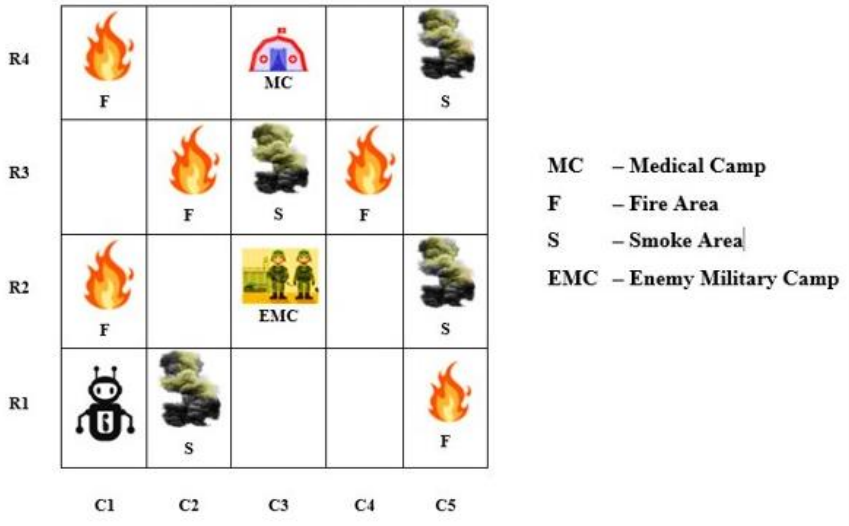
Birla Institute of Technology & Science, Pilani
Work Integrated Learning Programmes Division
First / 2023-2024

Mid-Semester Test
(EC-2 Makeup)

Course No.	: AIMLCZG557
Course Title	: Artificial and Computational Intelligence
Nature of Exam	:
Weightage	: 30%
Duration	: 2 Hours
Date of Exam	: 27-07-2024 (AN)

No. of Pages = 3
No. of Questions = 4

Note to Students:
1. Please follow all the *Instructions to Candidates* given on the cover page of the answer book.
2. All parts of a question should be answered consecutively. Each answer should start from a fresh page.
3. Assumptions made if any, should be stated clearly at the beginning of your answer.

Q1	A city in Ukraine has become a battleground, surrounded in fire and smoke. The AI agent is positioned at the city's entrance, located at (R1, C1). The critical mission is to deliver essential medical supplies to a medical camp situated within the city at (R4, C3). The AI agent must find the shortest and safest path from the starting location to the medical camp, navigating through the hazardous environment filled with obstacles such as fire, smoke, and enemy military camps. The agent must efficiently plan the route to ensure the timely delivery of the medical supplies. The city is represented as a 4x5 grid. The agent is equipped with four distinct actions: Move Up, Move Down, Move Left, and Move Right. However, it cannot move into cells occupied by enemy military camp (EMC) **[3+4+3 = 10 Marks]** ***Initial State:***  a) Expand & depict the search tree for up to exactly three levels (level 1, level 2 & level 3). (Given initial state can be assumed to be on level-0.) b) Calculate the path cost and heuristic values for all generated nodes in the search tree.	10 Marks

Path cost calculation:

If the agent enters a cell with smoke, the cost increases by +5; if it enters a cell with fire, the cost increases by +10. For entering an empty or safe cell, the cost increases by +2.

Heuristic design for calculation:

H(n) = Manhattan distance (Agent current position, Medical Camp) + Number of safe cell /empty cell adjacent to Agent's position in the resultant state + No of fire cells adjacent to Agent's position in the resultant state

c) Apply Iterative Deepening A* search algorithm for the search tree obtained from part a and using heuristic design calculated under part b, only till first 4 closed list updates or till no more nodes are left. Show the status of OPEN and CLOSE list at each level and the step by step procedure as discussed in the class.

