Maa omwati degree college Hassanpur

Class:- BCA 5^{th} sem

Subject:- AI and Expert System

UNIT I – Introduction to Artificial Intelligence (AI)

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1. Artificial Intelligence (AI)

Definition (100 Words)

Artificial Intelligence (AI) is a branch of computer science that focuses on creating intelligent machines and software systems capable of performing tasks that normally require human intelligence. AI enables computers to learn from experience, understand natural language, recognize patterns, solve problems, make decisions, and perform reasoning. It combines techniques from mathematics, computer science, psychology, and cognitive science to develop systems that can simulate human thinking abilities. AI applications include expert systems, robotics, natural language processing, computer vision, recommendation systems, and autonomous vehicles. The main goal of AI is to develop intelligent agents that can perceive environments and perform actions to achieve specific objectives.

Concepts of Artificial Intelligence

AI is based on the following important concepts:

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1. Intelligent Agents

Definition:

An intelligent agent is a system that observes its environment through sensors and performs actions using actuators.

Examples:

- Robots.
- Virtual assistants.
- Self-driving cars.

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2. Machine Learning

Definition:

Machine Learning enables computers to learn from data and improve performance without being explicitly programmed.

Types:

- Supervised learning.
- Unsupervised learning.
- Reinforcement learning.

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3. Knowledge Representation

Definition:

Knowledge representation is the method of storing information in a computer system so that it can reason and make decisions.

Examples:

- Rules.
- Frames.
- Semantic networks.

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4. Reasoning

Definition:

Reasoning allows AI systems to draw conclusions from available information.

Types:

- Deductive reasoning.
- Inductive reasoning.

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5. Learning

Definition:

Learning is the ability of an AI system to improve its performance through experience.

Applications of Artificial Intelligence

Definition (100 Words)

The **Applications of Artificial Intelligence** refer to the practical uses of AI techniques in different fields to solve complex problems and automate intelligent tasks. AI systems are widely used because they can analyze large amounts of data, recognize patterns, make predictions, and support decision-making. Major applications include healthcare, education, banking, robotics, transportation, entertainment, agriculture, cybersecurity, and natural language processing. AI helps organizations improve efficiency, reduce human effort, and provide better services. Examples include medical diagnosis systems, chatbots, recommendation systems, autonomous vehicles, fraud detection systems, and voice assistants. AI continues to transform industries by providing intelligent and automated solutions.

Major Applications of AI

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1. Expert Systems

AI systems that provide decisions similar to human experts.

Examples:

- Medical diagnosis.
- Financial advice systems.

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2. Robotics

AI enables robots to perform intelligent tasks.

Examples:

- Industrial robots.
- Service robots.

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3. Natural Language Processing (NLP)

Allows computers to understand and process human language.

Examples:

- Chatbots.
- Language translation.

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4. Computer Vision

Enables machines to interpret images and videos.

Examples:

- Face recognition.
- Medical image analysis.

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5. Autonomous Vehicles

AI helps vehicles make decisions without human control.

Examples:

- Self-driving cars.

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6. Game Playing

AI systems compete in games using search and learning.

Examples:

- Chess programs.

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7. Healthcare

Applications:

- Disease prediction.
- Drug discovery.
- Patient monitoring.

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2. Problem Solving in AI

Definition (100 Words)

Problem Solving in Artificial Intelligence is the process of finding a sequence of actions that transforms an initial state into a desired goal state. AI problem solving involves representing problems in a suitable form and applying search techniques to find solutions efficiently. An AI system analyzes the problem, defines possible actions, explores available states, and selects the best path to reach the goal. Problem solving is used in areas such as game playing, robotics, planning, and decision-making systems. The effectiveness of AI problem solving depends on proper problem representation, search strategies, and knowledge about the problem environment.

Steps of AI Problem Solving

1. Define the Problem

Identify:

- Initial state.
- Goal state.
- Possible actions.

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2. Represent the Problem

Convert the problem into a mathematical or logical form.

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3. Search for Solution

Apply search techniques to find a path from initial state to goal state.

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4. Execute Solution

Perform actions to achieve the goal.

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3. Defining Problem as State Space Search

Definition (100 Words)

State Space Search is a problem-solving approach in Artificial Intelligence where a problem is represented as a collection of possible states and transitions between those states. A state represents a situation or condition of the problem, while operators define possible actions that transform one state into another. The objective of search is to find a sequence of actions that moves from the initial state to the goal state. State space representation provides a systematic way to solve problems by exploring possible solutions. It is widely used in AI applications such as puzzle solving, game playing, planning, and navigation systems.

Components of State Space Search

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1. Initial State

The starting condition of the problem.

Example:

Initial position in chess.

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2. Goal State

The desired final condition.

Example:

Winning position in chess.

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3. Operators

Actions that change one state into another.

Example:

Moving chess pieces.

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4. State Space

All possible states reachable from the initial state.

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5. Path

Sequence of states leading to the goal.

Example: Water Jug Problem

Initial State:

(0,0)

Goal State:

(2,0)

Operators:

- Fill jug.
- Empty jug.
- Transfer water.

State Space Representation Diagram

```
        Initial State
              |
              ↓
        Possible States
        /      |       \
      S1       S2       S3
       |
       ↓
    Goal State
```

---

4. Production Systems

Definition (100 Words)

A **Production System** is a rule-based problem-solving model used in Artificial Intelligence where knowledge is represented as a collection of production rules. Each production rule consists of a condition and an action in the form of IF-THEN statements. A production system contains three main components: a set of production rules, a working memory containing current information, and a control strategy that selects applicable rules. When a condition matches the current state, the corresponding action is executed. Production systems are widely used in expert systems, automated reasoning, and decision-making applications because they provide a flexible method for representing knowledge.

Components of Production System

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1. Production Rules

Rules represented as:

```
IF condition THEN action
```

Example:

```
IF temperature is high
THEN turn on fan
```

---

2. Working Memory

Stores current facts and information.

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3. Control Strategy

Determines which rule should execute.

Types of Production Systems

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1. Monotonic Production System

- Applying rules does not remove existing facts.

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2. Non-Monotonic Production System

- New information may change previous conclusions.

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3. Partially Commutative Production System

- Order of rule application does not affect final result.

Advantages of Production Systems

- Easy knowledge representation.
- Modular structure.
- Easy rule modification.
- Supports reasoning.

Disadvantages

- Large number of rules may reduce efficiency.
- Difficult conflict resolution.

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5. Problem Characteristics

Definition (100 Words)

Problem Characteristics describe the features and nature of a problem that influence the selection of suitable AI problem-solving techniques. Different problems require different search strategies depending on their complexity, size, and structure. Understanding problem characteristics helps AI systems choose efficient methods for finding solutions. Important characteristics include whether the problem is decomposable, whether solutions require a sequence of actions, whether information is complete, and whether the environment is predictable. Problems can be classified as simple or complex, static or dynamic, deterministic or uncertain. Proper analysis of problem characteristics improves the efficiency and accuracy of AI-based problem-solving systems.

Important Problem Characteristics

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1. Decomposability

Meaning:

Whether a problem can be divided into smaller independent problems.

Example:

Large mathematical problems.

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2. Nature of Solution Steps

Some problems require:

- Sequence of actions.
- Single final solution.

---

3. Predictability

Deterministic Problem:

Same action always produces same result.

Example:

Chess.

Non-deterministic Problem:

Result may vary.

Example:

Weather prediction.

---

4. Static or Dynamic Environment

Static:

Environment does not change.

Example:

Puzzle solving.

Dynamic:

Environment changes during problem solving.

Example:

Driving system.

---

5. Availability of Information

Complete Information:

All information is available.

Example:

Chess.

Incomplete Information:

Some information is unknown.

Example:

Medical diagnosis.

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6. Solution Quality

Some problems require:

- Exact solution.
- Approximate solution.

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6. Search Techniques in AI

Definition (100 Words)

Search Techniques in Artificial Intelligence are methods used by AI systems to explore possible solutions in a problem space and find a path from the initial state to the goal state.

Search techniques are essential because many AI problems involve finding the best solution among many possibilities. They are mainly divided into uninformed search and informed search. Uninformed search methods, also called brute force search, use no additional knowledge about the problem. Informed search methods, called heuristic search, use domain-specific knowledge to guide the search process. Efficient search techniques reduce computational effort and improve the performance of AI systems.

Types of Search Techniques

```
                 Search Techniques
                        |
          -----------------------------
          |                            |
    Brute Force Search          Heuristic Search
```

---

7. Brute Force Search (Uninformed Search)

Definition (100 Words)

Brute Force Search is a search technique in Artificial Intelligence that explores possible solutions without using any additional knowledge about the problem. It systematically examines states until a goal state is found. Since it does not use heuristics, it is also called uninformed search. Brute force methods are simple and guaranteed to find solutions if sufficient time and memory are available. However, they may require large computational resources for complex problems. Common brute force search techniques include Breadth First Search, Depth First Search, Uniform Cost Search, and Depth Limited Search. These methods are mainly used for small or simple problem spaces.

Brute Force Search Techniques

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1. Breadth First Search (BFS)

Definition:

BFS explores nodes level by level from the starting node.

Working:

```
Start
  |
A B C
  |
D E F
```

Advantages:

- Finds shortest path.
- Complete.

Disadvantages:

- Requires large memory.

---

2. Depth First Search (DFS)

Definition:

DFS explores one path completely before moving to another path.

Advantages:

- Requires less memory.
- Simple implementation.

Disadvantages:

- May not find shortest path.
- Can get stuck in deep paths.

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3. Uniform Cost Search (UCS)

Definition:

Expands the node with the lowest path cost first.

Advantage:

Finds optimal solution.

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4. Depth Limited Search

Definition:

DFS with a fixed depth limit.

Advantage:

Avoids infinite search.

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8. Heuristic Search (Informed Search)

Definition (100 Words)

Heuristic Search is an Artificial Intelligence search technique that uses additional knowledge about a problem to guide the search process toward the goal state. This additional information is called a heuristic function. Heuristic methods reduce the number of states explored and improve search efficiency compared to brute force methods. The heuristic function estimates the distance or cost from the current state to the goal state. Heuristic search is widely used in complex AI applications where exhaustive search is impractical. Common heuristic search techniques include Best First Search and A* Search. These methods provide faster solutions by intelligently selecting promising states.

Heuristic Function

Represented as:

h(n)h(n)h(n)

Where:

- h(n) = estimated cost from node n to goal.

Heuristic Search Techniques

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1. Best First Search

Definition:

Best First Search selects the node that appears closest to the goal using heuristic value.

Formula:

f(n)=h(n)f(n)=h(n)f(n)=h(n)

Advantages:

- Faster than brute force.
- Uses problem knowledge.

Disadvantages:

- Not always optimal.

---

2. A* Search Algorithm

Definition:

A* combines actual path cost and heuristic cost.

Formula:

f(n)=g(n)+h(n)f(n)=g(n)+h(n)f(n)=g(n)+h(n)

Where:

- g(n) = cost from start node.
- h(n) = estimated cost to goal.

Advantages:

- Complete.
- Optimal.
- Efficient.

Disadvantages:

- Requires high memory.

