CS302/ CS633 Introduction to Artificial Intelligence
End Semester Examination
Winter 2021-22

Instructions:

I. This is a closed book/ notes/ internet examination. The duration of the examination is 100 minutes. No need to hurry, the problems are intentionally designed so that you can not solve them in 100 minutes. Pick problems in which you are comfortable. Not every problem is for you to solve. However, you are encouraged to attempt as many problems as you can.

II. Clearly state all the assumptions, if any, while answering the problem.

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1. Suppose you are an investor and, can invest INR 10,000 either in a safe asset, say government bonds, which brings 10% return in one year, or in a risky asset say a stock issued by a corporation, which either brings 20% return (if the company performance is good) or zero return (if the company performance is bad).

	State	
	Good	Bad
Bonds	10%	10%
Stocks	20%	0%

Let us denote the probability of the good state occurring by p and that of the bad state 1-p. You wish to maximize the amount of money you have at the end of the year.

a. What will be your preference for investment as a function of p?

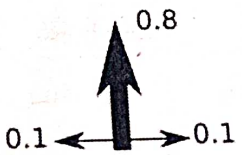
b. Suppose you are allowed to invest a sum total of INR 10,000 in any way you prefer to in both, i.e. bonds and stocks, what will be your preference for investment as a function of p?

[15 Points]

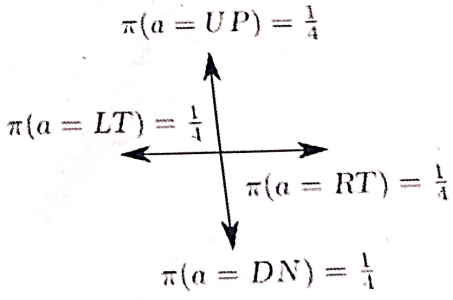
2. Suppose that an agent is situated in the 2x2 grid environment as shown below.

r(S1)=-1	r(S3)=-1
r(S2)=+1	r(S4)=-1

2-D Grid World



Stochastic Environment



Policy : π

Beginning in the start state, it must choose an action at each time step. The interaction with the environment terminates when the agent reaches the goal state (S2), marked +1.

We assume that the environment is fully observable, so that the agent always knows where it is. You may decide to take the following four actions in every state: Up, Down, Left and Right. However, the environment is stochastic, that means the action that you take may not lead you to the desired state. Each action achieves the intended effect with probability 0.8, but the rest of the time, the action moves the agent at right angles to the intended direction with equal probabilities. Furthermore, if the agent bumps into a wall, it stays in the same square. The immediate reward for moving to any state, denoted by r(state), except for the terminal states is r(s)= -1. And the reward for moving to the terminal state is +1 respectively.

a. Setup the Markov Decision Process for the above problem.
b. Define the value function for a given policy and explain the same using a backup diagram.
c. Write down the Bellman equation for the value function corresponding to a given policy.
d. Set up the system of linear equations, solve the same and find the value function corresponding to the uniform (equiprobable actions) policy.

[20 Points]

3. Flexibility in the education system allows for a lot of scope for innovation. In one such system, you are posed with a question to decide on the mode through which you will appear for the examination. However, the examiner has to put different amounts of effort into designing and evaluating the exams in given modes. And, so the examiner after the exam may decide to take one of the views on evaluation. Based on various factors, the agreed upon pay off (utility) matrix for both examiner and you is given below. The numbers in brackets are indicative of the utilities of the examiner and you respectively.

