

Artificial Intelligence (AI):

AI is a technology that enables machines & computers to perform tasks that typically require human intelligence.

It helps systems learn from data, recognize patterns & make decisions to solve complex problems.

Thinking Humanly:

It means understanding & modeling how humans actually think, not just solving problem like a machine.

Cognitive Science:

The brain as an information processing machine. It views the human brain as if it works like a computer.

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Requirement:

Scientific theories of how the brain works.

To study thinking scientifically, we need theories & models that explain mental processes.

☐ How to understand cognition as a computational process?

Cognition is mental activities like thinking, learning, problem-solving & decision-making.

Viewing cognition as a computational process means treating the mind like a computer. It takes input, processes it through rules/steps & produces output.

Cognition can be seen as computation a series of steps that process information systematically.

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This means our mind breaks down problems into smaller steps, applies logical rules & arrives at a solution.

Ex: puzzle solving.

• Introspection:

It means examining our own thoughts & mental processes. It's a subjective way of understanding cognition — "What's happening inside our head when we try to solve this?"

• Predict & Test behavior of Human subject:

Another method is experimentation — predicting how people will behave in certain situations & then testing it.

• Imaging the Brain & Neurological Data:

Modern methods include using brain imaging technologies

(like fMRI, EEG) to study which parts of the brain are active during different tasks.

Domains of Study :

The last 2 methodologies are the main focus of

- Cognitive science
- Cognitive Neuroscience — linking brain activity to mental processes

2. Acting Humanly :

Proposed the Turing Test to ~~test~~ check if a machine can act like a human.

If a human judge chats with both a person & a ~~hum~~ machine & can't reliably tell which is which → the machine passes.

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Capabilities Required to pass the Turing Test

1. Natural Language Processing (NLP) :

- Understand & respond in human language.
- Ex : ChatGPT answering questions in English.

2. Knowledge Representation :

- Store info about the world to answer questions.
- Ex : AI storing facts, like "water boils at 100°C ".

3. Automated Reasoning :

- Use logic to draw conclusions
- Ex : if "all humans are mortal" & "Socrates is human". AI should conclude "Socrates is mortal."

4. Machine Learning :

- Learn from experience & improve over time
- Ex : AI improving at chess after playing many games.

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Turing's Prediction :

By the year 2000, machines would be able to fool 30% of human judges for 5 minutes in a conversation.

3. Thinking Rationally :

It means following an idealized or "night" way of thinking.

Logic :

Logic is the study of patterns of argument that always produce correct conclusions if the premises are true.

~~Logicist Approach~~

Logicist Approach in AI :

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The logicist approach involves:

1. Describing a problem in formal logical notation
2. Applying general deduction procedures to find solutions.

Problems with the logicist approach:

1. Computational Complexity
Finding solutions can require enormous computational resources, making it inefficient for real world problems.
2. Describing real world problems:
3. Intelligent behaviour beyond logic:

many forms of rational or intelligent behaviour do not rely solely on formal logic.

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4. Acting Rationally : Rational Agent :

A rational agent is an entity that acts to achieve the best expected outcome given the circumstances.

Rationality is measured by how well an agent achieves its goals, not necessarily by how it thinks.

Goals & Utility

- Goals vary depending on the application or context.
- They're expressed in terms of utility of outcomes.

Maximizing Expected Utility :

Being rational means choosing actions that maximize expected utility.

• Expected utility considers:

1. Possible actions an agent can take
2. likely outcomes of each action
3. Probability of each outcome
4. Value of each outcome.

Examples of AI in Daily Life :

1. Virtual Assistants
2. Recommendation System
3. Self Driving Cars.
4. Chatbots & Customer Support
5. Healthcare AI
6. Smart home Devices.
7. Image & voice recognition.

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Information Agents

Information agents are AI systems that collect, process and act on information to help users or organizations make decisions or perform tasks.

Example Applications

- Search engines
- Recommendation systems
- Spam Filtering
- Automated Helpdesks
- Medical Diagnosis Systems
- Fraud Detection
- Automated Trading

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High level vs low level Approaches:

⇒ High-level approach:

- * Focus: Abstract reasoning & logic.
- * Method: Build a general reasoning engine.

- * Involves hand-coding knowledge bases & application-specific rules.

⇒ Low-level approach:

- * Focus on simple cognitive units, inspired by neurons.

- * Method - Build pattern recognition machines.

- * Relies on learning from data instead of manually coded rules.

