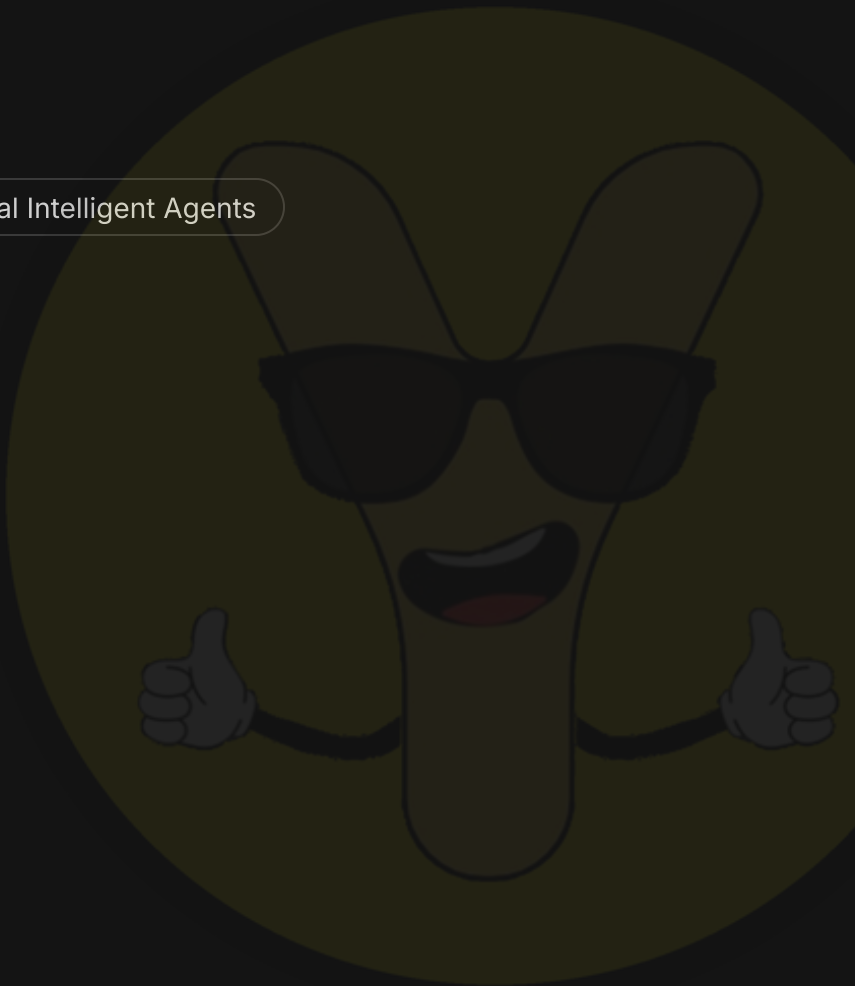
AKTU · 3RD YEAR · SEMESTER 5 · BCAI501

Artificial Intelligence

Unit 1 — Introduction

- Introduction
- Definition
- Future of Artificial Intelligence
- Characteristics of Intelligent Agents
- Typical Intelligent Agents
- Problem Solving Approach to Typical AI Problems



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Introduction and Definition of AI

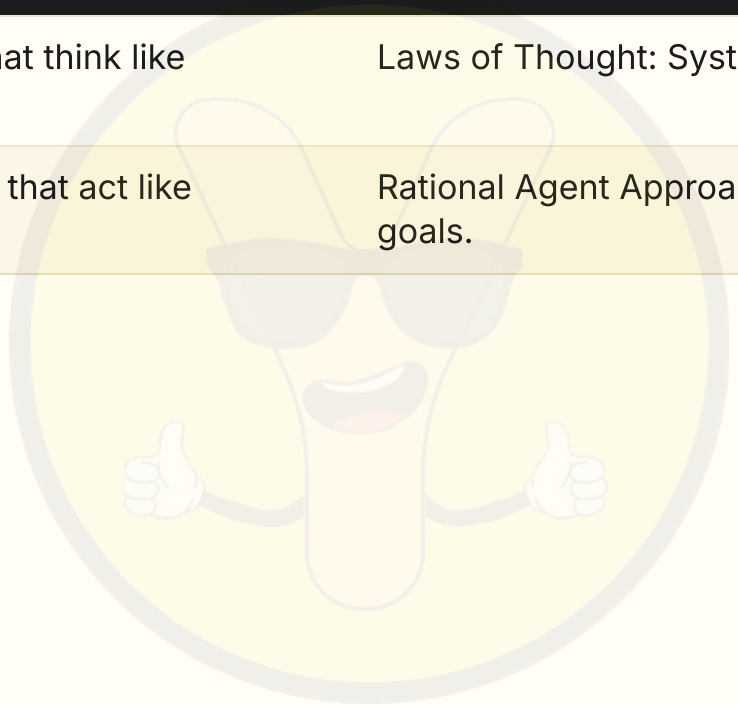
ARTIFICIAL INTELLIGENCE (AI)

Artificial Intelligence is a branch of computer science concerned with building smart machines capable of performing tasks that typically require human intelligence, such as reasoning, learning, perception, and decision-making.