Comparison Between Brute Force and Heuristic Search

Brute Force Search	Heuristic Search
No additional knowledge	Uses problem knowledge
Slower	Faster
Explores many states	Explores promising states
Simple implementation	More complex
Example: BFS, DFS	Example: A*, Best First

Quick Revision Table

Topic	Key Point
AI	Simulation of human intelligence by machines
State Space Search	Represents problems as states and transitions
Production System	Rule-based AI problem-solving model
Problem Characteristics	Features affecting solution methods
Brute Force Search	Searches without knowledge
Heuristic Search	Uses knowledge to guide search
BFS	Level-by-level search
DFS	Depth-based search

Topic	Key Point
A*	Uses cost + heuristic

Intelligent Agents in Artificial Intelligence

1. Intelligent Agents

Definition (100 Words)

An **Intelligent Agent** is an autonomous computer system that perceives its environment through sensors and takes actions using actuators to achieve specific goals. It is a fundamental concept in Artificial Intelligence that enables machines to perform intelligent tasks without continuous human intervention. An intelligent agent observes the current situation, processes available information, makes decisions, and performs suitable actions. Agents can learn from experience and improve their performance over time. Examples of intelligent agents include robots, virtual assistants, self-driving cars, recommendation systems, and game-playing programs. The main objective of intelligent agents is to maximize performance and achieve desired goals efficiently.

Components of Intelligent Agent

An intelligent agent consists of the following components:

```
Environment
     ↓
 Sensors
     ↓
 Agent Program
     ↓
 Actuators
     ↓
 Actions
```

---

1. Sensors

Topic	Key Point

Definition:

Sensors allow an agent to perceive information from its environment.

Examples:

- Camera.
- Microphone.
- Keyboard.
- Temperature sensors.

---

2. Actuators

Definition:

Actuators help the agent perform actions in the environment.

Examples:

- Robot arms.
- Vehicle controls.
- Speakers.

---

3. Agent Program

Definition:

The software that processes information and decides actions.

---

4. Environment

Definition:

The external world in which the agent operates.

Topic	Key Point

Characteristics of Intelligent Agents

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1. Autonomy

- Operates without direct human control.

Example:

A self-driving car making driving decisions.

---

2. Reactivity

- Responds to changes in the environment.

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3. Proactiveness

- Takes actions to achieve goals.

---

4. Learning Ability

- Improves performance using experience.

---

5. Rationality

- Selects the best possible action.

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2. Types of Intelligent Agents

Topic	Key Point

Definition (100 Words)

Types of Intelligent Agents classify AI agents according to their decision-making abilities and the amount of intelligence they possess. Different agents use different methods to select actions based on current information, previous experiences, goals, and expected outcomes. The major types of intelligent agents are simple reflex agents, model-based reflex agents, goal-based agents, utility-based agents, and learning agents. Simple reflex agents react only to current perceptions, while advanced agents maintain internal models, consider future goals, evaluate possible actions, and learn from experience. These agent types help AI systems solve problems efficiently in different environments and applications.

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1. Simple Reflex Agent

Definition (100 Words)

A **Simple Reflex Agent** is the simplest type of intelligent agent that selects actions based only on the current perception of the environment. It does not store previous experiences or maintain any internal model of the world. The agent follows condition-action rules in which a specific condition produces a specific action. Simple reflex agents are suitable for completely observable environments where the current situation provides enough information for decision-making. They are easy to design and implement but have limited intelligence because they cannot handle situations requiring memory or prediction. Examples include automatic doors, thermostat systems, and simple game-playing agents.

Working of Simple Reflex Agent

```
Current Perception
        ↓
Condition Checking
        ↓
Rule Selection
        ↓
Action
```

Topic	Key Point

Example

Automatic temperature controller:

```
IF temperature is low
THEN turn heater ON
```

Advantages

- Simple design.
- Fast response.
- Easy implementation.

Disadvantages

- No memory.
- Cannot handle partially observable environments.
- Limited decision capability.

---

2. Model-Based Reflex Agent

Definition (100 Words)

A **Model-Based Reflex Agent** is an intelligent agent that maintains an internal model of the environment to make better decisions. Unlike simple reflex agents, it remembers previous states and uses this information to understand situations that are not completely observable. The internal model represents knowledge about how the world works and how actions affect the environment. The agent updates its internal state whenever it receives new perceptions and chooses actions based on both current information and past knowledge. Model-based agents are more powerful than simple reflex agents and can operate effectively in partially observable environments.

Working

Topic	Key Point

```
Current Perception
        ↓
Update Internal Model
        ↓
Decision Making
        ↓
Action
```

Example

A robot that remembers obstacles while navigating.

Advantages

- Uses previous information.
- Handles incomplete information.
- Better decision-making.

Disadvantages

- Requires more memory.
- More complex design.

---

3. Goal-Based Agent

Definition (100 Words)

A **Goal-Based Agent** is an intelligent agent that selects actions by considering future goals and choosing steps that lead toward achieving those goals. Unlike reflex agents, it does not only react to current situations but evaluates possible future states. The agent uses search and planning techniques to determine the best sequence of actions required to reach a goal. Goal-based agents require knowledge about possible actions and their consequences. They are commonly used in navigation systems, planning applications, and problem-solving tasks. Although they are more flexible than reflex agents, they may require greater computational resources for decision-making.

Topic	Key Point

Working

```
Current State
      ↓
Goal Identification
      ↓
Search Possible Actions
      ↓
Select Action
```

Example

GPS navigation system finding the shortest route.

Advantages

- Future-oriented decisions.
- Flexible behavior.
- Handles complex problems.

Disadvantages

- Requires search algorithms.
- More computational cost.

4. Utility-Based Agent

Definition (100 Words)

A **Utility-Based Agent** is an intelligent agent that selects actions by evaluating their usefulness or satisfaction level. It does not only focus on achieving a goal but chooses the action that provides the highest utility among available options. Utility represents the quality or value of a particular outcome. These agents are

Topic	Key Point
	useful when multiple solutions are possible and the best choice must be selected. Utility-based agents consider factors such as efficiency, cost, risk, and performance before making decisions. They are widely used in robotics, autonomous vehicles, and decision-support systems where optimal choices are required.

Utility Function

The utility function measures the desirability of a state.

Formula:

```
Utility = Value of Result
```

Example

Self-driving car choosing the safest and fastest route.

Advantages

- Selects optimal solutions.
- Handles uncertainty.
- Considers multiple factors.

Disadvantages

- Difficult utility calculation.
- Requires more knowledge.

---

5. Learning Agent

Definition (100 Words)

Topic	Key Point
	A **Learning Agent** is an intelligent agent that improves its performance by learning from experiences and feedback received from the environment. It can modify its behavior automatically without requiring complete reprogramming. Learning agents consist of four main components: learning element, performance element, critic, and problem generator. The learning element improves the agent's knowledge, while the critic provides feedback about performance. Learning agents are capable of adapting to new situations and are widely used in machine learning applications. Examples include recommendation systems, speech recognition systems, and autonomous robots. Learning ability makes agents more intelligent and effective over time.

Components of Learning Agent

```
             Learning Agent

        --------------------
        |                  |
Learning Element     Performance Element
        |
      Critic
        |
 Problem Generator
```

---

1. Learning Element

Improves agent performance.

---

2. Performance Element

Selects actions.

---

3. Critic

Provides feedback.

Topic	Key Point

4. Problem Generator

Suggests new actions for learning.

Advantages

- Improves automatically.
- Adapts to changes.
- Handles complex environments.

Disadvantages

- Requires training data.
- Training may take time.

Comparison of Agent Types

Agent Type	Knowledge Used	Memory	Example
Simple Reflex	Current perception	No	Thermostat
Model-Based	Current + past state	Yes	Robot navigation
Goal-Based	Goals	Yes	GPS system
Utility-Based	Utility values	Yes	Self-driving car
Learning Agent	Experience	Yes	Recommendation system

---

3. Agent Environment

Definition (100 Words)

An **Agent Environment** is the external world in which an intelligent agent operates and interacts. The environment provides information through sensors and receives actions through actuators. The nature of the environment affects the

Topic	Key Point
	design and behavior of an intelligent agent. AI environments are classified based on different properties such as observability, predictability, and changes over time. Important types include static and dynamic environments, fully observable and partially observable environments, and deterministic and stochastic environments. Understanding environment characteristics helps developers choose appropriate agent architectures and algorithms. Intelligent agents must be designed according to the specific conditions of their operating environment.

Types of Agent Environments

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1. Static and Dynamic Environment

Definition (100 Words)

A **Static Environment** is an environment that does not change while an agent is making decisions. The agent only needs to consider the current state and does not need to worry about changes during processing. Examples include crossword puzzles and chess problems with no time limit. A **Dynamic Environment** changes continuously while the agent operates, requiring constant monitoring and quick decision-making. Examples include driving environments and robotic systems. Dynamic environments are more complex because agents must respond to unexpected changes. The classification helps determine the level of intelligence and adaptability required for an agent.

Static Environment

Characteristics:

- Does not change during decision-making.
- Easier to solve.
- Requires less computation.

Examples:

- Chess puzzle.

Topic	Key Point

- Mathematical problem.

Dynamic Environment

Characteristics:

- Changes continuously.
- Requires real-time decisions.
- More difficult.

Examples:

- Self-driving cars.
- Robot navigation.

---

2. Fully Observable and Partially Observable Environment

Definition (100 Words)

A **Fully Observable Environment** is one where an agent has complete access to all relevant information required for decision-making. The agent can accurately determine the current state of the environment using its sensors. Examples include chess, where all pieces are visible. A **Partially Observable Environment** is one where the agent receives incomplete or uncertain information about the environment. The agent must use memory, prediction, and reasoning to make decisions. Examples include driving in fog or medical diagnosis systems. The level of observability affects the complexity of designing intelligent agents.

Fully Observable

Examples:

- Chess.

Topic	Key Point

- Board games.

Advantages:

- Easier decision-making.
- Accurate planning.

Partially Observable

Examples:

- Robot navigation.
- Weather prediction.

Disadvantages:

- Requires estimation.
- Requires learning.

---

3. Deterministic and Stochastic Environment

Definition (100 Words)

A **Deterministic Environment** is an environment where the outcome of an action is completely predictable. The same action performed in the same situation always produces the same result. Examples include mathematical problems and chess. A **Stochastic Environment** is an environment where outcomes are uncertain and depend on probability. The same action may produce different results due to randomness or incomplete information. Examples include stock market prediction and medical diagnosis. Intelligent agents operating in stochastic environments require probability models and learning techniques to handle uncertainty effectively.

Deterministic Environment

Topic	Key Point

Features:

- Predictable outcomes.
- No randomness.
- Easier planning.

Example:

Chess.

Stochastic Environment

Features:

- Random outcomes.
- Requires probability.
- More complex.

Example:

Weather forecasting.

Comparison of Environment Types

Environment Type	Meaning	Example
Static	Does not change	Puzzle solving
Dynamic	Changes continuously	Driving
Fully Observable	Complete information available	Chess
Partially Observable	Limited information	Medical diagnosis
Deterministic	Predictable result	Mathematical problem
Stochastic	Uncertain result	Stock market

Quick Revision Table

Topic	Key Point

Topic	Key Point
Intelligent Agent	System that perceives and acts intelligently
Simple Reflex Agent	Uses current perception only
Model-Based Agent	Uses internal memory
Goal-Based Agent	Works toward goals
Utility-Based Agent	Selects best utility action
Learning Agent	Improves through experience
Static Environment	Environment remains unchanged
Dynamic Environment	Environment changes
Observable Environment	Information availability
Deterministic Environment	Predictable results

Ethical Considerations in Artificial Intelligence

1. Ethical Considerations in Artificial Intelligence

Definition (100 Words)

Ethical Considerations in Artificial Intelligence refer to the principles, guidelines, and moral issues that must be considered while designing, developing, and using AI systems. AI technologies can significantly influence individuals, organizations, and society, making it necessary to ensure fairness, transparency, privacy, accountability, and responsible use. Ethical AI focuses on preventing harmful consequences such as discrimination, misuse of personal data, unemployment due to automation, and unfair decision-making. It aims to create AI systems that respect human values, protect individual rights, and benefit society. Addressing ethical issues helps build trust, safety, and responsible development of artificial intelligence technologies.

