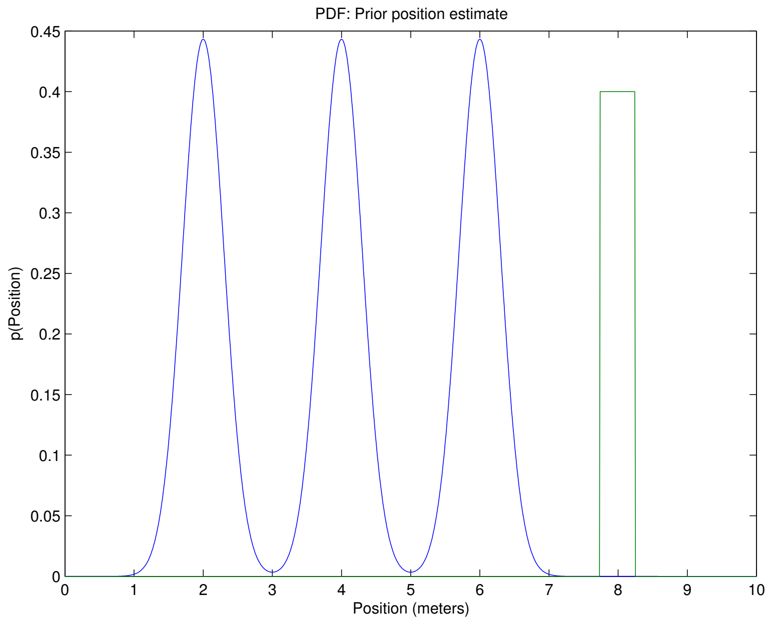
3.2

What is the area under your curve?

4 A sensor update

The following plot shows a map of a simple 2D environment and a robots belief about its position in the environment. The 3 Gaussian peaks to the left represent the robot's belief. The square at 8 meters is a marker - it has nothing to do

with the robot's belief about it's position; there is simply a marker at position 8 meters in the world.



The robot receives a sensor reading from vision telling it that there is a marker 4 meters in front of the robot. Given that sensor readings have Gaussian noise with a standard deviation of 50cm, sketch the new curve representing the robot's belief about its position.