

Assignment

on

Fundamental Approaches for Research (PHD650)

(This subject is a part of PhD CSE coursework)
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Unit-1

1. Define the differences between P, NP, NP-Complete, and NP-Hard problems. Give an example of each.
2. Explain the role of Greedy and Dynamic Approach in algorithm design and solve a sample problem.
3. A logistics company is developing a system to determine the most cost-effective way to deliver goods across multiple cities. One team proposes using Dynamic Programming (DP) to ensure an optimal solution by evaluating all subproblems, while another team suggests a Greedy Algorithm to make quick, locally optimal decisions at each step to save time. During testing, the DP approach provides accurate results but consumes high memory and computation time, whereas the Greedy approach is faster but sometimes produces suboptimal routes. Based on this scenario, discuss the limitations of Dynamic Programming and compare it with Greedy Algorithms in terms of efficiency, optimality, and applicability.
4. A student is designing an algorithm to find the minimum cost path from one city to another using multiple intermediate cities. While solving the problem, they notice that certain route calculations are repeated multiple times, and the optimal solution can be constructed from optimal solutions of smaller routes. Based on this scenario, explain the concepts of overlapping subproblems and optimal substructure, and how they justify the use of dynamic programming.
5. A delivery company has a truck with a maximum capacity of 60 kg. The company needs to select items to maximize profit. Each item has a weight and value as follows:
(5, 30), (10, 20), (20, 100), (30, 90), (40, 160). Unlike traditional selection problems, the company is allowed to break items into fractions to maximize total value.
 - (a) Apply the Greedy approach using value-to-weight ratio to select items.
 - (b) Show the order in which items are selected.
 - (c) Calculate the maximum profit that can be obtained.
 - (d) Explain why a strategy that selects items based on the highest value-to-weight ratio at each step leads to an optimal solution when items can be divided into smaller parts.

6. A conference hall can host only one event at a time. You are given a list of proposed events along with their start time (S) and finish time (F). Your goal is to schedule the maximum number of non-overlapping events.

Event	Start (S)	Finish (F)
E1	1	4
E2	3	5
E3	0	6
E4	5	7
E5	3	8
E6	5	9
E7	6	10
E8	8	11
E9	8	12
E10	2	13
E11	12	14

- Design an algorithmic strategy to select events such that the total number of events conducted is maximized.
- Show the order in which events should be selected.
- Justify why selecting events based on earliest finishing time leads to an optimal solution.
- Analyze the time complexity of your approach.

Unit-2

7. A company is developing an Optical Character Recognition (OCR) system to digitize scanned documents. However, the input images often contain noise, shadows, and uneven lighting, making it difficult to clearly distinguish text from the background. Do you think to improve text extraction, the system needs to convert grayscale images into binary images.
- Explain the concept of digital image binarization and its importance in this context.
 - Describe the commonly used binarization methods, and discuss which method would be most suitable for handling uneven illumination and noisy images.
8. Explain the process of binarization in digital images. Discuss how adaptive thresholding improves results compared to global thresholding, with examples.
9. Describe the K-means clustering algorithm for image segmentation. Provide a simple example.
10. Compare K-means and Fuzzy C-means algorithms in image segmentation.
11. Describe the working principle of Fuzzy C-means clustering for image segmentation. How does it handle uncertainty in pixel classification compared to K-means?

12. Discuss the challenges in extracting objects from color images. How can neural networks be applied to improve object extraction accuracy?
13. Compare clustering-based and edge-based image segmentation techniques. Provide advantages and limitations of each approach.
14. Categorize the role of fuzzy logic and neural networks in digital image processing? Discuss their applications and limitations in this domain.
15. Describe neural networks in image segmentation and the challenges in handling color images.
16. List four major application areas of digital image processing and briefly describe one of them.

