SI04 1-2023 ACI MID Exam Answers

Artificial and Computational Intelligence (Birla Institute of Technology and Science, Pilani)

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

Mid-Semester Test
(EC-2 Regular)

Course No.	: DSESIZG557
Course Title	: Artificial and Computational Intelligence
Nature of Exam	: Open Book
Weightage	: 30%
Duration	: 2 Hours
Date of Exam	: 3rd August 2024 (FN)

No. of Pages = 3
No. of Questions = 5

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.

Q.1. Answer the below 3 questions for the given scenarios. Vague theory will not be awarded marks. [2+2+2=6 Marks]

"A forest fire has broken out in a remote area, posing a threat to human lives and wildlife. Emergency response teams have deployed a rescue agent to assist in the rescue operations. The rescue agent analyzes the sensor data to assess the severity of the fire, identify areas of high heat intensity, and locate trapped or stranded individuals. The thermal cameras on the rescue agent help detect human presence in areas affected by smoke or low visibility. By analyzing the thermal signatures, the agent can pinpoint the location of individuals, even in challenging conditions. Using GPS data and mapping algorithms, the rescue agent plan the safest and most efficient routes for rescue teams to reach affected areas."

(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 thirty words.

Answer:

Sample solution and marking scheme

a) **2 marks** for complete problem formulation.
   Sample solution –
   - initial state (cameras, sensors in position, database of location information, agent starting position, etc.),
   - transition function (change in thermal intensity, thermal signatures, camera input to locate individuals and agent movement from one location to another, etc.), for example At (X, Fire) -> At(Y, safety), etc.
   - Actions (capture temperature, thermal signature data and gps location data to identify presence of human beings and their locations and move to the area for rescue),
   - goal state (correct identification of human beings and their location coordinates, efficient route to save humans, all lives saved), and
   - cost function or Path cost = The path with minimum smoke + minimum fire(temperature) + has an individual to be saved.

   0.5 mark for just mentioning the components of the problem with no definition.

b) **0.5*4** for PEAS (Performance measure=Correct identification and rescue of humans by finding their location, Environment = Forest area under fire with human beings, other objects in the area, Actuators include identification of individuals through thermal signatures, smoke, temperature measurement, etc., The devices for agent movement like artificial limbs, computer vision, etc. Sensors include smoke detectors, GPS, temperature sensors.

c) Dimension of task environment
   Single-agent, Dynamic, Continuous, Sequential, fully observable **0.5 mark**
   Justification for each **1.5 mark.**

Q.2. You have been asked to solve the below linear equation problem with multiple variables using genetic algorithm. [1+1+3 = 5 Marks]

$$10a - 2b + 6c + d = 80$$

where a, b, c, and d are integers in the range [-15,16] (equation can have more than one solution)

(a) Design the Problem Solving Agent formulation & fitness function. The fitness score of a particular state can be determined by calculating the difference between the left-hand side (LHS) and right-hand side (RHS) values of the equation. A higher difference will result in a lower fitness score. Explain with numerical example.

(b) Describe the Chromosome/String representation of a parent state for five randomly selected states with their fitness score.

(c) Detail the approach toward the selection, crossover, and mutation steps for this problem. Show these with only one iteration of numerical example.

Sample solution and marking scheme

- Most likely representation of chromosome could be a list with 5 integers with each integer representing variables a,b,c,d
- For example [3,2,3,1] would imply a=3,b=2,c=3,d=1
- Generate random population (list of lists)
- Fitness function - use a fitness function (most likely f(x) = 10a-2b+6c+d) and calculate the fitness of each individual
- Apply some selection criteria based on fitness value (could be roulette or the best fit etc.) to come up with initial population
- Apply crossover and mutation (how students chose to incorporate crossover and mutation may differ but it should be consistent)

a) For Complete problem formulation (Initial state, Goal test, transition, path cost, possible action) – 0.5 Mark

Numerical example for Fitness score calculation – 0.5 Mark

b) Chromosome representation of 5 randomly selected state with fitness score – 1 Marks

c) Selection with justification – 1 Mark, without justification 0.5
Crossover steps as discussed in class- 1 Mark without explanation 0.5
Mutation with detailed explanation - 1 Mark without explanation 0.5

Q.3. Consider the initial and goal states below (Two equally acceptable goals are given) for a formation problem and answer the following questions. The agent can move the red duck on top of the other red duck in this problem as well as the yellow ducks on top of the other yellow ducks. No ducks are allowed to be placed above Height 3 of any column. An agent should find a path i.e., series to legal moves from the Initial state to achieve the Goal state. [3+2+4 = 9 Marks]

(a) Depict the search tree for up to exactly 4 levels and find the heuristic values of all the generated nodes. (Given initiate state can be assumed to be on level-0.)

