CMSC 671 (Introduction to AI)

Homework 5 (85 points)

Turnin: Blackboard.

Please turn in all parts together as a single PDF file named *lastname*_hw5.pdf.

All work should be completed individually. This homework is *optional*—you do not have to do it! However, it *is not extra credit*. If you turn the homework in, your results will be graded and averaged into your overall homework grade.

PART I. PLANNING (35 PTS.)

Consider the following four operators (from the textbook):

Operators

	RightShoe	RightSock	LeftShoe	LeftSock
preconds:	RightSockOn	-	LeftSockOn	-
adds:	RightShoeOn	RightSockOn	LeftShoeOn	LeftSockOn
deletes:	-	-	-	-

Assignment:

1. Define additional operators for putting on a shirt, hat, and coat, assuming that you must have a coat on before you can put a hat on. Give preconditions, additions, and deletions for your new operators. *(5 pts)*

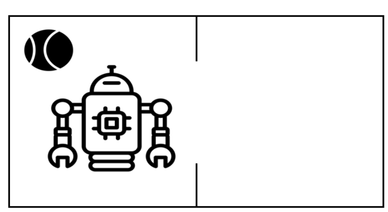
2. Give (that is, draw) a **partially ordered plan** that is a solution to the problem of getting dressed (wearing all seven different articles of clothing). Assume that you start the plan wearing none of them. Do not give a single linear plan. *(5 pts)*

3. Give one linearized plan derived from the partially ordered plan in question 2. *(5 pts)*

Next, consider a robot with two grippers (`gripper1` and `gripper2`). It can pick up and put down objects with the grippers, and each gripper can hold only one object. The following operators represent these actions:

Operators

	Pick(obj,room,gripper)	Drop(obj,room,gripper)
preconds:	At(obj,room) At-robot(room) Empty(gripper)	Carry(obj,gripper) At-robot(room)
adds:	Carry(obj,gripper)	At(obj,room) Empty(gripper)
deletes:	At(obj,room) Empty(gripper)	Carry(obj,gripper)



room1 *room2*

Assignment:

4. Write an operator `Move`, representing the action of moving from one room to another. Give preconditions, additions, and deletions for your new operator. *(5 pts)*

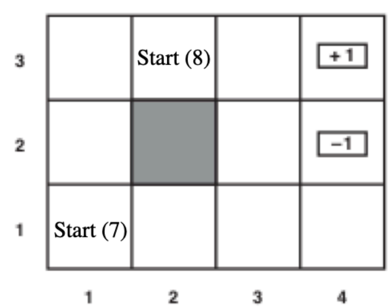
Now consider the situation depicted in the figure. There are two rooms (`room1` and `room2`). The robot is in `room1`, and both its grippers are empty. There is one ball (`ball1`), and it is also in `room1`. The goal is to move `ball1` from `room1` to `room2`.

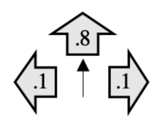
Assignment:

5. Write out the initial situation and the goal state using the predicates given. *(5 pts)*

6. Give a plan that is a solution to the stated problem. How many linearizations exist for this plan? *(10 pts)*

PART II. SEQUENTIAL DECISION MAKING (25 PTS.)





Consider the problem-solving scenario we have been using in class (drawn from the textbook): An agent is navigating in a grid-world, trying to reach state (4,3) while avoiding the state (4,2). Each time the agent moves, it goes the intended direction with probability 0.8, or goes off to one side or the other with probability 0.1 – so, for example, if the agent tries to go Right, it has a 10% chance of moving Up, a 10% chance of moving Down, and an 80% chance of successfully moving Right. When the robot hits a wall or obstacle, it stays in place (and receives a reward for the state it is in).

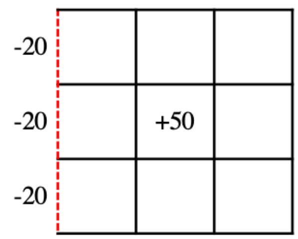
Assignment:

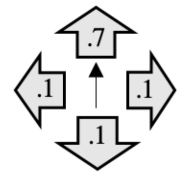
7. Calculate all possible squares that can be reached from (1,1) by the action sequence [Right,Right,Right,Up,Up] and with what probabilities they are reached. *(10 pts)*

8. Now consider the case where the agent starts in state (2,3) and performs the action sequence [Right,Right,Up]. Remember that (4,3) and (4,2) are terminal states (if the robot reaches them the actions stop). Give all possible **sequences** of moves the robot may go through (not just the end states). *(10 pts)*

9. If the reward function is +1 and -1 as shown and -0.05 for all other actions, what total reward does the agent receive for each of the possible sequences of moves in problem **8**? *(5 pts)*

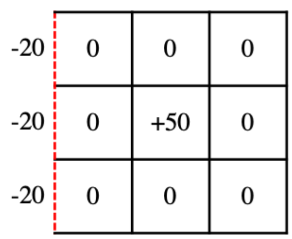
PART III. VALUE ITERATION (25 PTS.)





Consider a robot navigating in a 3x3 grid-world environment, as shown (right). The terminal state is in the center of the world, and the wall along the left-hand side is an electric fence (shown as a dashed line). Any time the robot moves, it has a probability = 0.7 of moving in the direction it intended, and a probability = 0.1 of moving in one of the other **three** directions (as shown on the right-hand side for an 'Up' movement).

The reward function for this problem-space is as follows: the robot receives a reward of 0 for every step it takes (there is no penalty for making moves); it receives a reward of +50 for entering the center square; and it receives a reward of -20 for bumping into the left-hand wall. We are going to use the Bellman equation to perform value iteration to begin the process of finding the optimal utility values for each state, with $\gamma = 0.9$. The utility values initially, and then after the first iteration, are:



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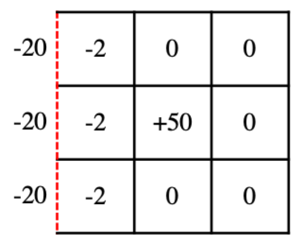

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Assignment:

10. Calculate and the utilities of all states after one more iteration. Show all work. *(25 pts)*