Importance of AI Ethics

- Ensures fair decision-making.
- Protects user privacy.
- Prevents discrimination.

- Builds trust in AI systems.
- Reduces social risks.
- Promotes responsible innovation.

Major Ethical Issues in AI

```
              AI Ethics
                  |
 --------------------------------
 |              |             |
Bias         Privacy     Job Displacement
                  |
          Societal Impact
```

---

2. AI Bias

Definition (100 Words)

AI Bias refers to unfair or inaccurate outcomes produced by artificial intelligence systems due to biased training data, algorithms, or human decisions during system development. AI systems learn patterns from available data, and if the data contains existing social, cultural, or historical biases, the AI may reproduce and even increase those biases. Bias can result in unfair treatment of individuals based on characteristics such as gender, race, age, or economic background. Reducing AI bias requires diverse datasets, transparent algorithms, regular testing, and human oversight. Eliminating bias is essential for developing fair, reliable, and trustworthy AI applications.

Causes of AI Bias

1. Biased Training Data

AI learns from historical data.

Example:

If hiring data contains past discrimination, AI may repeat unfair hiring decisions.

---

2. Algorithm Design

Poorly designed algorithms may favor certain groups.

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3. Lack of Diversity

Limited diversity among AI developers can introduce hidden biases.

---

4. Incorrect Data Collection

Incomplete or inaccurate data can create unfair results.

Types of AI Bias

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1. Data Bias

Occurs when training data is incomplete or unbalanced.

Example:

Facial recognition systems performing poorly on certain groups.

---

2. Algorithmic Bias

Occurs due to unfair mathematical models or design choices.

---

3. Human Bias

Occurs when developers unintentionally introduce personal assumptions.

Examples of AI Bias

- Biased recruitment software rejecting qualified candidates.
- Facial recognition systems showing different accuracy levels.
- Loan approval systems making unfair decisions.

Methods to Reduce AI Bias

1. Use Diverse Data

Training data should represent different groups.

---

2. Fairness Testing

Regularly evaluate AI decisions.

---

3. Transparent Algorithms

Make decision-making processes understandable.

---

4. Human Monitoring

Human experts should review important AI decisions.

Impact of AI Bias

Negative Effects:

- Discrimination.

- Loss of trust.
- Wrong decisions.
- Social inequality.

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3. Privacy in Artificial Intelligence

Definition (100 Words)

AI Privacy refers to protecting personal information collected, processed, and stored by artificial intelligence systems. AI applications often require large amounts of data to learn and make predictions, including sensitive information such as personal details, medical records, financial information, and user behavior. Improper collection, storage, or use of this data can create privacy risks. Ethical AI systems should ensure data protection, user consent, transparency, and secure processing methods. Privacy protection helps maintain user trust and prevents misuse of personal information. Organizations must follow privacy laws and security practices while developing and deploying AI-based systems.

Importance of Privacy in AI

- Protects personal information.
- Builds user confidence.
- Prevents unauthorized access.
- Maintains legal compliance.
- Reduces security risks.

Privacy Issues in AI

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1. Data Collection

AI systems collect large amounts of user data.

Problem:

Users may not know what information is collected.

2. Data Storage

Large databases may become targets for cyber attacks.

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3. Data Sharing

Personal information may be shared without proper permission.

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4. Surveillance

AI-powered monitoring systems may affect personal freedom.

Examples of AI Privacy Concerns

- Voice assistants storing conversations.
- Social media platforms analyzing user behavior.
- Facial recognition collecting biometric information.

Methods to Protect Privacy

1. Data Encryption

Protects stored information.

---

2. User Consent

Users should know and approve data usage.

---

3. Data Minimization

Collect only necessary information.

---

4. Anonymization

Remove personal identifiers from data.

---

4. Job Displacement Due to AI

Definition (100 Words)

Job Displacement Due to AI refers to the reduction or replacement of human jobs caused by automation and artificial intelligence technologies. AI systems and robots can perform many repetitive, predictable, and data-based tasks faster and more accurately than humans. While AI creates new job opportunities in technology and related fields, it may reduce employment in some traditional occupations. Industries such as manufacturing, transportation, customer service, and data processing are highly affected by automation. The ethical challenge is to balance technological progress with social responsibility by providing education, skill development, and opportunities for workers to adapt to changing job requirements.

Causes of Job Displacement

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1. Automation of Routine Tasks

Machines replace repetitive human activities.

Example:

Factory robots replacing manual assembly work.

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2. Increased Efficiency

Organizations use AI to reduce costs and increase productivity.

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3. Advanced Robotics

Robots perform physical tasks previously done by humans.

Industries Affected by AI Automation

Industry	AI Impact
Manufacturing	Robot-based production
Transportation	Autonomous vehicles
Customer Service	Chatbots
Banking	Automated processing
Data Entry	AI-based systems

Positive Effects of AI on Employment

- Creates new technology jobs.
- Improves productivity.
- Reduces dangerous work.
- Creates opportunities for innovation.

Negative Effects of AI on Employment

- Loss of traditional jobs.
- Need for new skills.
- Increased economic inequality.

Solutions for Job Displacement

1. Skill Development

Workers should learn new technologies.

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2. Education and Training

Provide AI-related training programs.

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3. Human-AI Collaboration

Use AI to support humans rather than completely replace them.

---

5. Societal Impact of AI

Definition (100 Words)

Societal Impact of Artificial Intelligence refers to the effects of AI technologies on individuals, communities, organizations, and society as a whole. AI has the potential to improve healthcare, education, transportation, communication, and economic development. However, it also creates challenges related to privacy, employment, security, inequality, and human decision-making. The widespread use of AI can influence social behavior, ethical values, and power structures. Responsible AI development requires considering both benefits and risks to ensure technology serves humanity. Society must establish appropriate regulations, ethical guidelines, and awareness programs to maximize positive impacts while minimizing harmful consequences.

Positive Societal Impacts of AI

---

1. Improved Healthcare

AI helps in:

- Disease diagnosis.
- Drug discovery.
- Patient monitoring.

---

2. Better Education

AI provides:

- Personalized learning.
- Online educational support.

---

3. Increased Productivity

Automation improves efficiency in industries.

---

4. Improved Safety

AI supports:

- Disaster prediction.
- Crime prevention.
- Accident reduction.

Negative Societal Impacts of AI

---

1. Inequality

Unequal access to AI technology may increase social gaps.

---

2. Privacy Loss

AI surveillance can affect personal freedom.

---

3. Employment Changes

Automation may reduce certain job opportunities.

---

4. Misuse of AI

AI can be used for harmful purposes.

Examples:

- Fake content generation.
- Cyber attacks.

Responsible AI Principles

---

1. Fairness

AI decisions should not discriminate.

---

2. Transparency

AI systems should provide understandable decisions.

---

3. Accountability

Developers and organizations should be responsible for AI outcomes.

---

4. Privacy Protection

Personal data must be secured.

---

5. Human Control

Humans should maintain control over important decisions.

Comparison of Ethical Issues

Issue	Main Concern	Example
Bias	Unfair decisions	Biased hiring AI
Privacy	Data misuse	Personal data collection
Job Displacement	Employment loss	Automated factories
Societal Impact	Social changes	AI inequality

Quick Revision Table

Topic	Key Points
AI Ethics	Responsible and fair use of AI
Bias	Unfair AI decisions due to data/algorithm problems
Privacy	Protection of personal information
Job Displacement	Human jobs replaced by automation
Societal Impact	Effects of AI on society

UNIT II – Knowledge Representation in Artificial Intelligence

1. Knowledge Representation (KR)

Definition (100 Words)

Knowledge Representation (KR) is a fundamental concept in Artificial Intelligence that deals with storing, organizing, and representing knowledge in a form that enables computers to understand, reason, and make decisions. It provides a way to convert real-world information into a structured format that AI systems can process. Knowledge representation allows machines to use facts, rules, relationships, and experiences to solve problems and perform intelligent tasks. It plays an important role in expert systems, natural language processing, robotics, and automated reasoning. Common knowledge representation techniques include logic-based representation, rule-based representation, semantic networks, frames, and ontologies.

Importance of Knowledge Representation

- Enables reasoning and decision-making.
- Helps computers understand real-world information.
- Supports problem-solving.
- Improves communication between humans and machines.
- Provides a foundation for expert systems.

Characteristics of Good Knowledge Representation

1. Representational Accuracy

The knowledge should correctly describe real-world information.

---

2. Inferential Ability

The system should derive new knowledge from existing facts.

---

3. Efficiency

Knowledge should be stored and processed efficiently.

---

4. Completeness

All necessary information should be represented.

---

5. Understandability

The representation should be easy to interpret.

---

2. Types of Knowledge

Definition (100 Words)

Types of Knowledge refer to different forms of information stored and processed by an AI system for reasoning and decision-making. Knowledge is an essential component of intelligent systems because it allows machines to understand situations, solve problems, and generate conclusions. In Artificial Intelligence, knowledge is generally classified into several types such as declarative knowledge, procedural knowledge, heuristic knowledge, meta knowledge, and structural knowledge. Each type represents information in a different way. Declarative knowledge describes facts, procedural knowledge explains actions, heuristic knowledge provides experience-based rules, meta knowledge describes knowledge about knowledge, and structural knowledge represents relationships between concepts.

Major Types of Knowledge in AI

---

1. Declarative Knowledge

Definition:

Declarative knowledge represents facts and information about objects, events, and situations.

It answers:

"What is true?"

Examples:

- Paris is the capital of France.
- Water freezes at 0°C.

Characteristics:

- Fact-based.
- Easy to represent.
- Used in databases and expert systems.

---

2. Procedural Knowledge

Definition:

Procedural knowledge represents knowledge about how to perform tasks or actions.

It answers:

"How to do something?"

Examples:

- Steps to solve a mathematical problem.
- Algorithm for sorting data.

Characteristics:

- Action-oriented.
- Stored as procedures or rules.

---

3. Heuristic Knowledge

Definition:

Heuristic knowledge represents experience-based knowledge used for solving problems efficiently.

Example:

A doctor using experience to diagnose diseases.

Characteristics:

- Based on practical experience.
- Helps reduce search time.

---

4. Meta Knowledge

Definition:

Meta knowledge is knowledge about knowledge.

It describes:

- How knowledge is organized.
- How knowledge should be used.

Example:

Rules for selecting a problem-solving method.

---

5. Structural Knowledge

Definition:

Structural knowledge represents relationships between concepts and objects.

Examples:

Relationships:

```
Bird → Animal
Animal → Living Thing
```

Used in:

- Semantic networks.
- Ontologies.