(b) Among the below two defined heuristics (H1 and H2), if you are restricted to choose only one of them, which one would you choose and why? Tile in the below definition does not include the empty tiles. Justify your choice with brief answer with appropriate numerical illustration with reference to the given problem.

H1(n) = Goal orientation with respect to positioning of yellow ducks + Goal orientation with respect to the positioning of red ducks.
H2(n) = Number of legal moves possible with respect to red and yellow ducks.

Note for calculation: For Goal orientation, if at least two yellow ducks are placed in same column add a cost of +5 else add a cost of +10. Similarly, if at least two red ducks are placed in same column add a cost of +5 else add a cost of +10.
Hence H1(Initial state) = 10 +10 = 20.

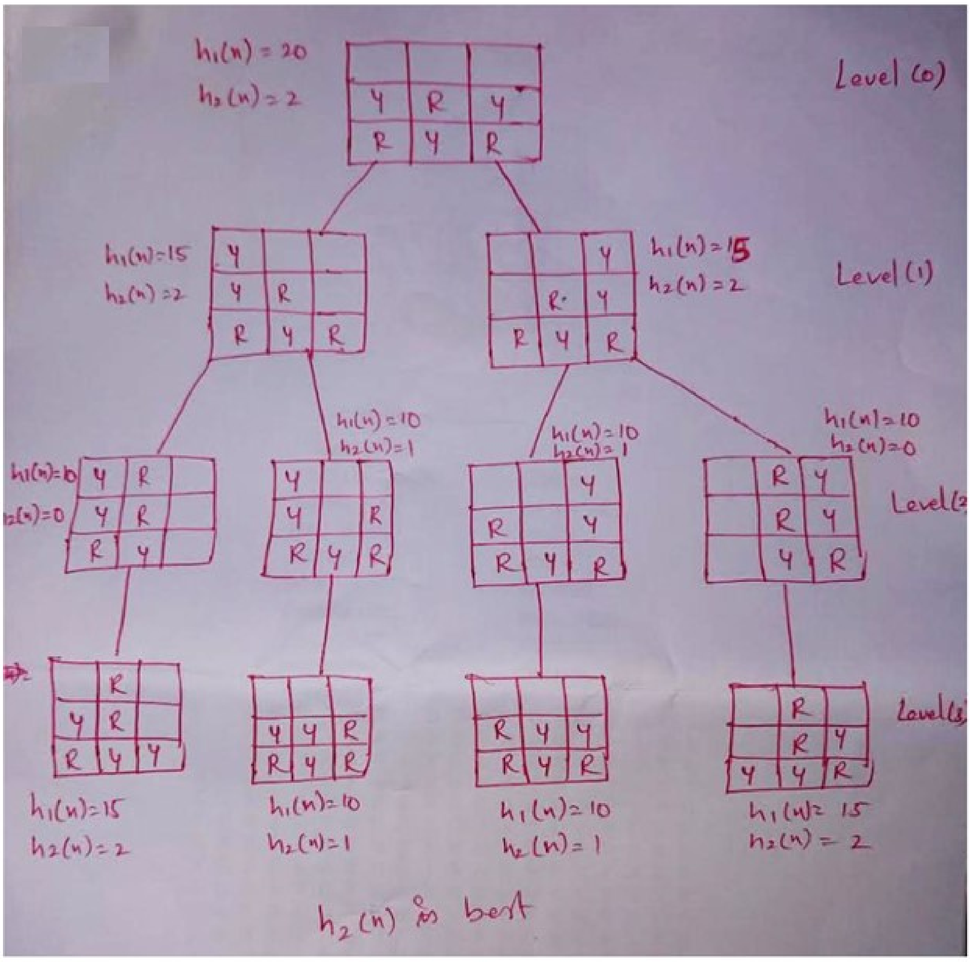
In initial state, the number of legal moves for yellow ducks are 2 and for red duck is 0. Hence, H2(initial state) = 2+0 = 2.

