Unit 1: Artificial Intelligence and Its Issues - Theory Answers

1. Name the elements of an agent and list down the characteristics of intelligent agent.

An agent in Artificial Intelligence is defined as an entity that perceives its environment through sensors and acts upon that environment using actuators. The role of an agent is central in AI, as it acts autonomously and intelligently in a given environment.

Elements of an Agent:

1. **Sensors:** These are the mechanisms through which an agent perceives its environment. For example, a robot may use cameras, microphones, or touch sensors.
2. **Actuators:** These allow the agent to act in the environment. Examples include wheels, arms, speakers, or display screens.
3. **Agent Function:** A mathematical function that maps a percept sequence (history of observations) to an action.
4. **Agent Program:** The actual implementation of the agent function which takes input from sensors and returns actions to the actuators.

Characteristics of an Intelligent Agent:

1. **Autonomy:** The agent operates on its own without human intervention. It has control over its internal state and decision-making process.
2. **Perception:** The agent can sense its environment accurately through sensors.
3. **Reactivity:** The agent responds promptly to changes in the environment.
4. **Pro-activeness:** It not only reacts to changes but also takes initiative to fulfill its goals.
5. **Social Ability:** Some agents can communicate with other agents or humans to share knowledge or collaborate.
6. **Learning Ability:** An intelligent agent improves its performance over time by learning from experiences.
7. **Rationality:** An agent is rational if it does the right thing to maximize its performance based on the given knowledge and percepts.

An example of an intelligent agent is a robotic vacuum cleaner. It uses dirt sensors and cameras (sensors), and it has brushes and suction pumps (actuators). It makes decisions about cleaning based on its current environment.

These elements and characteristics are crucial in designing AI systems that function effectively and intelligently in real-world scenarios.

(Refer to slides 23–27 from the provided unit notes.)

2. How would you quote PEAS description?

In Artificial Intelligence, the PEAS framework is used to specify the setting and operational design of intelligent agents. It stands for **Performance measure, Environment, Actuators, and Sensors**. This framework helps in clearly defining the tasks, operating environment, tools for sensing, and actions for any intelligent agent.

PEAS Components:

1. **Performance Measure:** It defines the criterion to evaluate the success of an agent. This varies with the application. For instance, in a cleaning robot, performance can be judged by the cleanliness level, power usage, and time efficiency.
2. **Environment:** Refers to the external world with which the agent interacts. For the cleaning robot, the environment includes rooms, furniture, dirt, and people.
3. **Actuators:** These are devices that carry out actions. In a robot, these include wheels, arms, brushes, and vacuum pumps.
4. **Sensors:** Devices that perceive the environment. For example, cameras, dirt sensors, infrared sensors.

Example - Vacuum Cleaner Agent:

- **Performance Measure:** Cleanliness, energy efficiency, cleaning time.
- **Environment:** Rooms, dirt on the floor, obstacles.
- **Actuators:** Wheels, brushes, suction system.
- **Sensors:** Dirt sensors, wall sensors, cameras.

The PEAS description is an essential tool for designing intelligent systems because it ensures all key aspects are considered before implementation.

(Refer to Slide 30 for PEAS framework explanation.)

3. What is an agent?

An **agent** is an autonomous entity in Artificial Intelligence that perceives its environment through **sensors** and acts upon it using **actuators**. An agent operates continuously, observing the environment and taking appropriate actions to achieve specific goals.

Agents are central to AI because they represent the system that carries out intelligent behavior. They can be hardware-based (robots) or software-based (chatbots).

Key Features of an Agent:

1. **Perception:** Uses sensors to gather data about the environment.
2. **Action:** Uses actuators to perform tasks that affect the environment.
3. **Autonomy:** Acts without direct human control.
4. **Intelligence:** Makes decisions based on percepts, goals, and knowledge.

Types of Agents:

- **Simple Reflex Agent:** Acts on current percept only.
- **Model-Based Agent:** Maintains internal state.
- **Goal-Based Agent:** Has goal-directed behavior.
- **Utility-Based Agent:** Uses a utility function to select the best action.
- **Learning Agent:** Learns and improves from past experiences.

Example: A smart thermostat acts as an agent. It senses room temperature (sensor), compares it with the set value (reasoning), and turns the heater on or off (actuator) to maintain desired conditions.

