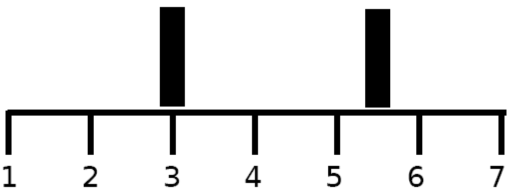
Cognitive Robotics

Assignment 5

5.1) Suppose your robot is equipped with a simple but noisy sensor that can detect a pole and returns the relative position of the pole. The possible measurements are: the pole is at the location to your left ($z = -1$), to your right ($z = 1$) or at your current position ($z = 0$). The maximum reading range is 1 meter, so sometimes you will not detect a pole at all ($z = n$). Your robot lives in a one-dimensional world and can be at one of seven possible locations ($x = 1, \ldots, x = 7$), each 1 meter apart. There a two poles at positions $x = 3$ and $x = 5.5$.



You are given the following sensor model:

$p(z \mid x)$	$x=1$	$x=2$	$x=3$	$x=4$	$x=5$	$x=6$	$x=7$
$z=-1$	0.0	0.00	0.25	0.50	0.0	0.5	0.0
$z=0$	0.0	0.25	0.50	0.25	0.5	0.5	0.0
$z=1$	0.0	0.50	0.25	0.00	0.5	0.0	0.0
$z=n$	1.0	0.25	0.00	0.25	0.0	0.0	1.0

Assume the following prior probabilities:
$p(x=1)=0.1$; $p(x=2)=0.2$; $p(x=3)=0.2$; $p(x=4)=0.2$; $p(x=5)=0.2$; $p(x=6)=0.1$; $p(x=7)=0.0$;

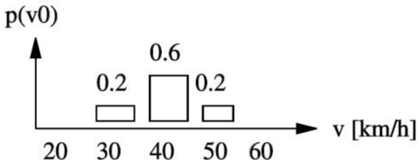
a) The robot makes a measurement $z=1$. Update the belief distribution of the robot over the robot locations by incorporating the likelihood of the measurement.

5 points

b) The robot tries to move one meter to the right, but the drive is imprecise. It might be that it stays where it is ($p=0.2$), that it really moves one meter to the right ($p=0.6$) or that it actually moves two meters to the right ($p=0.2$). Update the belief distribution by incorporating this motion model.

5 points

5.2) Consider the following every-day situation: You help your grandma to buy some groceries. Unfortunately, her car is rather old and the speed indicator is not working any more. Since you cannot afford another speeding ticket, you have to reason about your speed using just the public speed indicators on the side of the street (see the picture below). You guess, that your current speed v_0 is distributed as follows:



Of course, the acceleration is not perfect for such an old car. For each possible action, a = -10 (slowing down 10km/h), a = +10 (accelerating by 10 km/h), a = 0 (keeping the speed), the transition probabilities for the speed v of your car are given in the following table.

	$v_{i+1} = v_i - 10$	$v_{i+1} = v_i$	$v_{i+1} = v_i + 10$
$a_i = -10$	0.7	0.3	0
$a_i = 0$	0	1	0
$a_i = +10$	0	0.2	0.8

The public speed indicators that provide you with speed measurements m_i have the following measurement accuracy:

	$m_i < v_i - 10$	$m_i = v_i - 10$	$m_i = v_i$	$m_i = v_i + 10$	$m_i > v_i + 10$
probability	0	0.1	0.7	0.2	0

On the ride to the supermarket, you perform the following actions and obtain the following measurements. Each measurement m_i is obtained after the according action a_i has had its effect on the speed.

time i	**1**	**2**	**3**
action a_i	-10	0	+10
measurement m_i	40	50	50

Please use the Bayesian Filtering technique to calculate your belief about the car speed after each time step *i* !

6 points

5.3) Particles filters use a set of weighted state hypotheses, which are called particles, to approximate the true state x_t of the robot at every time step t. Think of three different techniques to obtain a single state estimate $\overline{x_t}$ given a set of N weighted samples:

$$S_t = \left\{ \left\langle x_t^{[i]}, w_t^{[i]} \right\rangle \middle| i = 1, \ldots, N \right\}$$

2 points

5.4) The samples are weighted according to the observation model. Provide a derivation that explains that.

2 points