- Coined by John McCarthy in 1956 at the Dartmouth Conference.
- Combines computer science, mathematics, psychology, and neuroscience.
- Focuses on creating systems that act rationally and think humanly.

Four Approaches to Defining Artificial Intelligence

Dimension	Human-like Behavior	Rational Behavior
Thinking	Cognitive Modeling: Systems that think like humans.	Laws of Thought: Systems that think rationally using logic.
Acting	Turing Test Approach: Systems that act like humans.	Rational Agent Approach: Systems that act rationally to achieve goals.



Turing Test and Operational Definition

Proposed by Alan Turing in 1950 to provide an operational, testable definition of machine intelligence.

- Test Setup
  - A human interrogator communicates via text with a human and a machine.
  - If the interrogator cannot reliably distinguish machine from human, the machine passes.
- Required Capabilities
  - Natural Language Processing to communicate successfully in English.
  - Knowledge Representation to store information acquired before or during the test.
  - Automated Reasoning to use stored information to answer questions.
  - Machine Learning to adapt to new circumstances and extrapolate patterns.
- Total Turing Test
  - Adds Computer Vision and Robotics to test physical interaction abilities.

Future of Artificial Intelligence

AI is evolving from narrow task-specific applications toward broad general intelligence and autonomous decision-making.

- Artificial General Intelligence (AGI)
  - Transitioning from Artificial Narrow AI (ANI) to systems possessing human-level intellect across all domains.
- Autonomous Systems
  - Widespread adoption of self-driving vehicles, fully autonomous logistics, and robotic surgery.
- Generative & Explainable AI
  - Shift toward Explainable AI (XAI) for transparent decisions and advanced multimodal generative systems.
- Quantum AI Integration
  - Combining quantum computing with AI algorithms to solve exponentially complex optimization problems.

Future Impact and Ethical Considerations

The future advancement of AI presents both transformative technological opportunities and societal challenges.

- Healthcare Revolution
  - Accelerated AI-driven drug discovery, genomic analysis, and personalized predictive treatment.
- Workforce Transformation
  - Shift in human employment toward high-skill supervision, algorithm design, and AI management.
- Ethical Governance
  - Mitigating algorithmic bias, ensuring data privacy, and developing AI safety alignment protocols.
- Resource Optimization
  - Smart grid power management and detailed computational modeling for climate sustainability.