G:Game		You (Player 2)	
		A:Remote	B:On-campus
Examiner (Player 1)	1:Lenient	(75, 80)	(10, 70)
	2:Moderate	(60, 50)	(50, 60)
	3:Strict	(40, 20)	(90, 20)

a. Is this a normal form zero-sum game?

b. Define Nash Equilibrium. For the above game, are there any pure NE? Explain weak and strong pure NE in context of the game G.

c. Consider that the examiner's view is probabilistic and expressed by p(1)=0.2, p(2)=0.7 and p(3)=0.1. What are your expected utilities for both Remote and On-campus choices?

d. What is your best response correspondence given the examiner's mixed strategy described by the above probability distribution on its strategies?

e. What is the examiner's best response correspondence given that your mixed strategy is (p(A)=1, p(B)=0)?

f. Are there any mixed strategies NE (excluding the pure ones) for this game? Explain.

[15 Points]

4. The lights-out game is played on a 5 by 5 board. Each square can be in two positions, ON or OFF. The game is in some initial state, where at least one square is ON. The moves constitute clicking on a particular square. The effect of the click is to toggle the position of its four neighboring squares. The task is to bring all squares to the OFF position.

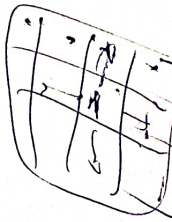
   A. Pose the above problem as a state space search problem.
   B. Suggest a heuristic function to guide the search.
   C. Out of the possible choices, which heuristic search algorithm would you prefer for this problem, provide sufficient reasoning for your choice. Explain the working of the suggested algorithm.

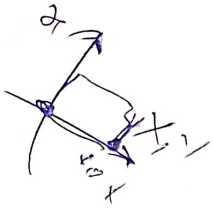
[15 points]

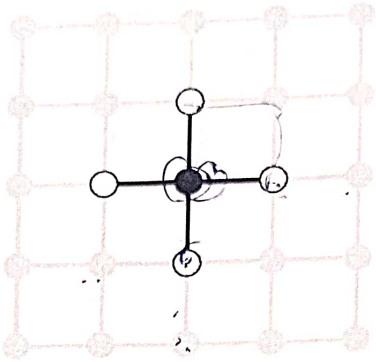
5. Maan, Maaeri and their grandparents have to cross a bridge over the river within one hour to catch a train. It is raining and they have only one umbrella which can be shared by two people. Assuming that no one wants to get wet, how can they get across in an hour or less? Maan can cross the bridge in 5 minutes, Maaeri in 10, their grandmother in 20, and their grandfather in 25. Pose this problem as a state space search problem. Find a solution using your *preferred* algorithm and explain the solution step by step.

[20 Points]

6. Consider the unbounded version of the regular 2D grid, with neighboring nodes being one unit distance apart, shown in the figure below. The start state is at the origin, **(0,0)** (filled node), and the goal state is at **(x,y)**.







a. What is the branching factor **b** in this state space?
b. How many distinct states are there at depth **k** (for **k>0**)?
c. What is the maximum number of nodes expanded by breadth-first graph search?
d. Is **h=|u-x|+|v-y|** an admissible heuristic for a state **(u,v)**? Explain.
e. How many nodes are expanded by A* graph search using **h**?
f. Will the **h** remain admissible if some links are removed?
g. Does **h** remain admissible if some links are added between nonadjacent states?

[20 points]

7. Represent flow of the course in the form of a graph/ tree, where the nodes are the topics and the directed edges are indicative of the transition order in which the nodes were traversed. Assign weights to the edges proportional to the time spent on creating the corresponding head nodes. Highlight the nodes on which you have spent a considerable amount of time due to your interest. According to you, which nodes can be removed without affecting the flow of the course. Add additional nodes, at appropriate locations, that according to you should be introduced in the next run of the course.

I have often pondered over the roles of knowledge or experience, on the one hand, and imagination or intuition, on the other, in the process of discovery. I believe that there is a certain fundamental conflict between the two, and knowledge, by advocating caution, tends to inhibit the flight of imagination. Therefore, a certain naivete, unburdened by conventional wisdom, can sometimes be a positive asset.

Quoted in R Langlands, Harish-Chandra, *Biographical Memoirs of Fellows of the Royal Society* 31 (1985) 197 - 225.