Sample Solution & Marking Scheme :

a) Search Tree if level 1 is expanded – 0.5 mark

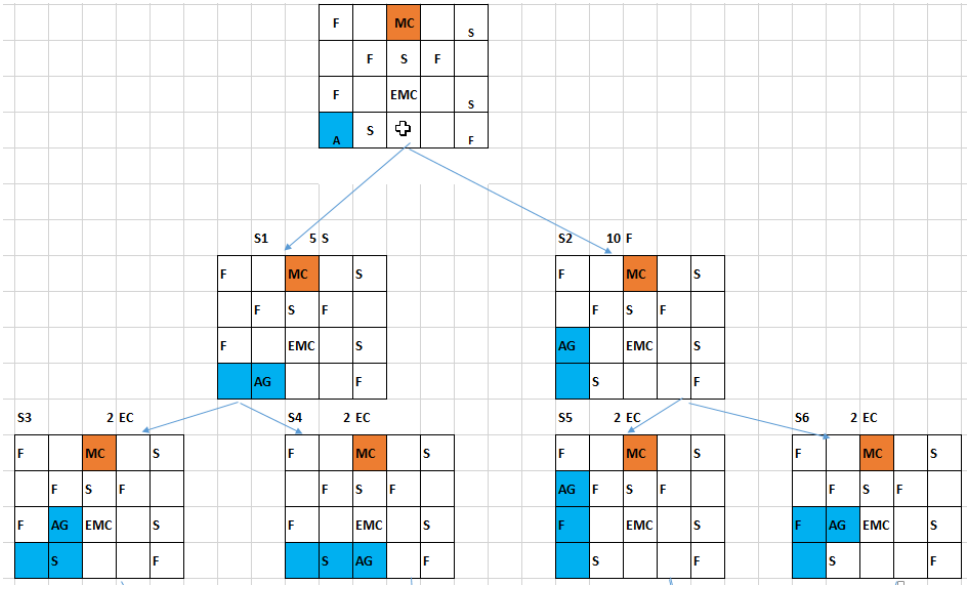
Search Tree if level 2 is expanded – 1 mark

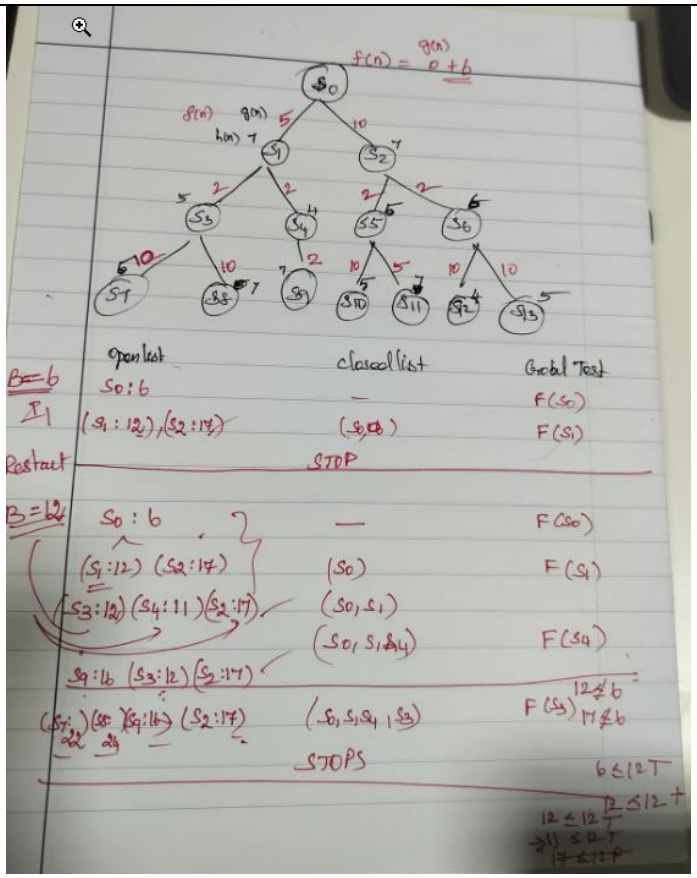
Search Tree if level 3 is expanded – 1.5 mark