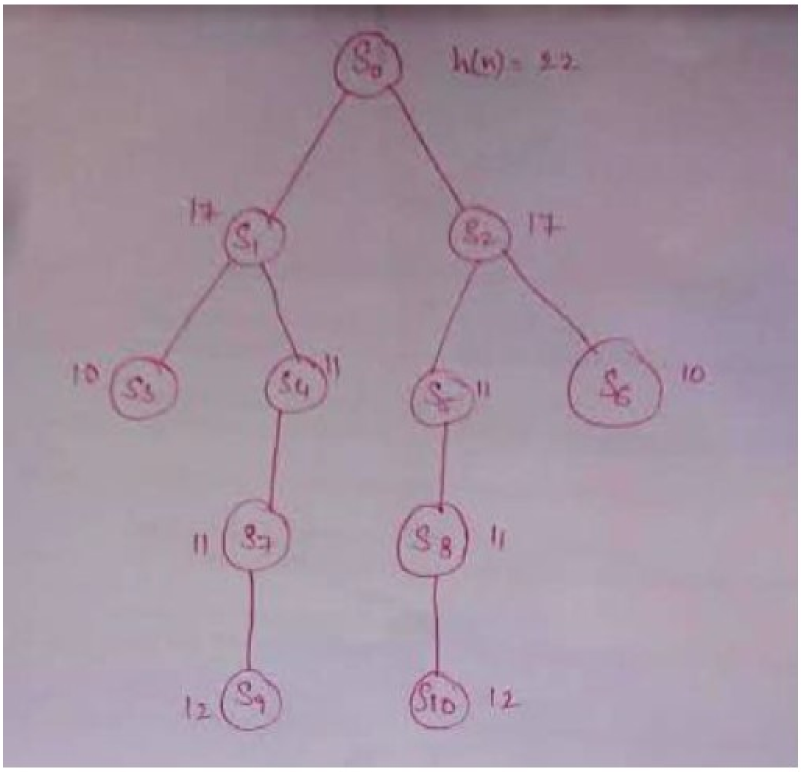
(c) By using heuristic function H(n) = H1(n) + H2(n), apply A* search algorithm till first 5 closed list updates. Show the status of OPEN and CLOSE list at each level.

Answer:

Sample solution and marking scheme:

a. Complete tree with 4 levels (1.5 M), Heuristic values of all the nodes (1.5M)
b. Any mathematical calculation/reason for choosing either h1(n) or h2(n) (1M), Propoer justification for choosing the heuristic (1 M)
c. Correct calculation of H(n)=h1(n)+h2(n) (1M), A* search algorithm till first 5 closed list updates, status of OPEN list (2M) and CLOSED list (1M).





open list	closed list	Goal	Successors.
S_0 { }	{ }	Fail	$S_1(17)$, $S_2(17)$
$S_1(17)$, $S_2(17)$	{S_0}	Fail, S_1 is not goal	$S_3(10)$, $S_4(11)$
$S_3(10)$, $S_4(11)$, $S_2(17)$	{S_0, S_1}	Fail, S_3 is not goal	No successors for S_3
$S_4(11)$, $S_2(17)$	{S_0, S_1, S_3}	Fail, S_4 is not goal	$S_7(11)$
$S_7(11)$, $S_2(17)$	{S_0, S_1, S_3, S_4}	Fail, S_7 is not goal	$S_9(12)$
$S_9(12)$, $S_2(17)$	{S_0, S_1, S_3, S_4, S_7}	Fail, S_9 is not goal	

Q.4. For each of the following assertions, say whether it is true or false and justify your answer with examples or counter examples where appropriate. [5 Marks]

a. An agent that senses only partial information about the state cannot be perfectly rational.
b. There exists a task environment in which every agent is rational.
c. The input to an agent program is the same as the input to the agent function.
d. Every agent function is implementable by some program/machine combination.
e. Every agent is rational in an unobservable environment.