Comparison of Knowledge Types

Knowledge Type	Meaning	Example
Declarative	Facts	Earth revolves around Sun
Procedural	Procedures	Cooking steps
Heuristic	Experience-based rules	Medical diagnosis
Meta	Knowledge about knowledge	Selecting methods
Structural	Relationships	Class hierarchy

---

3. Inferencing in AI

Definition (100 Words)

Inferencing is the process of deriving new information or conclusions from existing knowledge using logical reasoning techniques. It is an important function of AI systems because it enables machines to make decisions and solve problems based on available facts and rules. During inferencing, an AI system applies inference methods to analyze stored knowledge and generate new conclusions. Inferencing is widely used in expert systems, decision-support systems, natural language processing, and automated reasoning. The quality of inference depends on the accuracy of the knowledge base and the reasoning mechanisms used. Common inference approaches include deductive reasoning, inductive reasoning, and abductive reasoning.

Types of Inferencing

---

1. Deductive Reasoning

Definition:

Deductive reasoning derives specific conclusions from general facts.

Example:

Rule:

All humans are mortal.

Fact:

John is human.

Conclusion:

John is mortal.

---

2. Inductive Reasoning

Definition:

Inductive reasoning derives general rules from specific examples.

Example:

Observation:

All observed birds fly.

Conclusion:

All birds can fly.

---

3. Abductive Reasoning

Definition:

Abductive reasoning finds the most likely explanation for an observation.

Example:

Observation:

The road is wet.

Possible conclusion:

It may have rained.

Inferencing Process

```
Knowledge Base
       ↓
Apply Inference Rules
       ↓
Generate New Facts
       ↓
Conclusion
```

---

4. Inference Rules

Definition (100 Words)

Inference Rules are logical principles used by Artificial Intelligence systems to derive new knowledge from existing facts and statements. They define how conclusions can be generated from available information in a knowledge base. Inference rules provide the foundation for reasoning mechanisms in expert systems and intelligent agents. They allow AI systems to perform automatic deduction and decision-making. Common inference rules include Modus Ponens, Modus Tollens, Resolution, and Universal Instantiation. These rules ensure that conclusions are logically valid and consistent with existing knowledge. Inference rules are widely used in logic-based systems, theorem proving, and knowledge-based applications.

Major Inference Rules

---

1. Modus Ponens

Definition:

If a statement is true and its condition is true, then the conclusion is true.

Form:

```
If P → Q
P is true
Therefore Q is true
```

Example:

Rule:

If it rains, roads become wet.

Fact:

It rains.

Conclusion:

Roads are wet.

---

2. Modus Tollens

Definition:

If a conclusion is false, then the condition causing it is also false.

Form:

```
If P → Q
Not Q
Therefore Not P
```

Example:

If machine works → light is ON.

Light is not ON.

Therefore machine is not working.

---

3. Resolution Rule

Definition:

A rule used to combine logical statements and derive conclusions.

Example:

```
P OR Q
NOT Q
Therefore P
```

---

4. Universal Instantiation

Definition:

A general statement is applied to a specific object.

Example:

All humans are mortal.

John is human.

Therefore John is mortal.

---

5. Forward and Backward Chaining

Forward Chaining

Definition:

A reasoning method that starts with known facts and applies rules to generate new conclusions until a goal is reached.

Approach:

```
Facts → Rules → Conclusion
```

Example:

Used in:

- Expert systems.

Advantage:

- Data-driven.

Backward Chaining

Definition:

A reasoning method that starts with a goal and works backward to find supporting facts.

Approach:

```
Goal → Rules → Facts
```

Example:

Used in:

- Medical diagnosis systems.

Advantage:

- Goal-driven.

Difference Between Forward and Backward Chaining

Forward Chaining	Backward Chaining
Starts with facts	Starts with goal
Data-driven	Goal-driven
Finds all possible conclusions	Finds required facts

Forward Chaining	Backward Chaining
Used in prediction	Used in diagnosis

---

5. Logic-Based Knowledge Representation

Definition (100 Words)

Logic-Based Knowledge Representation is a method of representing knowledge using formal mathematical logic. It expresses facts and relationships through logical statements that can be processed by AI systems for reasoning and decision-making. Logic-based representation provides a precise and unambiguous way to describe knowledge. It mainly uses propositional logic and predicate logic to represent objects, properties, and relationships. AI systems apply inference rules to derive new conclusions from logical statements. This approach is widely used in expert systems, automated theorem proving, and intelligent reasoning systems because it provides accuracy, consistency, and a strong foundation for knowledge processing.

Types of Logic-Based Representation

---

1. Propositional Logic

Definition:

Represents knowledge using simple statements that are either true or false.

Example:

```
P: It is raining
Q: Road is wet
```

Limitations:

- Cannot represent relationships.
- Limited expressive power.

---

2. Predicate Logic (First Order Logic)

Definition:

Represents objects, properties, and relationships using predicates.

Example:

```
Human(John)
Likes(John, Music)
```

Components of Predicate Logic

1. Objects

Entities in the world.

Example:

John, Car.

---

2. Predicates

Represent properties or relationships.

Example:

Tall(John)

---

3. Variables

Represent unknown objects.

Example:

X, Y.

---

4. Quantifiers

Two types:

Universal (∀)

Means all.

Example:

∀ humans are mortal.

Existential (∃)

Means there exists.

Example:

∃ a student.

Advantages of Logic-Based Representation

- Precise.
- Supports reasoning.
- Avoids ambiguity.
- Easy inference.

Disadvantages

- Difficult for complex knowledge.
- Requires formal representation.
- Computationally expensive.

---

6. Rule-Based Knowledge Representation

Definition (100 Words)

Rule-Based Knowledge Representation is a technique in Artificial Intelligence where knowledge is represented using a collection of IF-THEN rules. These rules describe relationships between conditions and actions or conclusions. A rule-based system consists of a knowledge base containing rules and a reasoning engine that applies these rules to derive conclusions. This representation method is commonly used in expert systems because it closely resembles human decision-making processes. Rule-based systems are easy to understand, modify, and maintain. Examples include medical diagnosis systems, troubleshooting systems, and decision-support applications where knowledge is represented as logical rules.

Structure of Rule-Based Representation

General form:

```
IF condition
THEN action/conclusion
```

Example:

```
IF patient has fever
AND cough
THEN possible flu
```

Components of Rule-Based System

---

1. Knowledge Base

Contains:

- Facts.
- Rules.

---

2. Inference Engine

Applies rules to generate conclusions.

---

3. Working Memory

Stores current information.

Types of Rule-Based Systems

---

1. Production Rule System

Uses IF-THEN rules.

Example:

Expert systems.

---

2. Expert System

A computer system that uses rules to provide expert-level decisions.

Examples:

- Medical diagnosis.
- Fault detection.

Advantages of Rule-Based Representation

- Easy to understand.
- Easy modification.
- Supports reasoning.
- Similar to human decision-making.

Disadvantages

- Large rule sets become difficult to manage.
- Limited learning ability.
- Conflict between rules may occur.

Logic-Based vs Rule-Based Knowledge Representation

Logic-Based KR	Rule-Based KR
Uses formal logic	Uses IF-THEN rules
Mathematical representation	Production rules
More precise	Easier to understand
Used in theorem proving	Used in expert systems

Quick Revision Table

Topic	Key Point
Knowledge Representation	Method of storing knowledge for AI reasoning
Declarative Knowledge	Facts and information
Procedural Knowledge	Steps and procedures
Inferencing	Deriving new conclusions
Inference Rules	Logical methods for reasoning
Logic-Based KR	Uses mathematical logic
Rule-Based KR	Uses IF-THEN rules

Knowledge Representation in Artificial Intelligence (Advanced Topics)

1. Non-Monotonic Reasoning

Definition (100 Words)

Non-Monotonic Reasoning is a reasoning technique in Artificial Intelligence where previously accepted conclusions can be withdrawn when new information becomes available. Unlike traditional logical reasoning, where adding new facts only increases knowledge, non-monotonic reasoning allows the knowledge base to be revised according to changing information. It is useful in real-world situations where information is incomplete, uncertain, or changes over time. Human reasoning often follows non-monotonic patterns because people make assumptions based on current knowledge and modify decisions when new evidence appears. Non-monotonic reasoning is widely used in expert systems, intelligent agents, databases, and knowledge-based systems.

Concept of Non-Monotonic Reasoning

In classical logic:

```
New Knowledge → More Conclusions
```

Knowledge only increases.

In non-monotonic reasoning:

```
New Knowledge → Previous Conclusions May Change
```

The system can remove earlier conclusions.

Example

Initial Knowledge:

"Birds can fly."

Given:

Tweety is a bird.

Conclusion:

Tweety can fly.

Later:

New information:

"Tweety is a penguin."

Updated Conclusion:

Tweety cannot fly.

The previous conclusion is withdrawn.

Need for Non-Monotonic Reasoning

- Real-world information is incomplete.
- Knowledge changes frequently.
- Human decisions are based on assumptions.
- Helps handle exceptions.
- Supports intelligent decision-making.

Characteristics of Non-Monotonic Reasoning

1. Dynamic Knowledge

Knowledge can change with new information.

---

2. Exception Handling

Allows exceptions to general rules.

Example:

General rule:

Birds fly.

Exception:

Penguins cannot fly.

---

3. Belief Revision

Allows modification of existing beliefs.

Types of Non-Monotonic Reasoning

---

1. Default Reasoning

Uses assumptions when complete information is unavailable.

Example:

"Normally birds fly."

---

2. Circumscription

Limits assumptions by considering only necessary facts.

---

3. Truth Maintenance Systems

Maintain consistency when knowledge changes.

Advantages

- Handles incomplete information.
- Similar to human reasoning.
- Supports changing environments.

Disadvantages

- More complex than classical logic.
- Difficult to implement.
- Requires knowledge revision mechanisms.

2. Knowledge Representation Based on Probability and Uncertainty

Definition (100 Words)

Knowledge Representation Based on Probability and Uncertainty is an AI technique used to represent and reason with incomplete, uncertain, or unreliable information using mathematical probability methods. Real-world situations often contain uncertainty because information may be missing, noisy, or unpredictable. Probability-based representation allows AI systems to assign confidence values to facts and make decisions under uncertain conditions. It is widely used in medical diagnosis, weather prediction, robotics, and machine learning systems. Instead of representing knowledge as simply true or false, probability-based systems represent the likelihood of different possibilities. This approach helps intelligent systems handle uncertainty and make more realistic decisions.

Need for Uncertainty Representation

Real-world problems involve:

- Incomplete information.
- Unknown situations.
- Random events.
- Measurement errors.

Example:

A doctor cannot always be 100% sure about a disease diagnosis.

Probability in AI

Probability represents the likelihood of an event.

Formula:

P(A)=Number of favorable outcomesTotal possible outcomesP(A)=\frac{\text{Number of favorable outcomes}}{\text{Total possible outcomes}}P(A)=Total possible outcomesNumber of favorable outcomes

Range:

`0 ≤ P(A) ≤ 1`

Types of Uncertainty

---

1. Random Uncertainty

Occurs due to unpredictable events.

Example:

Weather changes.

---

2. Incomplete Knowledge

Occurs when information is missing.

Example:

Unknown patient history.

---

3. Imprecise Information

Information is available but not exact.

Example:

"Temperature is high."

Methods for Representing Uncertainty

---

1. Bayesian Networks

Definition:

A Bayesian Network is a probabilistic graphical model that represents relationships between variables using probability.