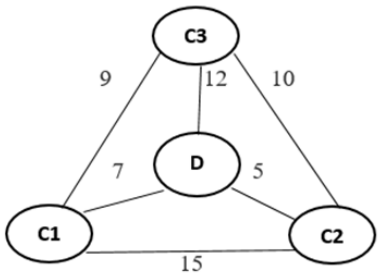
a) Cost calculation for all the nodes – 2 mark

Heuristic calculation for all the nodes – 2 mark

b) Find first 4 closed list updates – 3 marks



		
Q2	Answer to the below question for the following scenarios. Vague theory will not be awarded marks. **[2+2+2 = 6 Marks]** Imagine you are tasked with designing an automated surveillance and defense system for a military base. The system is equipped with drones and sensors positioned at strategic points around the perimeter to monitor and gather data on potential threats. It scans for unauthorized activities and intrusions, comparing them with a database of known threat patterns to ensure the base remains secure. a. Provide the complete problem formulation. b. Provide the PEAS description. c. Identify the various dimensions of the task environment with appropriate justification for each in no more than 30 words Sample Solution a. Problem formulation: Initial state : Automated surveillance and defense system in positions, Database of unauthorized activities and intrusions, database of known threat patterns. Goal State : Correct identification of unauthorized activities and intrusions. Transition function : At(X, No unauthorized activity) -> At(Y, unauthorized activity detected). At(X, No intruder identified) -> At(Y, intruder identified) Cost : Cost = Maximum detection of unauthorized activities and intrusions and minimize false detection b. Performance – Correct detection of unauthorized activities and intrusions,	6 Marks

	Environment- High intrusion areas, people and their movement., Actuator – Scanning of peoples unauthorized activities and intrusions, Sensors – surveillance and defense system c. Dimensions of task environment – Multi agent, continuous, deterministic, episodic, and dynamic. Justification for all the dimensions Marking scheme: a. Problem formulation Initial state, Goal state, Transition function, Cost – If all present 2 marks (0.5 marks each) b. PEAS – 2 marks (0.5 marks each) c. Dimension of the task environment (at least 4 dimensions) 1 mark, Justification 1 mark.	
Q3	Suppose you are managing a fleet of delivery vehicles for a courier company. You have a depot (D) where all the delivery trucks start, and a list of customers (C1, C2, C3) that need to be visited. The distances between the depot and the customers, as well as between the customers themselves, are given in the form of graph. Your task is to plan the most efficient routes for a delivery trucks (D) to deliver packages to a group of customers and return to the depot. Use ACO to find the optimal routes for the delivery truck. **[8 Marks]** Rate of evaporation = 0.1; the relative importance of pheromone is 0.6 and the relative importance of distance is 0.7; Q = 80; Pheromone matrix is as given below: $\begin{array}{c\|cccc} & D & C1 & C2 & C3 \\ \hline D & 0 & 0.15 & 0.26 & 0.48 \\ C1 & 0.15 & 0 & 0.48 & 0.26 \\ C2 & 0.26 & 0.48 & 0 & 0.15 \\ C3 & 0.48 & 0.26 & 0.15 & 0 \end{array}$  Solution & Marking scheme: Next Probability calculation from D & Pheromone update = 4 Mark Next Probability calculation from C2 & Pheromone update = 2 Mark Next Probability calculation from C3 & Pheromone update = 1 Mark Final Path : 1 Mark	8 Marks

inverse of distance		
DC1	0.142857	C1D
DC2	0.2	C2D
DC3	0.083333	C3D
C1C2	0.066667	C2C1
C1C3	0.111111	C3C1
C3C2	0.1	C2C3

1st iteration	Node transition probability			Pheromone updation				
DC1	0.082051	0.241641			D	C1	C2	C3
	0.144446			D	0			
	0.113062			C1	0.015	0		
DC2	0.144446	0.425392		C2	16.026	0.048	0	
DC3	0.113062	0.332968		C3	0.048	0.026	0.015	0

2nd iteration								
C1C2	0.024293	0.602062		Pheromone updation				
	0.016057				D	C1	C2	C3
C2C3	0.016057	0.397938		D	0			
				C1	0.0015	0		
				C2	1.6026	5.333833333	0	
				C3	0.0048	0.0026	0.0015	0