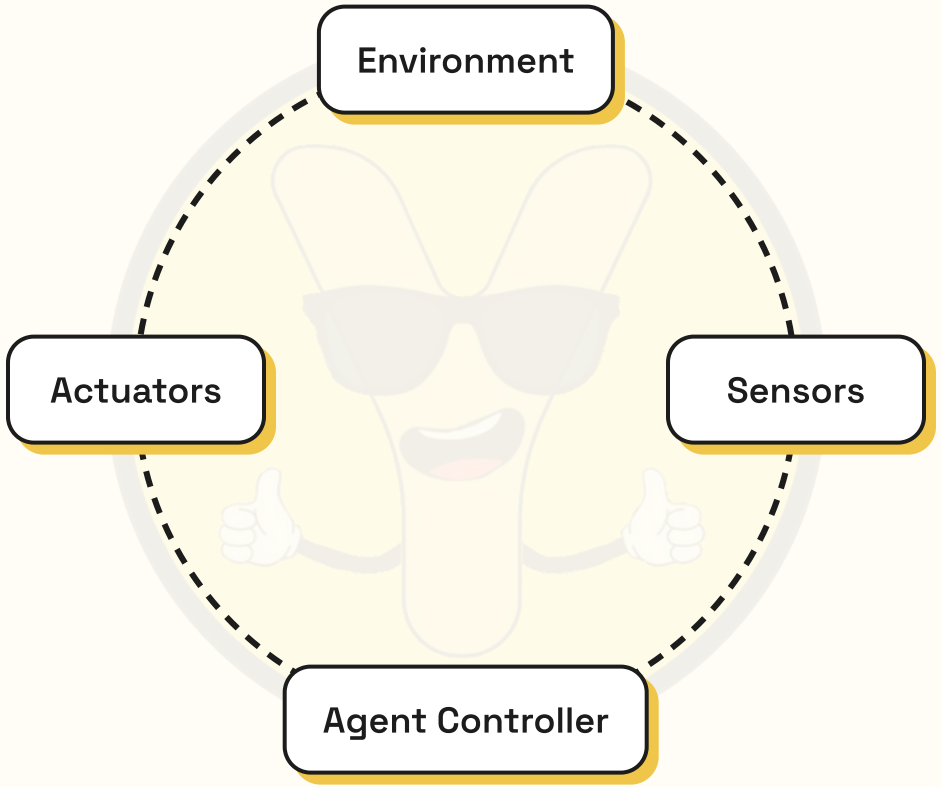
Concept of Intelligent Agents

INTELLIGENT AGENT

An agent is anything that can perceive its environment through sensors and act upon that environment through actuators according to an agent function $f : P^* \rightarrow A$.

- Percept Sequence P^*: The complete history of everything the agent has perceived.
- Sensors: Inputs such as cameras, sonar, infrared, or software input logs.
- Actuators: Output mechanisms such as motors, robotic limbs, or screen displays.

Agent-Environment Interaction Architecture



The continuous closed-loop interaction between an Agent and its Environment.

PEAS Framework for Agent Specifications

Agent Type	Performance Measure	Environment	Actuators	Sensors
Automated Taxi	Safety, speed, passenger comfort, profit	Roads, traffic, weather, pedestrians	Steering, accelerator, brake, signal	Camera, radar, sonar, GPS, speedometer
Medical Diagnosis	Healthy patient, minimized costs, accuracy	Patient, hospital staff, laboratory	Display test results, diagnoses, treatments	Keyboard, touch screen, monitor inputs
Vacuum Cleaner	Cleanliness, battery efficiency, low noise	Rooms, wooden floor, carpet, obstacles	Wheels, suction motor, brush rotator	Dirt sensor, cliff sensor, bump sensor

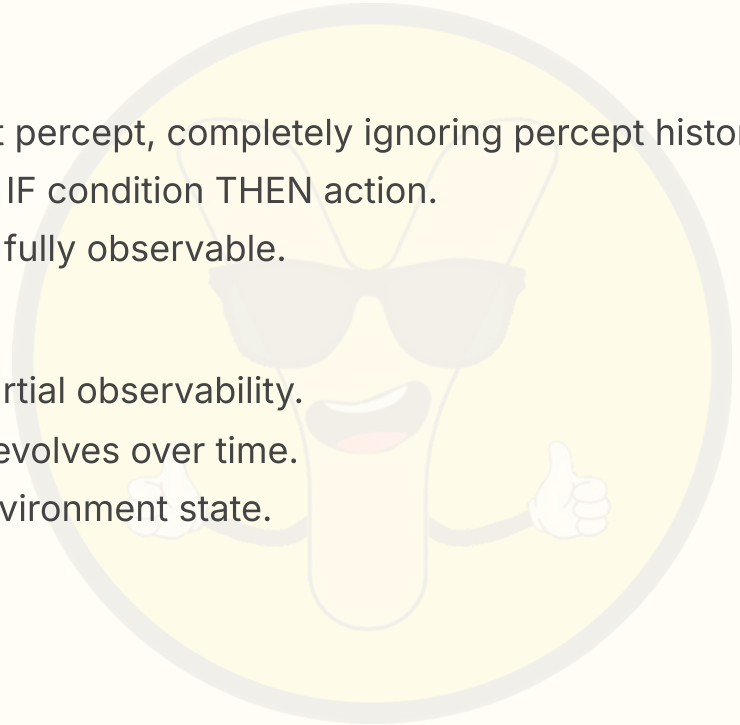
Properties of Task Environments

Property Pair	Description	Example
Fully vs Partially Observable	Sensors capture complete state at any given point in time	Chess (Fully) vs Poker (Partially)
Deterministic vs Stochastic	Next state is fully determined by current state and action	Chess (Deterministic) vs Taxi Driving (Stochastic)
Episodic vs Sequential	Current action choice does not affect future choices	Image Classification (Episodic) vs Chess (Sequential)
Static vs Dynamic	Environment does not change while agent deliberates	Crossword (Static) vs Taxi Driving (Dynamic)
Discrete vs Continuous	Finite, distinct state space, percepts, and action steps	Chess (Discrete) vs Autonomous Driving (Continuous)
Single vs Multi-Agent	Environment contains only one agent operating independently	Crossword (Single) vs Soccer Game (Multi-Agent)

Typical Intelligent Agents: Reflex Agents

Agents are classified based on their structural complexity and decision-making logic.