Example:

Disease diagnosis:

```
Disease → Symptoms
```

Advantages:

- Handles uncertain knowledge.
- Supports prediction.
- Uses probability calculations.

---

2. Fuzzy Logic

Definition:

Fuzzy logic represents knowledge using degrees of truth instead of only true or false values.

Example:

Traditional Logic:

```
Temperature = Hot or Cold
```

Fuzzy Logic:

```
Temperature = 70% Hot
```

---

3. Certainty Factor Model

Used in expert systems to represent confidence levels.

Example:

"Patient has flu with 80% confidence."

Advantages of Probability-Based Representation

- Handles uncertainty effectively.
- Supports decision-making.
- Suitable for real-world problems.
- Provides confidence levels.

Disadvantages

- Requires probability data.
- Calculations can be complex.
- Difficult to represent all situations.

---

3. Knowledge Representation Schemes

Definition (100 Words)

Knowledge Representation Schemes are methods used in Artificial Intelligence to organize and store knowledge in a structured form so that computers can process, reason, and make decisions. Different schemes represent knowledge according to the type of information and the requirements of the application. Common knowledge representation schemes include formal logic, semantic networks, frames, and scripts. Formal logic represents knowledge using mathematical expressions, semantic networks represent relationships between concepts, frames organize knowledge about objects and situations, and scripts represent sequences of events. These schemes help AI systems understand complex information and perform reasoning tasks efficiently in various applications.

Major Knowledge Representation Schemes

```
Knowledge Representation Schemes

          |
 -----------------------------
 |          |        |        |
Logic   Semantic  Frame   Script
        Network
```

---

4. Formal Logic

Definition (100 Words)

Formal Logic is a knowledge representation technique in Artificial Intelligence that uses mathematical symbols and logical rules to represent facts, relationships, and reasoning processes. It provides a precise and unambiguous method for expressing knowledge. Formal logic allows AI systems to derive new conclusions from existing facts using inference rules. The two main forms of formal logic used in AI are propositional logic and predicate logic. It is widely used in automated theorem proving, expert systems, and intelligent reasoning applications. Formal logic provides accuracy and consistency but may become complex when representing large amounts of real-world knowledge.

Types of Formal Logic

---

1. Propositional Logic

Definition:

Represents knowledge using simple statements that are either true or false.

Example:

```
P: It is raining.
Q: Road is wet.
```

Limitations:

- Cannot represent relationships.
- Limited expression capability.

---

2. Predicate Logic

Definition:

Represents objects, properties, and relationships.

Example:

`Student(Ravi)`

`Likes(Ravi, AI)`

Components of Predicate Logic

1. Constants

Represent specific objects.

Example:

Ravi.

---

2. Variables

Represent unknown objects.

Example:

X.

---

3. Predicates

Represent properties.

Example:

Tall(Ravi).

---

4. Quantifiers

Universal Quantifier (∀)

Means "for all".

Example:

All humans are mortal.

Existential Quantifier (∃)

Means "there exists".

Example:

There exists a student.

Advantages of Formal Logic

- Precise representation.
- Supports automatic reasoning.

- Removes ambiguity.

Disadvantages

- Difficult for complex knowledge.
- Requires formal structure.
- Computationally expensive.

---

5. Semantic Network

Definition (100 Words)

Semantic Network is a graphical knowledge representation technique in Artificial Intelligence that represents knowledge using nodes and links. Nodes represent objects, concepts, or entities, while links represent relationships between them. Semantic networks organize information in a structure similar to human memory, making it easier for AI systems to understand relationships between concepts. They support inheritance, where properties of higher-level concepts can be transferred to lower-level concepts. Semantic networks are widely used in natural language processing, expert systems, and knowledge management. They provide a visual and intuitive method of representing knowledge but may have limitations in handling complex reasoning.

Structure of Semantic Network

```
Animal
   |
is-a
   |
 Bird
   |
is-a
   |
Sparrow
```

Components

1. Nodes

Represent objects or concepts.

Examples:

- Person.
- Animal.
- Vehicle.

---

2. Links

Represent relationships.

Examples:

- Is-a.
- Has.
- Part-of.

Types of Relationships

---

1. IS-A Relationship

Represents inheritance.

Example:

Dog is an animal.

---

2. PART-OF Relationship

Represents component relationship.

Example:

Engine is part of car.

Advantages

- Easy visualization.
- Supports inheritance.
- Similar to human thinking.

Disadvantages

- Difficult to represent complex logic.
- Lack of standard structure.
- Large networks become complex.

---

6. Frame Representation

Definition (100 Words)

Frame Representation is a knowledge representation technique in Artificial Intelligence that organizes knowledge about objects, concepts, and situations using structured data units called frames. A frame contains information about an object through slots and values. Slots represent properties or attributes, while values provide specific information about those properties. Frames support inheritance, allowing objects to acquire characteristics from related higher-level frames. They are similar to human memory organization and are useful for representing common situations and objects. Frames are widely used in expert systems, natural language processing, and computer vision. They provide an efficient method for storing structured knowledge.

Structure of Frame

Example:

Frame: Student

Slot	Value
Name	Ravi
Age	20
Course	BCA

Components of Frame

---

1. Frame Name

Identifies the object.

Example:

Student.

---

2. Slots

Represent properties.

Example:

Age, Name.

---

3. Values

Provide information.

Example:

Age = 20.

---

4. Facets

Describe additional information about slots.

Example:

Default values.

Advantages

- Easy organization.
- Supports inheritance.
- Similar to human understanding.

Disadvantages

- Less suitable for complex reasoning.
- Requires predefined structures.

---

7. Scripts

Definition (100 Words)

Scripts are a knowledge representation technique in Artificial Intelligence used to represent stereotypical sequences of events that occur in a particular situation. Scripts describe the expected order of actions and activities in common events. They are useful for understanding natural language and predicting missing information in conversations. A script contains information about roles, objects, conditions, and sequences of events. For example, a restaurant script describes entering a restaurant, ordering food, eating, and paying the bill. Scripts are mainly used in natural language processing and understanding systems. They help AI systems interpret events and predict future actions based on previous knowledge.

Components of Scripts

---

1. Entry Conditions

Conditions required before the script begins.

Example:

Customer enters restaurant.

---

2. Roles

People involved in events.

Example:

Customer, waiter.

---

3. Props

Objects involved.

Example:

Food, table, menu.

---

4. Scenes

Sequence of events.

Example:

Order → Eat → Pay.

---

5. Results

Final outcome.

Example:

Customer leaves restaurant.

Example: Restaurant Script

```
Enter restaurant
       ↓
Find table
       ↓
Order food
       ↓
Eat food
       ↓
Pay bill
       ↓
Leave
```

Advantages

- Represents common situations.
- Helps language understanding.
- Predicts missing information.

Disadvantages

- Limited to known situations.
- Difficult for unexpected events.
- Requires predefined scripts.

Comparison of Knowledge Representation Schemes

Scheme	Representation	Example
Formal Logic	Logical statements	Predicate logic
Semantic Network	Graph structure	Concept relationships

Scheme	Representation	Example
Frame	Objects and attributes	Student frame
Script	Event sequences	Restaurant activities

1.

Quick Revision Table

Topic	Key Point
Non-Monotonic Reasoning	Allows changing conclusions
Probability Representation	Handles uncertainty
Formal Logic	Uses mathematical logic
Semantic Network	Uses nodes and links
Frame	Uses slots and values
Script	Represents event sequences

UNIT – III

Expert System in Artificial Intelligence

1. Expert System

Definition (100 Words)

An **Expert System** is an Artificial Intelligence-based computer system that simulates the decision-making ability of a human expert in a specific domain. It uses stored knowledge, facts, and reasoning techniques to solve complex problems and provide advice or solutions. An expert system consists of a knowledge base containing domain knowledge and an inference engine that applies logical rules to derive conclusions. These systems are designed to assist users in areas where expert knowledge is required, such as medical diagnosis, finance, engineering, and troubleshooting. Expert systems improve decision-making by providing fast, consistent, and reliable solutions similar to those provided by human specialists.

Concept of Expert System

An expert system is a knowledge-based AI system that can:

- Understand a specific problem domain.
- Apply expert knowledge.
- Make decisions.
- Provide explanations for conclusions.

Basic Working:

```
User
  |
  ↓
User Interface
  |
  ↓
Inference Engine
  |
  ↓
Knowledge Base
  |
  ↓
Solution / Advice
```

Characteristics of Expert Systems

1. Domain Specific

- Designed for a particular field.
- Example: Medical diagnosis system.

---

2. Knowledge-Based

- Stores expert knowledge and facts.

---

3. Reasoning Ability

- Uses inference rules to solve problems.

---

4. Explanation Capability

- Explains how decisions are made.

---

5. User Interaction

- Communicates with users through an interface.

---

6. Reliability

- Provides consistent decisions.

Applications of Expert Systems

Field	Application
Medicine	Disease diagnosis
Banking	Loan approval
Agriculture	Crop disease detection
Engineering	Fault diagnosis
Education	Intelligent tutoring
Finance	Investment advice

---

2. Role of Knowledge in Expert Systems

Definition (100 Words)

**Knowledge plays a central role in expert systems because it provides the information required for reasoning and decision-making. The knowledge stored in an expert system represents the expertise, facts, rules, and experiences of human specialists. Without knowledge, an expert system cannot analyze problems or generate solutions. Knowledge is collected from experts, books, databases, and other sources and stored in a knowledge base. The inference engine uses this knowledge to draw conclusions and provide recommendations. The quality and completeness of knowledge directly affect the accuracy and performance of an expert system. Therefore, knowledge is considered the foundation of every expert system.

Importance of Knowledge in Expert Systems

1. Provides Expertise

Knowledge allows the system to perform tasks similar to human experts.

Example:

Medical knowledge helps diagnose diseases.

---

2. Supports Decision Making

Knowledge helps select appropriate solutions from available choices.

---

3. Enables Reasoning

Knowledge allows the inference engine to derive new conclusions.

Example:

```
Rule:
If fever and cough → Flu

Fact:
Patient has fever and cough

Conclusion:
Patient may have flu
```

---

4. Improves Accuracy

A larger and more accurate knowledge base produces better results.

---

5. Provides Explanation

Knowledge allows the system to explain the reason behind decisions.

Types of Knowledge Used in Expert Systems

---

1. Declarative Knowledge

Definition:

Knowledge about facts and information.

Example:

"Water boils at 100°C."

---

2. Procedural Knowledge

Definition:

Knowledge about procedures and methods.

Example:

Steps for diagnosing a disease.

---

3. Heuristic Knowledge

Definition:

Knowledge based on expert experience and rules of thumb.

Example:

Doctor's experience in identifying symptoms.

---

4. Meta Knowledge

Definition:

Knowledge about how to use other knowledge.

Example:

Selecting the best reasoning method.

---

5. Structural Knowledge

Definition:

Knowledge about relationships between concepts.

Example:

```
Dog → Animal → Living Thing
```

Knowledge Acquisition in Expert Systems

Definition:

Knowledge acquisition is the process of collecting knowledge from human experts and converting it into a form that can be stored in the knowledge base.

Sources of Knowledge

- Human experts.

- Books and documents.
- Research papers.
- Databases.
- Previous cases.

