T.E. (AI & Data Science) - Artificial Intelligence Examination Solutions

Course Code: 310253 | **Duration:** 1 Hour | **Maximum Marks:** 30

SET 1 - Q1: AI Foundations (15 Marks)

Q1a) Define Artificial Intelligence. State and explain the four approaches of Artificial Intelligence [5 marks]

Definition of Artificial Intelligence:
Artificial Intelligence (AI) is a branch of computer science concerned with creating machines that exhibit intelligent behavior, mimicking human cognitive functions such as learning, reasoning, problem-solving, perception, and language understanding. AI aims to automate intelligent behavior and enable computers to perform tasks that traditionally require human intelligence.

Four Approaches of Artificial Intelligence:

1. Acting Humanly (The Turing Test Approach)

- Focuses on building systems that perform tasks traditionally requiring human intelligence
- Success measured by passing the Turing Test - imitating human conversation convincingly
- Requires capabilities: Natural Language Processing, Knowledge Representation, Automated Reasoning, Machine Learning
- Example: Chatbots that can engage in human-like conversations

2. Thinking Humanly (The Cognitive Modeling Approach)

- Creates systems that think and reason similar to human cognition
- Involves studying how the human brain works and developing computational models
- Uses techniques from cognitive science and psychology
- Example: Expert systems that mimic human decision-making processes

3. Thinking Rationally (The Laws of Thought Approach)

- Based on Aristotle's concept of "right thinking" using formal logic
- Focuses on building systems that make correct inferences using established rules
- Uses logical reasoning and mathematical proofs
- Example: Logic programming languages like Prolog

4. Acting Rationally (The Rational Agent Approach)

- Designs autonomous agents that take actions to achieve best possible outcomes
- Emphasizes agents that perceive environment, adapt to changes, and maximize performance
- Focuses on doing the "right thing" based on available information
- Example: Autonomous vehicles making optimal driving decisions

Q1b) What is an agent? Draw and explain the Architecture of General Learning Agent [5 marks]

Agent Definition:
An agent is any entity that perceives its environment through sensors and acts upon that environment through actuators to achieve specific goals. An agent's behavior is determined by its agent function, which maps the sequence of perceptions to actions.

Architecture of General Learning Agent:

```
                    ENVIRONMENT
                         ↑
                    [Actuators]
                         ↑
                     Actions
                         ↑
    ┌────────────────────────────────────────────────┐
    │               LEARNING AGENT                │
    │                                             │
    │  ┌────────────────┐    ┌────────────────┐        │
    │  │   Problem     │    │ Performance  │      │
    │  │  Generator    │←──→│   Element    │      │
    │  └────────────────┘    └────────────────┘        │
    │         ↓                    ↑               │
    │    Experiments           Changes             │
    │         ↓                    ↑               │
    │  ┌────────────────┐    ┌────────────────┐        │
    │  │   Learning    │←──→│    Critic    │      │
    │  │   Element     │    │            │      │
    │  └────────────────┘    └────────────────┘        │
    │                        ↑                    │
    └───────────────────────────────────────────────┘
                               ↑
                           Feedback
                               ↑
                          [Sensors]
                               ↑
                           Percepts
                               ↑
                         ENVIRONMENT
```

Component Explanations:

1. Performance Element:

- Selects external actions based on current knowledge
- Implements the agent's current policy for action selection

2. Learning Element:

- Responsible for making improvements based on experience
- Modifies performance element to perform better in future

3. Critic:

- Provides feedback on agent's performance against predefined standards
- Evaluates how well the agent is doing relative to performance measure

4. Problem Generator:

- Suggests actions that lead to new and informative experiences
- Encourages exploration beyond current optimal behavior

Q1c) Enlist the advantages of Artificial Intelligence [5 marks]

Advantages of Artificial Intelligence:

1. Automation and Efficiency

- Automates repetitive and mundane tasks, freeing humans for creative work
- Example: Automated customer service chatbots handling routine inquiries