- Simple Reflex Agent
  - Selects actions based solely on current percept, completely ignoring percept history.
  - Operates using Condition-Action rules: IF condition THEN action.
  - Effective only when the environment is fully observable.
- Model-Based Reflex Agent
  - Maintains an internal state to handle partial observability.
  - Uses a model of how the environment evolves over time.
  - Tracks how its own actions alter the environment state.



Hierarchy of Intelligent Agent Types



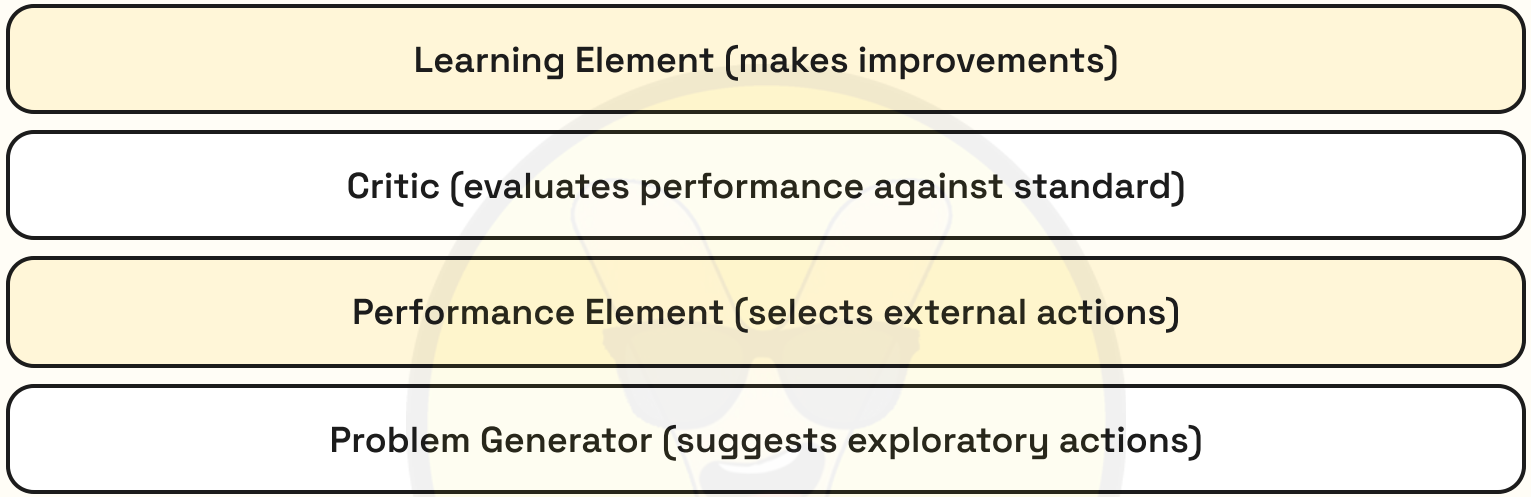
Taxonomy of intelligent agent architectures categorized by cognitive depth.

Goal-Based and Utility-Based Agents

Advanced agent architectures evaluate future sequences of states to optimize actions.

- Goal-Based Agent
  - Combines environment state information with explicit goal definitions.
  - Uses search and planning algorithms to find action paths leading to goal states.
  - Flexible structure: behavior updates easily when goals change.
- Utility-Based Agent
  - Uses a Utility Function mapping a state onto a real number representing success or happiness.
  - Evaluates trade-offs between competing goals such as speed versus safety.
  - Selects actions that maximize Expected Utility.

Architecture of a Learning Agent



Layered architecture separating external action selection from internal learning mechanisms.

Problem-Solving Approach in AI

PROBLEM-SOLVING AGENT

A goal-based agent that uses atomic state representations to discover sequences of actions that lead to desirable goal states.

- Goal Formulation: Defines target objectives based on current situation and performance measures.
- Problem Formulation: Determines what states and actions to consider given the defined goal.
- Search: Simulates sequences of actions to discover a valid path from initial state to goal.
- Execution: Performs the real-world actions corresponding to the path discovered by search.

Formal Formulation of AI Problems

A well-defined AI problem consists of five formal components in state-space search.