Knowledge Representation Methods

Expert systems represent knowledge using:

1. Production rules.
2. Logic.
3. Frames.
4. Semantic networks.

---

3. Architecture of Expert System

Definition (100 Words)

The **Architecture of an Expert System** describes the structure and components that allow the system to store knowledge, perform reasoning, communicate with users, and provide solutions. The architecture consists of several important components including the knowledge base, inference engine, user interface, explanation facility, and knowledge acquisition module. The knowledge base stores domain-specific information, while the inference engine applies reasoning methods to generate conclusions. The user interface allows interaction between users and the system. The explanation facility provides justification for decisions, and the knowledge acquisition module helps update and improve the knowledge base. These components work together to simulate human expert behavior.

Architecture Diagram of Expert System

```
          User
           |
           ↓
     User Interface
           |
           ↓
     Inference Engine
           |
```

```
       --------------------
       |                  |
       ↓                  ↓
Knowledge Base     Explanation Facility
       |
       ↓
Knowledge Acquisition
       |
       ↓
Human Expert
```

Components of Expert System Architecture

---

1. Knowledge Base

Definition (100 Words)

The **Knowledge Base** is the most important component of an expert system that stores domain-specific knowledge, facts, rules, and relationships required for solving problems. It contains information collected from human experts, documents, databases, and previous experiences. The knowledge base represents the expertise of a specialist and provides the information required by the inference engine for reasoning. It may contain facts, IF-THEN rules, concepts, and procedures. A well-designed knowledge base improves the accuracy and reliability of an expert system. Updating and maintaining the knowledge base is essential to keep the expert system effective and useful.

Contents of Knowledge Base

- Facts.
- Rules.
- Relationships.
- Heuristic knowledge.
- Procedures.

Example:

Medical Expert System:

```
IF patient has fever AND cough
```

```
THEN possible influenza
```

---

2. Inference Engine

Definition (100 Words)

The **Inference Engine** is the reasoning component of an expert system that applies logical rules to the knowledge stored in the knowledge base to generate conclusions and solutions. It acts as the brain of the expert system by analyzing facts, selecting appropriate rules, and performing reasoning. The inference engine uses techniques such as forward chaining and backward chaining to solve problems. Forward chaining starts with available facts and derives conclusions, while backward chaining starts with a goal and searches for supporting facts. The efficiency of an expert system largely depends on the capability of its inference engine.

Functions of Inference Engine

- Matches facts with rules.
- Applies reasoning techniques.
- Generates conclusions.
- Controls search process.

Reasoning Methods

1. Forward Chaining

Definition:

A data-driven reasoning method that starts from known facts and applies rules to reach conclusions.

Example:

```
Facts → Rules → Solution
```

---

2. Backward Chaining

Definition:

A goal-driven reasoning method that starts with a goal and finds supporting facts.

Example:

```
Goal → Rules → Facts
```

---

3. User Interface

Definition (100 Words)

The **User Interface** is the communication component of an expert system that allows users to interact with the system. It provides a simple way for users to enter problems, provide information, and receive solutions or recommendations. The user interface converts user input into a format that the inference engine can process and displays the generated results in an understandable form. A good user interface improves the usability and effectiveness of an expert system. It may include text-based interfaces, graphical interfaces, or voice-based communication systems. The user interface acts as a bridge between the user and the expert system.

Functions

- Accepts user queries.
- Displays results.
- Provides interaction.
- Collects required information.

---

4. Explanation Facility

Definition (100 Words)

The **Explanation Facility** is a component of an expert system that explains the reasoning process used to reach a particular conclusion. It helps users understand why a specific decision or recommendation was generated. This feature increases user confidence and trust in the system. The explanation facility can provide information about the rules applied, facts considered, and steps followed during reasoning. It is especially important in critical applications such as medical diagnosis and financial decision-making where users need justification for decisions.

Explanation facilities make expert systems more transparent, understandable, and acceptable to users.

Functions

- Explains conclusions.
- Shows reasoning steps.
- Provides confidence levels.

---

5. Knowledge Acquisition Module

Definition (100 Words)

The **Knowledge Acquisition Module** is responsible for collecting, updating, and maintaining knowledge in an expert system. It helps transfer knowledge from human experts, databases, documents, and other sources into the knowledge base. Since knowledge changes over time, this module ensures that the expert system remains accurate and up-to-date. It reduces the difficulty of manually programming new knowledge and allows continuous improvement of the system. Knowledge acquisition involves identifying useful information, representing it properly, and storing it in a structured format. This module is essential for maintaining the effectiveness and reliability of expert systems.

Functions

- Collects expert knowledge.
- Updates knowledge base.
- Converts knowledge into rules.
- Maintains system accuracy.

Advantages of Expert Systems

1. Fast Decision Making

Provides solutions quickly.

---

2. Availability

Can provide expert advice anytime.

---

3. Consistency

Provides the same quality of decisions repeatedly.

---

4. Reduced Cost

Reduces dependence on human experts.

---

5. Knowledge Preservation

Stores expert knowledge permanently.

Limitations of Expert Systems

1. Limited Domain

Works only in specific areas.

---

2. No Common Sense

Cannot think like humans.

---

3. Knowledge Acquisition Problem

Collecting expert knowledge is difficult.

---

4. Expensive Development

Requires time and resources.

Difference Between Expert System and Human Expert

Expert System	Human Expert
Computer-based	Human-based
Fast processing	Slow compared to computers
Limited knowledge area	Broad understanding
No emotions	Uses experience and intuition
Requires programming	Uses natural intelligence

Quick Revision Table

Topic	Key Point
Expert System	AI system that imitates human expert decision-making
Knowledge Base	Stores facts and rules
Inference Engine	Performs reasoning
User Interface	Allows user interaction
Explanation Facility	Explains decisions
Knowledge Acquisition	Updates knowledge

Expert System Development Life Cycle (ESDLC)

1. Expert System Development Life Cycle (ESDLC)

Definition (100 Words)

The **Expert System Development Life Cycle (ESDLC)** is a systematic process used for designing, developing, implementing, and maintaining an expert system. It defines the different stages involved in transforming human expert knowledge into a computer-based intelligent system. The life cycle begins with identifying a suitable problem domain and selecting the problem, followed by prototype construction, knowledge formalization, system implementation, evaluation, and maintenance. During development, knowledge engineers collect knowledge from domain experts and represent it using appropriate techniques. The ESDLC ensures that the expert system is accurate, reliable, efficient, and capable of solving problems similar to a human expert.

Stages of Expert System Development Life Cycle

```
Problem Selection
        ↓
Prototype Construction
        ↓
Knowledge Formalization
        ↓
Implementation
        ↓
Evaluation
        ↓
Knowledge Acquisition
        ↓
Maintenance & Improvement
```

---

1. Problem Selection

Definition (100 Words)

Problem Selection is the first stage of the expert system development life cycle where developers identify and select a suitable problem that can be solved using artificial intelligence techniques. The selected problem should require expert knowledge, involve decision-making, and have a well-defined domain. During this stage, developers analyze the feasibility, objectives, available resources, and expected benefits of creating an expert system. A proper problem selection ensures successful development because not every problem requires an expert system. The problem should be complex enough to need expert reasoning but structured enough to be represented using rules, facts, and knowledge.

Explanation of Problem Selection

In this stage, developers decide:

- What problem needs to be solved?
- Is an expert system suitable?
- Who are the domain experts?
- What knowledge is required?

Activities in Problem Selection

1. Identify Problem Domain

Explanation:

The area where the expert system will operate is selected.

Examples:

- Medicine.
- Finance.
- Agriculture.
- Engineering.

---

2. Analyze Feasibility

Explanation:

Developers check whether the project is possible technically and economically.

Feasibility includes:

- Availability of experts.
- Required technology.
- Development cost.
- Time requirements.

---

3. Define Objectives

Explanation:

Clear goals are established.

Example:

"Develop a system that diagnoses plant diseases."

---

4. Select Domain Experts

Explanation:

Experts who possess knowledge about the problem are identified.

Example:

Doctors for medical systems.

Example of Problem Selection

Creating a medical expert system:

Problem:

"Diagnosis of heart diseases."

Reasons:

- Requires expert knowledge.
- Has clear symptoms.
- Needs decision support.

2. Prototype Construction

Definition (100 Words)

Prototype Construction is the stage in expert system development where a preliminary working model of the system is created to test ideas, knowledge representation methods, and reasoning techniques. The prototype contains limited knowledge and basic functionality. It helps developers understand system requirements and identify problems before building the complete expert system. The prototype is developed with the cooperation of domain experts and knowledge engineers. It allows continuous improvement through feedback and testing. Prototype construction reduces development risks, improves system design, and ensures that the final expert system meets user requirements effectively.

Explanation of Prototype Construction

A prototype is a small working version of the final system.

It helps to:

- Test ideas.
- Check knowledge representation.
- Identify missing knowledge.
- Receive expert feedback.

Activities

1. Design Basic System

Explanation:

Developers create the initial structure:

- User interface.
- Knowledge base.
- Inference mechanism.

---

2. Add Initial Knowledge

Explanation:

Basic facts and rules are entered into the system.

Example:

Medical rules:

```
IF fever AND cough
THEN flu possibility
```

---

3. Test Prototype

Explanation:

The system is tested using sample problems.

---

4. Improve Prototype

Explanation:

Feedback from experts is used to improve the system.

Advantages of Prototype Construction

- Reduces development errors.
- Improves communication with experts.
- Helps identify missing requirements.
- Saves development time.

---

3. Formalization

Definition (100 Words)

Formalization is the process of converting collected expert knowledge into a structured and understandable form that can be processed by a computer. In this stage, knowledge engineers organize facts, rules, concepts, and relationships obtained from experts. The informal knowledge of human experts is transformed into formal knowledge representation methods such as production rules, semantic networks, frames, or logic. Formalization ensures that knowledge is represented accurately and can be used by the inference engine for reasoning. This stage is important because the quality of knowledge representation directly affects the performance and reliability of the expert system.

Explanation of Formalization

Human experts usually express knowledge in natural language.

Example:

Human statement:

"Patients with high fever and cough may have influenza."

Converted into rule:

```
IF fever = high
AND cough = yes
THEN disease = influenza
```

Activities

1. Knowledge Organization

Explanation:

Arrange knowledge into categories.

Example:

- Symptoms.
- Causes.
- Solutions.

2. Knowledge Representation

Explanation:

Convert knowledge into machine-readable format.

Methods:

- Rules.
- Frames.
- Logic.
- Semantic networks.

---

3. Rule Development

Explanation:

Create IF-THEN rules for decision-making.

---

4. Implementation

Definition (100 Words)

Implementation is the stage where the complete expert system is developed by integrating the knowledge base, inference engine, user interface, and other system components. During implementation, the formalized knowledge is converted into a working software application. Programming languages, expert system shells, and AI tools are used to build the system. The system is tested with real-world problems to ensure correct reasoning and performance. Implementation also includes database integration, user interface development, and system configuration. A successful implementation produces a functional expert system capable of providing solutions and recommendations similar to a human expert.

Explanation of Implementation

Activities include:

---

1. Develop Knowledge Base

Explanation:

All collected rules and facts are stored.

---

2. Develop Inference Engine

Explanation:

Reasoning mechanism is created.

Methods:

- Forward chaining.
- Backward chaining.

---

3. Create User Interface

Explanation:

Allows users to interact with the system.

---

4. Testing

Explanation:

The system is checked for:

- Accuracy.
- Speed.
- Reliability.

