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B.Tech DEGREE EXAMINATION, NOVEMBER 2023

Seventh Semester

18CSE480T - NATURE INSPIRED COMPUTING TECHNIQUES

(For the candidates admitted during the academic year 2020 - 2021 & 2021 - 2022)

Note:

- i. **Part - A** should be answered in OMR sheet within first 40 minutes and OMR sheet should be handed over to hall invigilator at the end of 40th minute.
- ii. **Part - B** and **Part - C** should be answered in answer booklet.

Time: 3 Hours

Max. Marks: 100

PART - A (20 × 1 = 20 Marks)

Answer all Questions

Marks BL CO

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|---|---|---|---|
| <p>1. What is the significance of parallel processing in natural systems?</p> <p>(A) It simplifies the complexity of these systems (B) It enables the emergence of self-organized patterns</p> <p>(C) It eliminates the need for individual agents (D) It ensures centralized control over the processes</p> | 1 | 2 | 1 |
| <p>2. Which of the following is an example of positive feedback in nature?</p> <p>(A) A thermostat regulating room temperature (B) A company lowering prices to increase sales</p> <p>(C) Ripening fruits releasing ethylene to accelerate nearby fruit ripening (D) Blood glucose levels decreasing after a meal rich in sugar</p> | 1 | 2 | 1 |
| <p>3. Which one of the following is not a type of computing inspired by nature?</p> <p>(A) Quantum computing (B) Swarm Intelligence</p> <p>(C) Artificial Immune System (D) Genetic programming</p> | 1 | 2 | 1 |
| <p>4. What is the significance of fractals in chaos theory?</p> <p>(A) They describe shapes that are regular and easily predictable (B) They represent mathematical concepts that have no practical applications</p> <p>(C) They provide a way of describing irregular and fragmented shapes found in complex phenomena (D) They indicate the end of chaos theory's relevance in natural sciences</p> | 1 | 1 | 1 |
| <p>5. The cooling strategy in Simulated Annealing does not determine the _____.</p> <p>(A) Maximum number of iterations in the search process (B) Temperature-decrease steps</p> <p>(C) Selection of a successor state (D) Number of iterations for each step</p> | 1 | 2 | 2 |
| <p>6. Which of the following is not a property of the Hill-climbing algorithm?</p> <p>(A) Terminates when a peak is reached (B) Does not look ahead of the immediate neighbors of the current state</p> <p>(C) Chooses randomly among the set of best successors (D) Does backtrack</p> | 1 | 2 | 2 |
| <p>7. Genetic algorithms work best when _____.</p> <p>(A) There is a large population of diverse candidates (B) There is a large population of similar candidates</p> <p>(C) There is a small population of diverse candidates (D) There is a small population of similar candidates</p> | 1 | 2 | 2 |

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| 8. | Which crossover operators are used in evolutionary programming? | 1 | 1 | 2 |
| | (A) Single-point crossover | | | |
| | (B) Two-point crossover | | | |
| | (C) Uniform crossover | | | |
| | (D) They do not use crossover operators | | | |
| 9. | What does the term "swarm intelligence" refer to? | 1 | 1 | 3 |
| | (A) The study of individual insects in isolation | | | |
| | (B) Algorithms based on the collective behavior of social organisms | | | |
| | (C) The behavior of single agents without interaction | | | |
| | (D) Computational models of quantum physics | | | |
| 10. | What is the role an individual ant plays in the Ant Colony Algorithm? | 1 | 2 | 3 |
| | (A) It conveys the messages from the queen to the soldiers | | | |
| | (B) It constructs a candidate solution using divide and conquer approach | | | |
| | (C) It constructs a candidate solution using a greedy stochastic search approach | | | |
| | (D) It guards the entrance of the ant colony | | | |
| 11. | How is task accomplishment achieved in swarm robotics? | 1 | 2 | 3 |
| | (A) Through individual robots with advanced reasoning capabilities | | | |
| | (B) By defining a set of individual behavior rules for interactions | | | |
| | (C) Through a centralized control system managing all robots | | | |
| | (D) By using highly specialized and expensive robots | | | |
| 12. | In Particle Swarm Optimization, each particle accelerates towards | 1 | 1 | 3 |
| | (A) Best position found by it so far (pbest) | | | |
| | (B) Global best position found so far (gbest) | | | |
| | (C) Either pbest or gbest | | | |
| | (D) Both pbest and gbest | | | |
| 13. | According to the immune network theory, what are the molecular patterns around the receptors of immune cells called? | 1 | 1 | 4 |
| | (A) Epitopes | | | |
| | (B) Idiotoxes | | | |
| | (C) Paratopes | | | |
| | (D) Antigens | | | |
| 14. | What is the main focus of the danger theory in immunology? | 1 | 2 | 4 |
| | (A) Self-tolerance | | | |
| | (B) Foreignness | | | |
| | (C) Tumor rejection | | | |
| | (D) Antibody production | | | |
| 15. | Which immune algorithm is responsible for generating repertoires of immune cells driven by antigens and regulating various aspects of their behavior? | 1 | 1 | 4 |
| | (A) Bone marrow | | | |
| | (B) Negative selection | | | |
| | (C) Clonal selection | | | |
| | (D) Discrete immune network models | | | |
| 16. | In Forrest's algorithm for clonal selection, which fitness measure is used to maintain diversity among antibodies during evolution? | 1 | 1 | 4 |
| | (A) Hamming distance | | | |
| | (B) Affinity score | | | |
| | (C) Random selection | | | |
| | (D) Mutation rate | | | |
| 17. | Which of the following correctly describes the bonding between nucleotides in a DNA molecule? | 1 | 1 | 5 |
| | (A) Covalent bonds between bases | | | |
| | (B) Hydrogen bonds between bases | | | |
| | (C) Covalent bonds between sugar molecules | | | |
| | (D) Hydrogen bonds between sugar molecules | | | |
| 18. | DNA polymerase synthesizes _____ | 1 | 1 | 5 |
| | (A) DNA in 5'-3' direction | | | |
| | (B) DNA in 3'-5' direction | | | |
| | (C) mRNA in 3'-5' direction | | | |
| | (D) mRNA in 5'-3' direction | | | |