2. 24/7 Availability

- AI systems can operate continuously without breaks, fatigue, or downtime
- Example: Online recommendation systems working round the clock

3. High Accuracy and Precision

- Eliminates human errors in calculations and data processing
- Example: Medical diagnosis systems with higher accuracy than human doctors

4. Fast Decision Making

- Processes large amounts of data quickly to make rapid decisions
- Example: High-frequency trading systems in financial markets

5. Risk Reduction

- Can perform dangerous tasks, reducing human exposure to hazardous situations
- Example: Bomb disposal robots, deep-sea exploration robots

6. Unbiased Decision Making

- Makes decisions based on data and algorithms, reducing human bias

- Example: AI-powered hiring systems that focus on qualifications

7. Pattern Recognition

- Identifies complex patterns in large datasets that humans might miss
- Example: Fraud detection in banking transactions

8. Cost Reduction

- Reduces operational costs by replacing expensive human labor
- Example: Automated manufacturing processes

9. Enhanced User Experience

- Provides personalized experiences based on user behavior and preferences
- Example: Netflix recommendation algorithms

10. Scientific Discovery

- Accelerates research and discovery in various scientific fields
- Example: AI-assisted drug discovery and development

SET 2 - Q3: Problem Solving & Search (15 Marks)

Q3a) Define problem? Write & explain the five components of Well-defined problem [5 marks]

Problem Definition:
In AI, a problem is a situation that requires finding a sequence of actions that leads from an initial state to a goal state while optimizing certain criteria. A problem defines what needs to be achieved and the constraints under which it must be solved.

Five Components of Well-Defined Problem:

1. Initial State

- The starting point or configuration of the problem
- Represents the current situation before any action is taken
- Example (8-Puzzle): Current arrangement of tiles with one empty space

2. Actions (Operators)

- Set of possible actions or moves available at each state
- Defined as Actions(s) = set of actions that can be executed in state s
- Example (8-Puzzle): Move blank space Up, Down, Left, Right (if valid)

3. Transition Model

- Describes the result of applying an action to a state

- Defined as Result(s, a) = state that results from doing action a in state s
- Example (8-Puzzle): Result of moving blank up changes tile positions

4. Goal Test

- Determines whether a given state is the goal state
- Can be explicit (specific state) or implicit (satisfying conditions)
- Example (8-Puzzle): Configuration where tiles are arranged in order 1-8

5. Path Cost Function

- Assigns a numeric cost to each path from initial to goal state
- Usually sum of step costs: c(s, a, s') = cost of action a from state s to s'
- Example (8-Puzzle): Each move costs 1, total cost = number of moves

Complete Example - 8-Puzzle:

```
Initial State:    Goal State:
┌───┬───┬───┐    ┌───┬───┬───┐
│ 2 │ 8 │ 3 │    │ 1 │ 2 │ 3 │
├───┼───┼───┤    ├───┼───┼───┤
│ 1 │ 6 │ 4 │    │ 8 │   │ 4 │
├───┼───┼───┤    ├───┼───┼───┤
│ 7 │   │ 5 │    │ 7 │ 6 │ 5 │
└───┴───┴───┘    └───┴───┴───┘
```

Q3b) Explain different search strategies [4 marks]

Classification of Search Strategies:

1. Uninformed (Blind) Search Strategies

- No additional information beyond problem definition
- Explore search space systematically without guidance

Types:

- **Breadth-First Search (BFS):** Explores level by level, guarantees optimal solution
- **Depth-First Search (DFS):** Explores deepest nodes first, memory efficient
- **Uniform Cost Search (UCS):** Expands lowest path cost node first
- **Depth-Limited Search (DLS):** DFS with predetermined depth limit
- **Iterative Deepening DFS (IDDFS):** Combines BFS optimality with DFS space efficiency