---

5. Evaluation

Definition (100 Words)

Evaluation is the stage of the expert system development life cycle where the developed system is tested and assessed to determine its accuracy, reliability, performance, and usefulness. The system is evaluated by comparing its results with decisions made by human experts. Evaluation identifies errors, missing knowledge, incorrect rules, and performance issues. Feedback from users and domain experts is collected to improve the system. Different testing methods are applied to ensure that the expert system produces correct and consistent solutions. A successful evaluation confirms that the system can effectively solve problems and provide expert-level assistance.

Explanation of Evaluation

Evaluation checks:

- Does the system provide correct answers?
- Is reasoning accurate?
- Is knowledge complete?
- Is the system user-friendly?

Evaluation Methods

1. Accuracy Testing

Checks correctness of results.

---

2. Performance Testing

Measures:

- Speed.
- Efficiency.

3. Expert Review

Human experts compare system decisions.

---

6. Knowledge Acquisition

Definition (100 Words)

Knowledge Acquisition is the process of collecting, extracting, organizing, and transferring knowledge from human experts and other sources into an expert system. It is one of the most important stages because the quality of an expert system depends on the quality of knowledge stored in its knowledge base. Knowledge acquisition involves gathering facts, rules, experiences, and problem-solving methods from domain experts, documents, databases, and observations. Knowledge engineers convert this information into a suitable representation format. Effective knowledge acquisition helps create accurate, reliable, and intelligent systems capable of performing expert-level reasoning.

Explanation of Knowledge Acquisition

Knowledge acquisition involves:

- Finding knowledge sources.
- Collecting information.
- Organizing knowledge.
- Representing knowledge in computer format.

Sources of Knowledge Acquisition

1. Human Experts

Explanation:

Experts provide experience and decision-making knowledge.

Example:

Doctor provides medical rules.

---

2. Books and Documents

Explanation:

Information is collected from written sources.

---

3. Databases

Explanation:

Existing data is analyzed to extract useful knowledge.

---

4. Observation

Explanation:

Experts are observed while solving problems.

Knowledge Acquisition Techniques

---

1. Interviewing

Explanation:

Knowledge engineer asks questions directly to experts.

Types:

- Structured interview.
- Unstructured interview.

Advantage:

Direct knowledge collection.

---

2. Observation

Explanation:

Knowledge engineer watches experts performing tasks.

Example:

Observing doctors diagnosing patients.

---

3. Questionnaire

Explanation:

Experts answer written questions.

Advantages:

- Saves time.
- Collects organized information.

---

4. Protocol Analysis

Explanation:

Experts explain their thinking process while solving problems.

Example:

A doctor explains diagnosis steps.

---

5. Document Analysis

Explanation:

Knowledge is collected from:

- Manuals.
- Reports.
- Research papers.

---

6. Machine Learning-Based Acquisition

Explanation:

AI automatically learns knowledge from data.

Example:

Learning disease patterns from medical records.

---

7. Knowledge Engineering

Definition (100 Words)

Knowledge Engineering is the process of designing, developing, and maintaining knowledge-based systems by collecting, organizing, representing, and applying expert knowledge. A knowledge engineer acts as a bridge between human experts and computer systems. The engineer extracts knowledge from experts, converts it into machine-readable formats, and develops the knowledge base and reasoning mechanisms. Knowledge engineering involves tasks such as knowledge acquisition, representation, validation, and maintenance. It plays a major role in expert system development because it ensures that knowledge is accurately stored and effectively used for problem-solving. Knowledge engineers require skills in AI, programming, and domain understanding.

Role of Knowledge Engineer

1. Collect Knowledge

Explanation:

Gathers information from experts and sources.

---

2. Represent Knowledge

Explanation:

Converts human knowledge into rules and structures.

---

3. Develop Knowledge Base

Explanation:

Stores facts and relationships.

---

4. Maintain System

Explanation:

Updates knowledge when new information becomes available.

---

8. Cognitive Behaviour

Definition (100 Words)

Cognitive Behaviour refers to the process of understanding how humans think, learn, remember, and make decisions. In expert systems, cognitive behaviour analysis helps capture the reasoning patterns and problem-solving methods used by human experts. Knowledge engineers study expert thinking processes to represent them in computer systems. Cognitive behaviour includes perception, reasoning, learning, memory, and decision-making. By modeling human cognitive processes, expert systems can imitate expert-level problem-solving abilities. Understanding cognitive behaviour is important because expert knowledge is not only based on facts but also on experience, intuition, and judgment developed through years of practice.

Explanation of Cognitive Behaviour in Expert Systems

Human experts use:

- Facts.
- Experience.
- Intuition.
- Logical reasoning.

Expert systems attempt to model these processes.

Components of Cognitive Behaviour

---

1. Perception

Explanation:

Ability to collect and understand information.

Example:

Doctor observes symptoms.

---

2. Learning

Explanation:

Ability to gain new knowledge from experience.

Example:

System improves using new data.

---

3. Reasoning

Explanation:

Ability to analyze information and reach conclusions.

---

4. Decision Making

Explanation:

Selecting the best solution among alternatives.

---

5. Memory

Explanation:

Storing and recalling knowledge.

Quick Revision Table

Topic	Key Point
Problem Selection	Selecting suitable AI problem
Prototype Construction	Building initial model
Formalization	Converting knowledge into rules
Implementation	Developing complete system
Evaluation	Testing system performance

Topic	Key Point
Knowledge Acquisition	Collecting expert knowledge
Knowledge Engineering	Managing knowledge development
Cognitive Behaviour	Modeling human thinking

Perception in Artificial Intelligence

Detailed and Brief Exam Notes

---

1. Perception in Artificial Intelligence

Definition

Perception in Artificial Intelligence is the process by which an intelligent system collects, interprets, and understands information from the surrounding environment using sensors and data processing techniques. It enables AI systems to identify objects, recognize patterns, understand speech, and make decisions based on environmental inputs. Perception acts as a bridge between the physical world and the AI system by converting raw sensory data into meaningful information. It is an important capability of intelligent agents, robots, autonomous vehicles, and computer vision systems. AI perception involves sensing, speech recognition, image processing, and understanding the environment for effective action.

Components of AI Perception

```
               Perception
                   |
 --------------------------------
  |              |              |
Sensing   Speech Recognition  Vision
                   |
                 Action
```

---

1. Sensing

Definition

Sensing is the process of collecting information from the environment using sensors and converting physical signals into digital data that can be processed by an AI system. Sensors act as the input devices of intelligent agents, allowing them to detect changes in their surroundings. Sensing enables AI systems to understand temperature, movement, sound, light, distance, and other environmental conditions. It is widely used in robotics, autonomous vehicles, smart devices, and industrial automation. The quality of sensing directly affects the accuracy of AI decisions because incorrect or incomplete data can lead to wrong conclusions.

Explanation

Sensing is similar to human senses such as:

- Eyes → Vision
- Ears → Hearing
- Skin → Touch

AI systems use artificial sensors instead of biological organs.

Types of Sensors Used in AI

1. Camera Sensors

Explanation:
Capture images and videos from the environment.

Applications:

- Face recognition.
- Object detection.
- Autonomous vehicles.

---

2. Microphone Sensors

Explanation:
Convert sound waves into digital signals.

Applications:

- Voice assistants.
- Speech recognition.

---

3. Temperature Sensors

Explanation:
Measure temperature changes.

Applications:

- Weather monitoring.
- Industrial systems.

---

4. Motion Sensors

Explanation:
Detect movement and position changes.

Applications:

- Robots.
- Security systems.

Importance of Sensing

- Provides environmental information.
- Helps AI understand surroundings.
- Supports decision-making.
- Enables interaction with the real world.

Example

A self-driving car uses sensors to detect:

- Roads.

- Vehicles.
- Pedestrians.
- Traffic signals.

---

2. Speech Recognition

Definition

Speech Recognition is an AI technology that enables computers to identify, process, and convert human speech into text or meaningful commands. It uses techniques from artificial intelligence, machine learning, and natural language processing to understand spoken language. Speech recognition systems analyze sound waves, identify speech patterns, and convert them into digital information. It allows humans to communicate with machines through voice instead of traditional input devices like keyboards. Speech recognition is widely used in virtual assistants, voice-controlled applications, customer service systems, and accessibility tools. It improves human-computer interaction by making communication faster and more natural.

Working of Speech Recognition

```
Human Voice
      ↓
Audio Input
      ↓
Signal Processing
      ↓
Speech Analysis
      ↓
Text/Command Output
```

Steps in Speech Recognition

1. Sound Capture

Explanation:

A microphone records the user's voice.

Example:

"Open the browser."

---

2. Signal Processing

Explanation:

The system removes noise and improves audio quality.

---

3. Feature Extraction

Explanation:

Important characteristics of speech are identified.

Examples:

- Tone.
- Frequency.
- Pronunciation.

---

4. Speech Understanding

Explanation:

AI analyzes words and identifies their meaning.

---

5. Response Generation

Explanation:

The system performs the requested action.

Example:

Opening an application.

Applications of Speech Recognition

1. Virtual Assistants

Examples:

- Voice search.
- Smart assistants.

---

2. Healthcare

Used for:

- Medical transcription.
- Patient records.

---

3. Customer Service

Used in:

- Automated call systems.
- Chatbots.

---

4. Accessibility

Helps people control devices using voice commands.

Advantages

- Easy human-machine interaction.
- Saves time.
- Supports hands-free operation.
- Improves accessibility.

Challenges

- Different accents.
- Background noise.
- Multiple languages.
- Speech ambiguity.

---

3. Vision (Computer Vision)

Definition

Computer Vision is an AI field that enables computers to capture, process, and understand visual information from images and videos. It allows machines to perform tasks similar to human vision, such as recognizing objects, identifying faces, detecting movements, and understanding scenes. Computer vision uses image processing, deep learning, and pattern recognition techniques to extract meaningful information from visual data. It is widely used in autonomous vehicles, medical imaging, security systems, robotics, and industrial inspection. The main goal of computer vision is to enable machines to interpret and respond to visual information accurately and intelligently.

Working of Computer Vision

```
Image/Video Input
        ↓
Image Processing
        ↓
Feature Extraction
        ↓
Pattern Recognition
        ↓
Decision Making
```

Components of Computer Vision

---

1. Image Acquisition

Explanation:

The system captures images using cameras or sensors.

Example:

Security camera capturing video.

---

2. Image Processing

Explanation:

Improves image quality by:

- Removing noise.
- Adjusting brightness.
- Enhancing details.

---

3. Feature Extraction

Explanation:

Identifies important features in images.

Examples:

- Edges.
- Shapes.
- Colors.
- Patterns.

---

4. Object Recognition

Explanation:

Identifies objects present in an image.

Example:

Recognizing a car, person, or animal.

Applications of Computer Vision

---

1. Face Recognition

Used for:

- Security systems.
- Phone unlocking.

---

2. Medical Imaging

Used for:

- Disease detection.
- X-ray analysis.

---

3. Autonomous Vehicles

Helps vehicles identify:

- Roads.
- Traffic signs.
- Obstacles.

---

4. Industrial Automation

Used for:

- Quality checking.
- Defect detection.

Advantages

- Fast image analysis.
- Reduces human effort.
- Improves accuracy.
- Enables automation.

Challenges

- Poor lighting conditions.
- Complex environments.
- Large data requirements.
- Privacy concerns.