Answers:

a. False. Perfect rationality refers to the ability to make good decisions given the sensor information received.

b. True. For example, in an environment with a single state, such that all actions have the same reward, it doesn't matter which action is taken. More generally, any environment that is reward-invariant under permutation of the actions will satisfy this property.

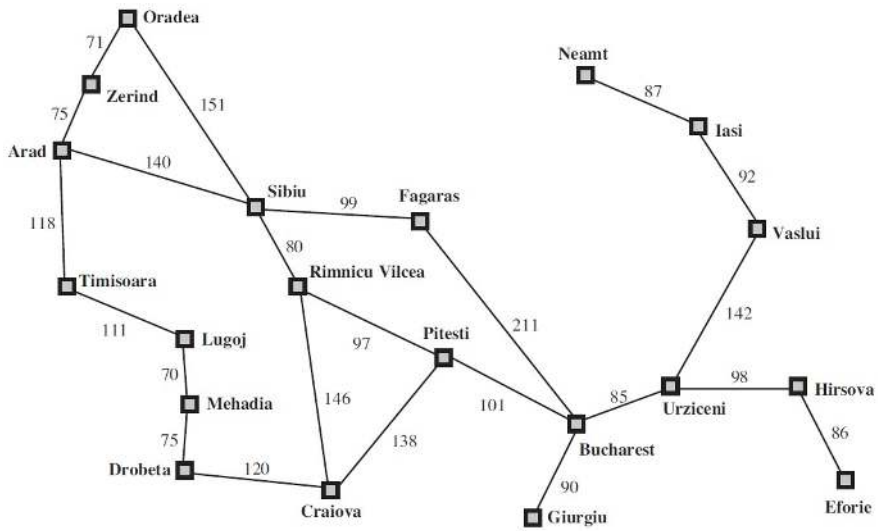
c. False. The agent function, notionally speaking, takes as input the entire percept sequence up to that point, whereas the agent program takes the current percept only.

d. False. For example, the environment may contain Turing machines and input tapes and the agent's job are to solve the halting problem; there is an agent function that specifies the right answers, but no agent program can implement it. Another example would be an agent function that requires solving intractable problem instances of arbitrary size in constant time.

e. False. Some actions are stupid – and the agent may know this if it has a model of the environment – even if one cannot perceive the environment's state.

For each question, correct True/False will get 0.5 mark and justification will get 0.5 mark.

Q.5. Suppose two friends live in different cities on a map, such as the Romania map shown in the following figure. On every turn, we can simultaneously move each friend to a neighboring city on the map. The amount of time needed to move from city 'i' to neighbor 'j' is equal to the road distance d(i,j) between the cities, but on each turn the friend that arrives first must wait until the other one arrives (and calls the first on his/her cell phone) before the next turn can begin. We want the two friends to meet as quickly as possible. [5 Marks]



a. Write a detailed formulation for this search problem. [2 Marks]
b. Let d(i, j) be the straight-line distance between cities i and j. Which of the following heuristic functions are admissible? (i) d(i, j) (ii) 2 * d(i, j) (iii) d(i, j)/2. Justify your answer. [1 Mark]
c. Are there completely connected maps for which no solution exists? [1 Mark]
d. Are there maps in which all solutions require one friend to visit the same city twice? [1 Mark]

Answers:

a. State space: States are all possible city pairs (i, j). The map is not the state space.

Successor function: The successors of (i, j) are all pairs (x, y) such that Adjacent (x, i) and Adjacent (y,j)
Goal: Be at (i, i) for some i.
Cost function: The cost to go from (i, j) to (x, y) is max (d(i, x), d(j, y)).
b. In the best case, the friends head straight for each other in steps of equal size, reducing their separation by twice the time cost on each step. Hence (iii) is admissible.
c. Yes, e.g., a map with two nodes connected by one link. The two friends will swap places forever. The same will happen on any chain if they start an odd number of steps apart. (One can see this best on the graph that represents the state space, which has two disjoint sets of nodes). The same even holds for a grid of any size or shape, because every move changes the Manhattan distance between the two friends by 0 or 2.
d. Yes: take any of the unsolvable maps from part (c) and add a self-loop to any one of the nodes. If the friends start an odd number of steps apart, a move in which one of the friends takes the self-loop changes the distance by 1, rendering the problem solvable. If the self-loop is not taken, the argument from (c) applies and no solution is possible.

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