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| 19. What advantage does DNA computing offer in terms of information storage compared to silicon-based computers? | 1 | 2 | 5 |
| (A) DNA computing uses faster algorithms for information storage | | | |
| (B) DNA computing requires less energy for information storage | | | |
| (C) DNA computing provides longer and more expensive information storage | | | |
| (D) DNA computing provides shorter and cheaper information storage | | | |
| 20. Which of the following is not a potential application of DNA computing in the biological domain? | 1 | 1 | 5 |
| (A) Sequencing and fingerprinting of DNA | | | |
| (B) Decoding the genetic material of living organisms | | | |
| (C) Creating wet databases of DNA | | | |
| (D) Developing alternative methods for space exploration | | | |

PART - B (5 × 4 = 20 Marks)

Answer any 5 Questions

Marks BL CO

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|--|---|---|---|
| 21. What is self-organization? List its characteristics and discuss the advantages and disadvantages of self-organization over its alternatives. | 4 | 1 | 1 |
| 22. One aspect of a simulated annealing cooling schedule is the temperature. What is the effect of having the starting temperature too high or too low? | 4 | 2 | 2 |
| 23. Outline the similarities and differences between Genetic Algorithms and Evolutionary Strategies. | 4 | 1 | 2 |
| 24. How does the unpredictability (or lack of knowledge) of individual behaviors lead to a loss of control over a swarm of robots in swarm intelligence approaches inspired by social insects? | 4 | 2 | 3 |
| 25. What is the significance of the concept of affinity in the field of immunocomputing? | 4 | 1 | 4 |
| 26. Write a short note on DNA molecule. | 4 | 1 | 5 |
| 27. What is the primary operation in splicing systems? How is it conceptually similar to the operation used in genetic algorithms? | 4 | 2 | 5 |

PART - C (5 × 12 = 60 Marks)

Answer all Questions

Marks BL CO

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|---|----|---|---|
| 28. (a) Explain the three main branches of Natural Computing in detail. | 12 | 1 | 1 |
| (OR) | | | |
| (b) Explain the following in detail: | | | |
| i. Parallelism and Distributivity | | | |
| ii. Interactivity | | | |
| iii. Stigmergy | | | |
| iv. Adaptation | | | |

29. (a) What are the drawbacks and constraints associated with the hill climbing algorithm, and what strategies can be employed to address these limitations? In what ways does simulated annealing outperform hill climbing techniques? 12 3 2

(OR)

- (b) Suppose a Genetic Algorithm uses chromosomes of the form $x=abcdefgh$ with a fixed length of eight genes. Each gene can be any digit between 0 and 9. Let the fitness of individual x be calculated as:

$$f(x) = (a+b) - (c+d) + (e+f) - (g+h)$$

And let the initial population consist of four individuals x_1, \dots, x_4 with the following chromosomes:

$X_1 = 6\ 5\ 4\ 1\ 3\ 5\ 3\ 2$

$X_2 = 8\ 7\ 1\ 2\ 6\ 6\ 0\ 1$

$X_3 = 2\ 3\ 9\ 2\ 1\ 2\ 8\ 5$

$X_4 = 4\ 1\ 8\ 5\ 2\ 0\ 9\ 4$

(i) Evaluate the fitness of each individual, showing all your workings, and arrange them in order with the fittest first and the least fit at the last.

(ii) Cross the fittest two individuals using one-point crossover at the middle point.

(iii) Cross the second and third fittest individuals using a two-point crossover (points b and f).

(iv) Cross the first and third fittest individuals (ranked 1st and 3rd) using a uniform crossover.

(v) Suppose the new population consists of the six offspring individuals received by the crossover operations in the above question. Evaluate the fitness of the new population, showing all your workings. Has the overall fitness improved?

30. (a) i. Describe how ants are able to find the shortest path to a food source. (4) 12 1 3
 ii. Using the traveling salesman problem as an example, define the following terms with relation to ant algorithms
 (i) Visibility (2)
 (ii) Evaporation (2)
 (iii) Transition probability (4)

(OR)

- (b) How are the velocity and position of particles updated in PSO? Explain in detail with the algorithm.

31. (a) How do gene libraries in bone marrow models contribute to the generation of antibody molecules within artificial immune systems, and how do these models replicate the natural process of antibody generation? What are the benefits of using gene libraries in terms of enhancing the diversity and adaptability of the antibodies produced? Also, explore the potential broader applications of bone marrow models beyond biological modeling, especially in problem-solving scenarios. 12 2 4

(OR)

- (b) Elucidate how Forrest's clonal selection algorithm simulates the mechanisms of clonal selection and affinity maturation in artificial immune systems.

32. (a) Explain the following operations performed in DNA computing: 12 1 5
 i. Amplification (4)
 ii. Gel electrophoresis (4)
 iii. Filtering (2)
 iv. Sequencing (2)

(OR)

- (b) Explain the algorithm used by Adleman in his DNA computing solution for solving the Hamiltonian path problem. Describe the specific encoding and molecular techniques employed in this experiment. Also, discuss the limitations of Adleman's approach.

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