3rd iteration

Unvisited C3

D-C2-C1-C3-D

Pheromone updation

	D	C1	C2	C3
D	0			
C1	0.00015	0		
C2	0.16026	0.533813333	0	
C3	0.00048	8.889148889	0.0015	0

Q4

Imagine a data center where four different computing tasks (Task 1, Task 2, Task 3, Task 4) need to be scheduled for execution. Each task involves specific CPU usage and execution times. The objective is to efficiently schedule these tasks to minimize CPU usage and execution time, ensuring optimal performance and resource utilization. **[2.5+3.5 = 6 Marks]**

6 Marks

Task Characteristics:

Task Name	CPU Utilization	Execution time
A	2	6
B	3	8
C	1	5
D	4	7

Each potential schedule is represented by a chromosome x = (t1,t2,t3,t4), where ti represents the i-th task in the schedule. The fitness of a schedule is determined by a function that balances CPU usage and execution time:

f(x) = w_1 * Total_CPU_Usage(x) + w_2 * Total_Execcution_Time(x)

Let's assume w_1=0.2, w_2=0.8

- TotalCPUUsage(x) is the sum of CPU requirements for all tasks in the schedule.
- TotalExecutionTime(x) is the total time taken to complete all tasks in the schedule.
- w1 and w2 are weight parameters that determine the importance of CPU

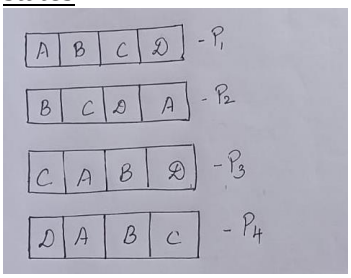
usage and execution time, respectively.

a. Describe the chromosome representation of a parent state for four randomly selected states along with their fitness scores. After calculating the fitness of these four randomly generated chromosome representations, what are your observations? Is the computed fitness value adequate for the selection process? If not, suggest an appropriate method for improvement.
b. Suggest an appropriate process of selection, crossover and mutation steps for this problem. Show these with only one iteration of numerical example.

Sample Solution & Marking Scheme :

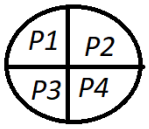
a) Fitness Score Calculation: 1 marks
Chromosomal representation with fitness score: 1 marks
Suggestion for an appropriate selection method ; 0.5 makrks
b) Selection: 1 marks
Crossover: 1.5 marks
Mutation: 1 mark

a) Chromosome representation of a parent state for four randomly selected states

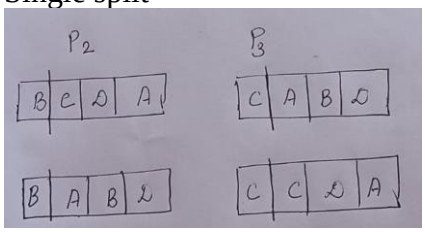


f(x)=w1*Total Resource Utilization(x) + w2*Total Completion time(x)
=0.2*10 + 0.8*26
=2+20.8
=22.8
All the states have same fitness score as 22.8

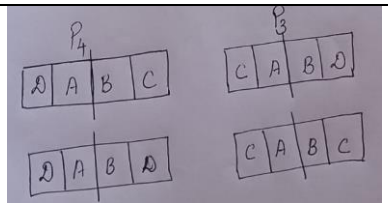
b) Selection
Since the fitness value is same for all states, randomization can be used.
Using **Roulette wheel,** the parent can be used as chance of
P2, P3, P4, P3



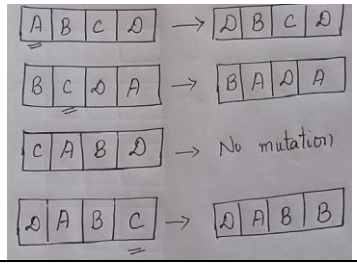
Crossover
Either using single split or multiple split
Single split



Double Split


P4
D A B C
D A B D
P3
C A B D
C A B C

Mutation


A B C D → D B C D
B C D A → B A D A
C A B D → No mutation
D A B C → D A B B

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