Unit-3

17. What are the differences between Unicast, Multicast, and Broadcast Routing in wireless networks?
18. Compare unicast and multicast routing based on routing mechanism, routing overhead, and network traffic. Discuss any routing algorithm in detail.
19. Explain how hierarchical routing helps in large-scale network scalability
20. Explain the concepts of registration and roaming in mobile communication and how they enable seamless connectivity for users.
21. Explain the registration process of the mobile communication system. Compare the hard and soft handoff methods.
22. Explain the significance of energy efficiency and Quality of Service (QoS) in wireless networks.
23. Identify QoS parameters and explain how they influence multimedia transmission.
24. Explain how hierarchical routing helps in large-scale network scalability.
25. Discuss probability theory, traffic theory, and queuing theory in wireless networks.

Unit-4

26. Define your understanding of an Intelligence Agent. Explain the types of Agents including rational agent and Learning Agent.
27. Describe the PEAS (Performance measure, Environment, Actuators, Sensors) framework for a smart home heating agent.
28. Design a simple reflex agent function for a vacuum cleaner operating in a two-room environment (Room A and Room B).
29. Differentiate between breadth-first search (BFS) and depth-first search (DFS) in terms of their exploration strategies and space complexity.

30. Explain the role of heuristic functions in A* (A star) search. How do they influence the algorithm's optimality and efficiency?
31. Explain the concepts of breadth-first search and depth-first search algorithms used by intelligent agents for problem-solving.
32. Examine the concept of alpha-beta pruning? Discuss its importance in gameplaying agents and how it helps in making optimal decision.
33. Describe the Minimax Algorithm with an example of a simple game tree.
34. Explain Alpha-Beta Pruning and provide a step-by-step example.

Unit-5

35. What do you mean by Soft Computing? What are its elements?
36. Explain how a fuzzy set generalizes a crisp set with suitable examples.
37. Differentiate between crisp logic and fuzzy logic with real-world examples.
38. An air conditioning system adjusts temperature based on terms like “cold”, “warm”, and “hot” rather than exact values. Explain how fuzzy logic can be used to model such a system.
39. Explain the fundamental principles of fuzzy logic and its application in engineering problems. Provide examples to illustrate its effectiveness in handling real-world uncertainties.
40. Explain membership functions and their role in fuzzy systems.
41. Explain the basic working principle of a Genetic Algorithm (GA).
42. A company wants to find the most efficient route for delivery to minimize cost and time. Traditional methods are slow due to large search space. Explain how a Genetic Algorithm can be applied to solve this problem.
43. Explain the dynamics of Genetic Algorithms (GAs) in optimization. Explain how GAs evolves over generations and address the trade-offs between exploration and exploitation in their application.
44. A smart home system automatically adjusts room temperature based on inputs such as “temperature” and “humidity,” using linguistic terms like low, medium, and high. The system uses a rule base to decide the fan speed and cooling level.
 - (a) Explain how a fuzzy model can be used to design this system.
 - (b) Identify which type of fuzzy model (Mamdani, Sugeno, or others) would be most suitable and justify your choice.
 - (c) Describe the steps involved in the fuzzy inference process.
45. Consider a fuzzy set “Temperature” with the following triangular membership function for “Medium”: $a = 20^{\circ}\text{C}$, $b = 30^{\circ}\text{C}$, $c = 40^{\circ}\text{C}$
The membership function is defined as:

- $\mu(x) = 0$, for $x \leq 20$ or $x \geq 40$
- $\mu(x) = (x - 20)/(30 - 20)$, for $20 < x \leq 30$
- $\mu(x) = (40 - x)/(40 - 30)$, for $30 < x < 40$

Tasks:

(a) Calculate the membership value $\mu(x)$ for:

- $x = 25^\circ C$
- $x = 30^\circ C$
- $x = 35^\circ C$

(b) Plot the membership function graph.

(c) Interpret the meaning of the membership values obtained.

46. Consider a maximization problem with fitness function:

$$f(x) = x^2, \quad x \in [0, 7]$$

The variable x is encoded using 3-bit binary representation.

Initial population:

Chromosome	Binary	x	f(x)
C1	001	1	1
C2	010	2	4
C3	101	5	25
C4	111	7	49

Tasks:

- Calculate the fitness value and selection probability of each chromosome.
- Perform roulette wheel selection.
- Apply single-point crossover (assume crossover point after 2nd bit).
- Perform mutation with mutation probability = 0.1 (assume mutation occurs on last bit of one offspring).
- Find the new population after one generation.