---

4. Action in Artificial Intelligence

Definition

Action in Artificial Intelligence refers to the ability of an intelligent agent to perform tasks or interact with the environment after processing information and making decisions. Actions are the outputs generated by an AI system based on its perception, reasoning, and goals. AI agents use actuators, software commands, or robotic mechanisms to perform actions. The action component allows AI systems to influence and modify their surroundings. Examples include robots moving objects, autonomous vehicles controlling speed and direction, and virtual assistants responding to user commands. Effective action requires accurate perception, planning, and decision-making abilities.

Working of AI Action

```
Environment
      ↓
Perception
      ↓
Decision Making
      ↓
```

```
Action
     ↓
Environment Changes
```

Types of AI Actions

---

1. Physical Actions

Explanation:

Actions performed by robots or machines in the physical world.

Examples:

- Robot movement.
- Manufacturing operations.

---

2. Digital Actions

Explanation:

Actions performed through software systems.

Examples:

- Sending emails.
- Searching information.
- Updating databases.

---

3. Communication Actions

Explanation:

Actions involving interaction with humans.

Examples:

- Voice responses.
- Chatbot replies.

Components Required for AI Action

---

1. Actuators

Explanation:

Devices that perform physical actions.

Examples:

- Motors.
- Robotic arms.

---

2. Decision System

Explanation:

Chooses the appropriate action based on available information.

---

3. Control System

Explanation:

Ensures actions are performed correctly.

Applications of AI Action

---

1. Robotics

Robots perform tasks such as:

- Assembly.
- Navigation.
- Object handling.

---

2. Autonomous Vehicles

Vehicles automatically:

- Control speed.
- Change direction.
- Avoid obstacles.

---

3. Smart Assistants

Perform actions such as:

- Setting reminders.
- Playing music.
- Controlling smart devices.

Advantages

- Automation of tasks.
- Faster execution.
- Reduced human effort.
- Improved accuracy.

Challenges

- Decision errors.
- Safety issues.

- Environmental uncertainty.
- Ethical concerns.

Difference Between Sensing, Speech Recognition, Vision and Action

Component	Purpose	Example
Sensing	Collects environmental data	Temperature sensor
Speech Recognition	Understands human voice	Voice assistant
Vision	Understands images/videos	Face recognition
Action	Performs tasks	Robot movement

Short Exam Notes (Revision)

Sensing:

Collects information from the environment using sensors and converts it into data for AI processing.

Speech Recognition:

Converts human speech into text or commands using AI and language processing techniques.

Vision:

Allows machines to understand images and videos using computer vision methods.

Action:

Enables AI systems to perform tasks and interact with the environment using actuators or commands.

UNIT – IV

Learning, Planning and Understanding in Artificial Intelligence

Detailed & Brief Exam Notes

---

1. Learning in Artificial Intelligence

Definition

Learning in Artificial Intelligence is the process by which an AI system improves its performance by acquiring knowledge, identifying patterns, and gaining experience from data or interactions with the environment. Machine learning enables computers to learn automatically without being explicitly programmed for every task. AI learning systems analyze previous experiences, modify their behavior, and make better predictions or decisions over time. Learning is an important capability of intelligent agents because it allows them to adapt to changing environments. Applications of AI learning include speech recognition, image classification, recommendation systems, medical diagnosis, and autonomous vehicles.

Concept of Learning in AI

Learning allows an AI system to:

- Acquire new knowledge.
- Improve performance.
- Adapt to new situations.
- Make accurate predictions.

Example:

A spam email detection system learns from previous emails and improves its ability to identify unwanted messages.

Types of Learning in AI

AI learning is mainly classified into:

```
                Learning
                    |
 -------------------------------
 |                 |                  |
```

```
Supervised   Unsupervised   Reinforcement
Learning      Learning       Learning
```

---

1. Supervised Learning

Definition

Supervised Learning is a machine learning technique where an AI system learns from labeled training data. In this method, the input data and the expected output are already provided, and the system learns the relationship between them. The model compares its predictions with the correct answers and improves its performance by reducing errors. Supervised learning is commonly used for classification and prediction problems. Examples include email spam detection, disease diagnosis, image recognition, and weather prediction. It requires a large amount of labeled data and is effective when historical examples are available for training.

Working of Supervised Learning

```
Input Data + Correct Output
          ↓
     Learning Algorithm
          ↓
     Trained Model
          ↓
    Prediction Result
```

Types of Supervised Learning

1. Classification

Explanation:

Classification assigns data into predefined categories.

Examples:

- Spam or not spam email.
- Disease categories.
- Image classification.

---

2. Regression

Explanation:

Regression predicts continuous numerical values.

Examples:

- House price prediction.
- Temperature forecasting.

Advantages

- High accuracy with good data.
- Easy evaluation.
- Useful for prediction tasks.

Disadvantages

- Requires labeled data.
- Data preparation is expensive.
- Cannot easily handle unknown situations.

---

2. Unsupervised Learning

Definition

Unsupervised Learning is a machine learning approach where an AI system learns patterns and structures from unlabeled data without predefined outputs. The system analyzes input data and discovers hidden relationships, groups, or patterns automatically. Unlike supervised learning, there is no teacher or correct answer provided during training. Unsupervised learning is useful when large amounts of raw data are available but labeling is difficult. Common applications include customer segmentation, anomaly detection, data clustering, and recommendation systems. It helps AI systems understand the structure of data and discover meaningful information without human guidance.

Working

```
Unlabeled Data
       ↓
Learning Algorithm
       ↓
Pattern Discovery
       ↓
Knowledge Extraction
```

Types of Unsupervised Learning

---

1. Clustering

Explanation:

Groups similar data objects together.

Example:

Customer grouping based on purchasing behavior.

---

2. Association

Explanation:

Finds relationships between different items.

Example:

Shopping recommendation:

"Customers who buy a phone also buy accessories."

Advantages

- Does not require labeled data.
- Finds hidden patterns.

- Useful for large datasets.

Disadvantages

- Results may be difficult to interpret.
- Accuracy is difficult to measure.
- Requires complex algorithms.

---

3. Reinforcement Learning

Definition

Reinforcement Learning is a type of machine learning in which an AI agent learns by interacting with an environment and receiving rewards or penalties for its actions. The goal of the agent is to select actions that maximize long-term rewards. Unlike supervised learning, reinforcement learning does not require labeled examples. The system learns through trial and error by observing the consequences of its actions. It is widely used in robotics, game playing, autonomous vehicles, and decision-making systems. Reinforcement learning enables machines to adapt to complex environments and improve their behavior through continuous experience.

Working

```
Environment
     ↓
Agent takes Action
     ↓
Receives Reward/Penalty
     ↓
Improves Future Actions
```

Components

1. Agent

The learner or decision-maker.

Example:

Robot.

---

2. Environment

The world in which the agent operates.

Example:

Game environment.

---

3. Action

The activity performed by the agent.

Example:

Moving left or right.

---

4. Reward

Feedback received after an action.

Example:

Points in a game.

Advantages

- Learns from experience.
- Suitable for complex problems.
- Does not require labeled data.

Disadvantages

- Requires many trials.

- Training can be slow.
- Difficult to design reward systems.

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4. Other Types of Learning in AI

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1. Semi-Supervised Learning

Explanation:

A combination of supervised and unsupervised learning.

It uses:

- Small amount of labeled data.
- Large amount of unlabeled data.

Example:

Image recognition systems.

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2. Deep Learning

Explanation:

Deep learning uses artificial neural networks with multiple layers to learn complex patterns.

Applications:

- Speech recognition.
- Face recognition.
- Natural language processing.

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2. Planning in Artificial Intelligence

Definition

Planning in Artificial Intelligence is the process of creating a sequence of actions that enables an intelligent agent to achieve a specific goal. AI planning involves deciding what actions should be performed, in what order, and under what conditions. A planning system represents the current state, desired goal state, and possible actions to find an effective solution. Planning helps AI agents operate efficiently in complex environments by predicting future actions and outcomes. It is widely used in robotics, automated systems, scheduling, navigation, and game playing. AI planning allows machines to make intelligent decisions and achieve objectives automatically.

Elements of AI Planning

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1. Initial State

Explanation:

The current condition of the problem.

Example:

Robot is at starting location.

---

2. Goal State

Explanation:

The desired final condition.

Example:

Robot reaches destination.

---

3. Actions

Explanation:

Possible operations that change the current state.

Example:

Move, pick, place.

---

4. Plan

Explanation:

A sequence of actions to achieve the goal.

Types of Planning

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1. Forward Planning

Explanation:

Starts from the initial state and moves toward the goal.

Flow:

```
Initial State → Actions → Goal
```

Example:

Robot navigation.

---

2. Backward Planning

Explanation:

Starts from the goal and works backward to find required actions.

Flow:

```
Goal → Required Actions → Initial State
```

---

3. Hierarchical Planning

Explanation:

Breaks a large problem into smaller tasks.

Example:

Travel planning:

- Book ticket.
- Pack luggage.
- Travel.

---

4. Conditional Planning

Explanation:

Creates plans that consider possible future situations.

Example:

"If it rains, carry an umbrella."

Applications of AI Planning

- Robot movement.
- Automated scheduling.
- Navigation systems.

- Game AI.
- Manufacturing systems.

Advantages

- Provides systematic decision-making.
- Reduces errors.
- Improves efficiency.

Challenges

- Large search space.
- Uncertain environments.
- Complex problems.

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3. Understanding in Artificial Intelligence

Definition

Understanding in Artificial Intelligence refers to the ability of AI systems to interpret, analyze, and extract meaningful information from data such as text, speech, images, and environmental signals. Understanding enables machines to recognize patterns, determine meaning, and respond appropriately. It is a major goal of AI because human intelligence depends on comprehension and interpretation. AI understanding involves techniques such as natural language processing, computer vision, knowledge representation, and reasoning. Applications include language translation, chatbots, voice assistants, image analysis, and information retrieval. Effective understanding allows AI systems to interact naturally with humans and make intelligent decisions.

Areas of AI Understanding

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1. Natural Language Understanding (NLU)

Explanation:

NLU enables computers to understand human language.

Tasks:

- Understanding sentences.
- Identifying meaning.
- Extracting information.

Examples:

- Chatbots.
- Voice assistants.

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2. Speech Understanding

Explanation:

AI interprets spoken language and converts it into meaningful information.

Applications:

- Voice commands.
- Virtual assistants.

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3. Visual Understanding

Explanation:

AI interprets images and videos.

Tasks:

- Object recognition.
- Face detection.

- Scene understanding.

---

4. Context Understanding

Explanation:

AI understands the situation in which information is used.

Example:

The word "bank" can mean:

- Financial institution.
- River side.

Context helps determine correct meaning.

Components Required for AI Understanding

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1. Knowledge Representation

Stores information in a structured format.

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2. Reasoning

Uses knowledge to draw conclusions.

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3. Learning

Improves understanding through experience.

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4. Perception

Collects information from the environment.

Applications of AI Understanding

- Search engines.
- Language translation.
- Medical diagnosis.
- Autonomous vehicles.
- Virtual assistants.

Difference Between Learning, Planning and Understanding

Learning	Planning	Understanding
Gains knowledge from experience	Creates action sequences	Interprets information
Improves performance	Achieves goals	Finds meaning
Example: Machine learning	Example: Robot navigation	Example: Language processing