- **Initial State**
  - The state from which the agent starts execution, denoted as S_0.
- **Actions**
  - Set of legal actions $A(s)$ available to the agent when in state s.
- **Transition Model**
  - Function returning the state resulting from action a in state s: $Result(s, a)$.
- **Goal Test**
  - Function determining whether a given state matches the target goal state.
- **Path Cost**
  - Numeric cost function $g(n)$ summing step costs $c(s, a, s')$ along a path.

Worked Example: 8-Puzzle Problem Formulation

Formulate the standard 8-puzzle game (3×3 grid with 8 numbered tiles and 1 empty space) as a state-space search problem.

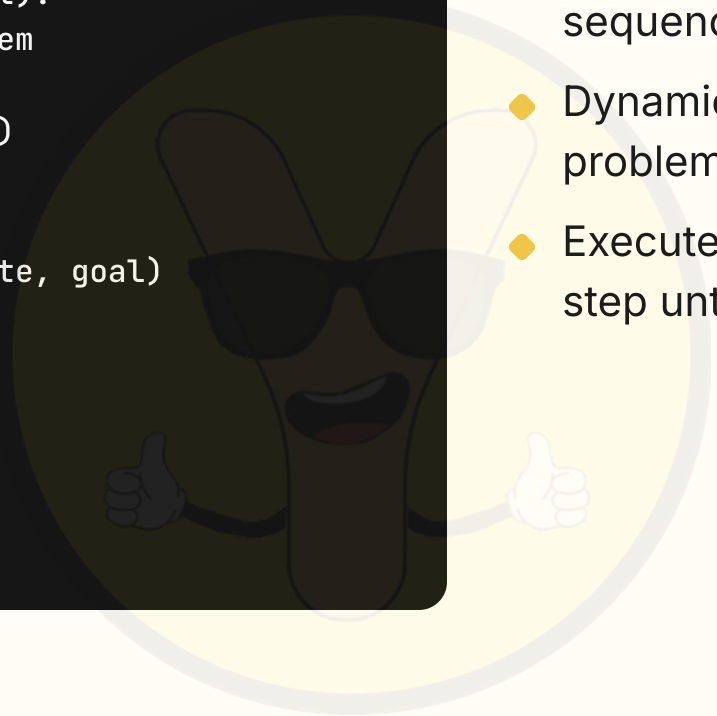
1. States: Location of each of the 8 tiles and the blank space in the 9 grid cells.
2. Initial State: Any specified initial arrangement of tiles on the grid.
3. Actions: Movement of the blank space (Left, Right, Up, Down).
4. Transition Model: Returns grid state produced after blank space shifts.
5. Goal Test: Checks if grid tiles match target order (1 to 8 sequentially).
6. Path Cost: Each move costs 1 unit; path cost equals total move count.

State space contains $9!/2 = 181,440$ reachable distinct states.

General State-Space Search Algorithm

```
def SIMPLE_PROBLEM_SOLVING_AGENT(percept):
    persistent: state, seq, goal, problem

    state = UPDATE_STATE(state, percept)
    if seq.is_empty():
        goal = FORMULATE_GOAL(state)
        problem = FORMULATE_PROBLEM(state, goal)
        seq = SEARCH(problem)
        if seq is None:
            return FAIL
    action = FIRST(seq)
    seq = REST(seq)
    return action
```



- Maintains persistent internal state and action sequence plan across executions.
- Dynamically formulates new goals and search problems when existing plan empties.
- Executes stored action sequence step-by-step until the target goal is achieved.

AKTU Unit 1 Exam Practice Questions

Q1 Define Artificial Intelligence. Explain the four views of AI definitions (Thinking/Acting Humanly/Rationally) with examples.

Q2 Explain the Turing Test for determining machine intelligence. What capabilities must an agent possess to pass the Total Turing Test?

Q3 Define an Intelligent Agent. Specify the PEAS description for an Automated Taxi driver and a Medical Diagnosis System.

Q4 Differentiate between: (a) Static vs Dynamic environment, (b) Deterministic vs Stochastic environment, (c) Discrete vs Continuous environment.

Q5 Draw structural block diagrams and explain the working of Model-Based Reflex Agents and Utility-Based Agents.

Q6 Explain the Learning Agent architecture with a block diagram, describing the roles of Critic, Learning Element, and Problem Generator.

Q7 Detail the four steps of the problem-solving approach in AI. Formulate the 8-puzzle problem by specifying its 5 key components.

Unit 1 done. You are exam-ready.

Revise the Exam corner once more, then open Unit 2 on theycotes.com. Every AKTU subject, unit by unit, free. Notes by Chirag Jain, Ycotes.