Neat vs Scruffies

⇒ Neats:

- * Believe in formal, clean, mathematical approaches.

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⇒ Scruffies:

- * Prefer practical, heuristic-based approaches.

□ AI-Effect:

— The AI effect is the observation that when a machine becomes good at a task, people stop considering that task as requiring "real intelligence".

Once AI success at something, it's no longer seen as AI.

Example:

- * Calculating Ability
- * Chess playing
- * Learning
- * Animal Intelligence Parallel.

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AI Agent: An AI agent is a software program that can interact with its environment, collect data and use that data to perform self-directed tasks that meet predetermined goals. Humans set goals, but an AI agent independently chooses the best actions it needs to perform to achieve those goals.

* It perceives its environment using sensors.

* Acts upon the environment using actuators.

Example:

⇒ Human Agent:

* sensors → eyes, ears, skin

* Actuators → Hands, legs, mouth.

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⇒ Robotic agent:

* sensors → cameras, microphones,

GBS

* Actuators → Motors, wheels, robotic arms.

☐ Agent Function:

The agent function is a mathematical mapping. It maps percept history to actions.

☐ Agent Program:

The agent program is the implementation that produces the agent function.

They run on the physical architecture to produce the agent function.

Agent = Architecture + Program

Example: A vacuum cleaner agent

* Percepts: Location & status; ex: Dirty

* Actions: Left, Right, Suck, Noop.

GOOD LUCK

1) Functional Vacuum Agent (Return an action):

- * If status = Dirty then it return 'suck'
- * Else if location = A then return 'Right'
- * Else if location = B then return 'Left'

2) Rational Agent:

It is an agent that performs actions to achieve the best possible outcomes based on its perceptions and knowledge. It operates under the premise of rationality, where it consistently makes decisions that maximize its expected utility or performance measure.

It uses both —

- * Evidence from percepts (what it has sensed)

- * Build in knowledge (Prior information, rules or models).

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Performance measure (utility function):

provides an objective criterion for judging how successful the agent is.

Q: Can a rational agent make mistake?
⇒ Yes, a rational agent can make mistake because —

* If makes decisions based on the information available at the time, not perfect future knowledge.

* If new, unexpected information arises later, an actions that seemed rational earlier may look like a mistake.

Example:

A self driving car may choose a faster route based on its knowledge.

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If an accident unexpectedly occurs, causing a traffic jam, the choice may look like a mistake.

However, the agent was still rational, since it maximized expected performance based on what it ~~knew~~ knew.

☐ Specifying the task environment:

To design an intelligent agent, we must specify its task environment clearly. This is done using the PEAS framework.

* Problem specification: performance measure, environment, actuators, sensors (PEAS).

— Example: Automated taxi driver.

- i) Performance measure: Safe, fast, legal, comfortable trip, maximize profits.
- ii) Environment: Roads, other traffic, pedestrians, customers.
- iii) Actuators: steering wheel, accelerator, brake, signal, horn.
- iv) Sensors: cameras, sonar, GPS, speed-meter, odometer, engine sensor, keyboard.

Spam Filter Agent: It is an AI program that automatically detects and filters unwanted (spam) emails from a user's inbox. It works as an information agent, continuously monitoring incoming messages & deciding where else is spam or legitimate.

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SPAM Filter Agent (PEAS example):

⇒ Performance measure:

1. Minimizing false positive, false negatives (spam emails not detected).

⇒ Environment:

A user's email account
email server.

⇒ Actuators:

mark as spam, delete etc.

⇒ Sensors:

Incoming messages, other
info about user's account.

Environment Types:



Fully Observable

vs. Partially Observable

* Fully Observable:

The agent's sensors
can access the complete state of
the environment at all times.

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Ex: Chess game — the board & pieces are fully visible.

* Partially Observable: The agent's sensors can only access partial info.

Example: Driving in fog — you can't see the whole road.

⇒ Deterministic vs Stochastic

* Deterministic: The next state of the environment is completely predictable, determined by the current state & the agent's action.

Ex: Solving a math problem.

* Stochastic: The environment has uncertainty, the same action may lead to different outcomes.

Ex: Rolling a dice in a game.

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3] → Episodic vs Sequential:

* Episodic: Experience is divided into independent episodes. The action chosen in one episode does not affect future episodes.

Example: Spam email classification - each email is judged independently.

* Sequential: Current actions influence future actions & outcomes.