Rational Agent: A rational agent does the right thing by choosing actions that maximize its performance measure, based on the percept history and built-in knowledge.

(Refer to Slides 23–25 for more about agents.)

4. What is AI? List the applications.

Artificial Intelligence (AI) is a branch of computer science aimed at creating systems that can perform tasks which typically require human intelligence. These tasks include learning, problem-solving, perception, understanding natural language, and decision-making.

Definition: John McCarthy, the father of AI, defined it as: "The science and engineering of making intelligent machines, especially intelligent computer programs."

Main Goals of AI:

- To make machines think and act like humans.
- To solve complex real-world problems using machine intelligence.
- To develop systems that can perceive, reason, learn, and act independently.

Applications of AI:

1. **Healthcare:** AI is used for medical imaging analysis, diagnosis, drug discovery, and personalized treatment plans.
2. **Finance:** Used for fraud detection, risk assessment, and personal investment advisory.
3. **Transportation:** Autonomous vehicles, traffic prediction, and smart routing.
4. **Natural Language Processing:** Chatbots, translators, sentiment analysis.
5. **Manufacturing and Robotics:** AI in industrial robots for assembling, quality control.
6. **Gaming:** AI for real-time decision making in complex games like Chess and Go.
7. **E-Commerce:** Product recommendations, customer support, and trend analysis.
8. **Smart Home Devices:** Voice assistants like Alexa, Google Assistant.

9. **Education:** Personalized learning, AI tutors, performance analysis.
10. **Space Exploration:** Autonomous robots and rovers for planetary missions.

Examples:

- Google Maps: Predicts traffic and suggests routes.
- Facial Recognition: In smartphones and security systems.
- Voice Assistants: Siri, Alexa perform tasks based on voice commands.
- Recommendation Systems: Netflix, YouTube, Amazon use AI to suggest content/products.

AI has become a transformative technology across industries and continues to evolve rapidly. Its ability to analyze large amounts of data and make intelligent decisions makes it highly valuable in today's digital world.

(Refer to Slides 3–10 for details on AI and its applications.)

5. What is meant by Knowledge-Based System?

A Knowledge-Based System (KBS) is a type of computer program that uses artificial intelligence techniques to solve complex problems by mimicking the decision-making ability of a human expert. These systems use a collection of facts and heuristics (rules of thumb) to simulate human reasoning.

Key Features of Knowledge-Based Systems:

1. **Knowledge Base:** A repository of domain-specific facts and rules. This forms the core of the system and represents structured knowledge.
2. **Inference Engine:** The component that applies logical rules to the knowledge base to deduce new facts or make decisions.
3. **Learning Element:** Some KBS include a learning component that helps update the knowledge base based on new experiences or data.
4. **User Interface:** Allows users to interact with the system, inputting problems and receiving solutions.

Purpose and Importance:

- Enables systems to provide expert-level solutions.
- Facilitates automation in areas requiring specialized knowledge.
- Enhances decision-making in uncertain or complex environments.

Example Applications:

- **Medical Diagnosis Systems:** Determine illnesses based on symptoms.
- **Expert Financial Advisors:** Provide investment advice.
- **Customer Support Systems:** Answer product-related queries based on existing knowledge.

Knowledge-Based Systems are essential in domains where decision-making involves a significant amount of specialized knowledge. They form the foundation of many AI applications like expert systems and intelligent agents.

(Refer to slides 41–44 for explanation.)

6. Explain components of knowledge-based systems.

A knowledge-based system (KBS) is primarily composed of two main components: the **knowledge base** and the **inference engine**. Additionally, other components like the learning element and interface are integral in modern systems.

Components:

1. **Knowledge Base (KB):**
    - Stores facts, rules, and knowledge about the problem domain.
    - Expressed in formal language for interpretation by the system.
    - Includes declarative and procedural knowledge.
2. **Inference Engine:**
    - Applies logical rules to the knowledge base to draw conclusions.
    - Uses methods like forward chaining and backward chaining.
    - Acts as the reasoning mechanism.
3. **Learning Element:**
    - Updates the knowledge base with new information.
    - Helps the system adapt to changing conditions or new knowledge.
4. **User Interface:**
    - Allows users to input queries or problems.
    - Presents the system's solutions or recommendations to the user.