2. Informed (Heuristic) Search Strategies

- Uses domain-specific knowledge (heuristics) to guide search
- More efficient than uninformed search

Types:

- **Greedy Best-First Search:** Expands node closest to goal (uses h(n))
- *A Search:** Combines actual cost and heuristic (uses f(n) = g(n) + h(n))
- **Hill Climbing:** Local search moving toward better neighboring states

Q3c) Explain Hill climbing algorithm. Explain Local Maxima, Global Maxima and plateau for an example [6 marks]

Hill Climbing Algorithm:

Hill climbing is a local search optimization algorithm that continuously moves in the direction of increasing value (uphill) until it reaches a peak where no neighbor has a higher value.

Algorithm Steps:

```
1. Start with initial state (current node)
2. Loop until goal is reached or no better neighbor exists:
   a. Generate all possible successor states
   b. Evaluate each successor using objective function
   c. Select the best successor
   d. If best successor is worse than current state: STOP
   e. Otherwise, move to best successor (current = best successor)
3. Return current state as solution
```

Pseudocode:

```
function HILL-CLIMBING(problem) returns a state
    current = problem.INITIAL-STATE
    loop:
        neighbors = EXPAND(current, problem.ACTIONS)
        next = highest valued neighbor in neighbors
        if VALUE(next) ≤ VALUE(current):
            return current
        current = next
```

Problems in Hill Climbing:

**Example: Maximizing f(x) = -x² + 4x in range **[1]

State-Space Landscape:

```
      f(x)
        4 ↑      *  ← Global Maximum at x=2, f(2)=4
          |   / | \
        3 ├  *  |  *  ← Local areas
          | /   |   \
        2 ├*    |    *
          |     |
```

```
1 ├     |      *
  |     |       \
0 ├─────┼──────────*──→ x
  0     2        4
```

1. Local Maxima:

- Definition: A state better than all neighboring states but not globally optimal
- Problem: Algorithm stops here thinking it found the best solution
- Example: If starting at x=3.5, might get stuck at a small peak instead of reaching x=2
- **Solution:** Random restart hill climbing, simulated annealing

2. Global Maxima:

- Definition: The best possible state in the entire search space
- Goal: What we actually want to find
- Example: At x=2, f(2)=4 is the highest value in the entire function
- **Identification:** Requires comparing with all possible states

3. Plateau:

- Definition: Flat area where neighboring states have same objective function value
- Problem: No clear direction to move, algorithm may wander aimlessly
- Example: Function f(x) = 0 for x ∈ - all points have same value[2] [3]
- **Types:**
  - **Shoulder:** Plateau with uphill edge
  - **Flat Maximum:** Broad peak area
- **Solutions:** Allow sideways moves, big jumps, random walk

Practical Example - Traveling Salesman Problem:

```
Cities: A, B, C, D with distances:
A-B: 10, A-C: 15, A-D: 20
B-C: 35, B-D: 25, C-D: 30

Initial Route: A→B→C→D→A (Cost: 95)
Neighbors (by swapping cities):
- A→C→B→D→A (Cost: 95)
- A→D→C→B→A (Cost: 95)
- A→B→D→C→A (Cost: 80) ← Best neighbor

Move to: A→B→D→C→A
Continue until no improvement possible...
```

Solutions to Hill Climbing Problems:

1. **Random Restart:** Run multiple times from different starting points

2. **Simulated Annealing:** Accept worse moves with decreasing probability
3. **Local Beam Search:** Keep track of k states instead of just one
4. **Stochastic Hill Climbing:** Choose among better neighbors randomly

This comprehensive solution covers all major topics in the AI examination with proper theoretical foundations, practical examples, diagrams, and step-by-step explanations suitable for the 30-mark, 1-hour examination format.

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1. ai-exam-notes.pdf
2. Oct-24-30M.pdf
3. AI-NOTES.pdf
4. AI-insem.pdf