Key Operations Performed:

- **TELL:** Adds new knowledge to the KB.
- **ASK:** Queries the KB to derive actions.
- **PERFORM:** Executes chosen actions based on reasoning.

KBS provides a structured approach to building intelligent systems by separating knowledge from processing, enabling easier updates and improvements over time.

(Refer to slides 45–47.)

7. Write various levels of Knowledge-Based System.

Knowledge-based agents operate across multiple levels, each representing a different stage in the understanding and utilization of knowledge.

Levels of Knowledge-Based System:

1. **Knowledge Level:**
    - Defines what the agent knows and its goals.
    - Represents abstract reasoning and high-level decision-making.
    - Example: An automated taxi agent knows the route from A to B.
2. **Logical Level:**
    - Describes how knowledge is logically represented.
    - Information is stored in the form of logical sentences or formal expressions.
    - Example: The route from A to B is represented as logical relations or statements.
3. **Implementation Level:**
    - The physical representation and actual execution of logic and knowledge.
    - Includes programming code, databases, and hardware.
    - Example: The taxi's control system executing decisions in real time.

Importance:

- These levels help distinguish between what an agent knows, how it represents and processes that knowledge, and how it is implemented in the real world.

(Refer to slides 49–51 for details.)

8. Explain various approaches and properties of knowledge representation.

Knowledge Representation (KR) is a fundamental aspect of AI where information about the world is structured so that a computer can use it to solve complex tasks. Various approaches exist, each with its own characteristics and use cases.

Approaches to Knowledge Representation:

1. **Simple Relational Knowledge:**
    - Uses relational tables (rows and columns) to represent facts.
    - Example: Table listing players with their weights and ages.
    - Suitable for database-like scenarios.
2. **Inheritable Knowledge (Frame-Based):**
    - Organizes information hierarchically using frames or classes.
    - Uses inheritance to share attributes between classes.

- Example: An 'Animal' class inherited by 'Dog' or 'Cat'.

3. **Inferential Knowledge (Logic-Based):**
    - Uses formal logic (e.g., propositional or predicate logic).
    - Supports inference through logical rules.
    - Example: "All men are mortal. Marcus is a man. => Marcus is mortal."
4. **Procedural Knowledge:**
    - Describes how to perform tasks using procedures or IF-THEN rules.
    - Often used in expert systems.
    - Example: If fever and rash => diagnose as measles.

Properties of Knowledge Representation:

- **Representational Adequacy:** Ability to represent all required knowledge.
- **Inferential Adequacy:** Ability to derive new knowledge.
- **Inferential Efficiency:** Perform reasoning efficiently.
- **Acquisitional Efficiency:** Ease of acquiring and updating knowledge.

These approaches ensure that AI systems can handle knowledge effectively, enabling them to make intelligent decisions.

(Refer to slides 61–67.)

9. Explain different types of environment.

AI agents operate in various types of environments, and understanding these types helps design better agents.

Types of Environments:

1. **Single Agent vs. Multi-Agent:**
    - **Single Agent:** One agent acting alone. (e.g., puzzle-solving robot)
    - **Multi-Agent:** Multiple agents interacting, either cooperatively or competitively (e.g., chess game).
2. **Complete vs. Incomplete:**
    - **Complete:** All information is available (e.g., chess).
    - **Incomplete:** Some data is missing or hidden (e.g., poker).
3. **Fully Observable vs. Partially Observable:**
    - **Fully Observable:** Sensors capture complete environment state.
    - **Partially Observable:** Limited or noisy sensory input (e.g., self-driving cars in fog).

4. **Competitive vs. Collaborative:**
    - **Competitive:** Agents compete to achieve goals (e.g., games).
    - **Collaborative:** Agents work together (e.g., smart traffic systems).
5. **Static vs. Dynamic:**
    - **Static:** Environment does not change while agent is deliberating.
    - **Dynamic:** Environment changes continuously (e.g., drones).
6. **Discrete vs. Continuous:**
    - **Discrete:** Finite set of states (e.g., chess).
    - **Continuous:** Infinite or unbounded state space (e.g., video processing).
7. **Deterministic vs. Stochastic:**
    - **Deterministic:** Outcome is predictable (e.g., simulations).
    - **Stochastic:** Randomness involved (e.g., real-world navigation).

Understanding the nature of the environment is crucial in developing rational agents and choosing appropriate strategies.

(Refer to slides 33–39.)