Example: Driving a taxi - one wrong turn affects the rest of the trip.

4] → Static vs Dynamic:

* Static: The environment does not change while the agent is thinking or deciding.

Ex: Crossword puzzle - the puzzle stays the same until solved.

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* Dynamic: — The environment changes while the agent is deliberating.

Example: Driving a car — traffic & pedestrians move while the agent decides.

* Semidynamic: — The environment itself doesn't change with time, but the performance score does.

Example: Chess with a timer.

5] ⇒ Discrete vs Continuous

* Discrete: — The environment has a finite number of states, actions & percepts.

Example: Chess — limited moves & board positions.

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* Continuous:

The environment has infinite states/actions, often involving continuous variables like time & space.

Example: Driving.

6] * Single Agent vs Multi-Agent:

* Single Agent:

Only one agent is operating in the environment.

example: Solving a sudaku puzzle.

* Multi-Agent: Multiple agents interact, which may involve competition or co-operation.

example: Football.

* Known vs Unknown:

* Known: The agent knows the rules, outcomes & environment model in advance. example: Board Games.

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* Unknown:

The agent must learn or explore the environment to understand how it works.

example:— a robot exploring an unfamiliar maze.

Hierarchy of Agent Types:

All agents can be classified based on the complexity of their decision-making and the information they use.

1) Simple Reflex Agents:

- * Act only based on current percept.
- * Do not consider history or future consequences.

If condition → do action

2) Model-Based Reflex Agents:

- * Maintain an internal model of the world.

- * Can track unobserved aspects of the environment.
- Decision depend on current percept state, model of the model.

3) Goal-Based Agents:

- * Make decisions based on achieving specific goals.
- * Uses goal into to select between possible actions in the current state.

4) Utility-Based Agents:

- * Use a utility function to measure how desirable each possible state is.

{ Lecture-4 }

{ Chapter-03 }

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☐ Search:

It is a problem solving technique where the system explores possible states to reach a goal.

☐ Designing goal based agents:

* Focus on goal-based agents.

⇒ Environment characteristics:

* Fully Observable

* Deterministic

* Discrete

* Known

⇒ Search Problem Components:

1) Initial State:

* The starting point of the agent in the environment.

2) Actions:

* The set of possible moves or operations the agent can take from each state.

3) Transition model:

- * Defines the result of performing an action in a given state.
- * Maps state + action $\rightarrow$ next state

4) Goal state:

- * The desired state the agent aims to reach.

5) Path cost:

- * Sum of nonnegative step costs along the path.
- * Measure the total cost to reach the goal.

6) Optimal Solution:

- * Sequence of actions that reaches the goal with the lowest path cost.

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Example: Romania

- * Initial state - Arad
- * Actions - Go from 1 city to another
- * Transition model - If we go from city A to city B, you end up in city B.
- * Goal State: Bucharest
- * Path Cost: Sum of edges costs.

State space in search problems:

⇒ State space: The state space is the set of all states reachable from the initial state by any sequence of actions.

It is defined by:

- * Initial state
- * Actions
- * Transition model

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⇒ Representation:

Can be visualized as a directed graph.

* Nodes : State

* Edges/Links : Actions that move the agent from one state to another

Example: Vacuum World

* States:

— Agent location & dirt location

* Actions:

— left, right, suck

Example: The 8-puzzle

* States:

— location of tiles

— 8-puzzle: 181,440 states

* Actions

— Move block left, right, up, down.

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1. The first group of people who came to the United States were the Spanish explorers. They came to the United States in the 16th century. They were looking for gold and silver. They found the first gold mine in the United States in 1545. They also found the first silver mine in 1563. They were the first people to discover gold and silver in the United States. They were the first people to settle in the United States. They were the first people to build a city in the United States. They were the first people to start a government in the United States. They were the first people to write a constitution in the United States. They were the first people to elect a president in the United States. They were the first people to start a war in the United States. They were the first people to end a war in the United States. They were the first people to sign a treaty in the United States. They were the first people to ratify a treaty in the United States. They were the first people to amend the Constitution in the United States. They were the first people to change the name of the United States in the United States. They were the first people to change the flag of the United States in the United States. They were the first people to change the capital of the United States in the United States. They were the first people to change the date of the United States in the United States. They were the first people to change the color of the United States in the United States. They were the first people to change the shape of the United States in the United States. They were the first people to change the size of the United States in the United States. They were the first people to change the location of the United States in the United States. They were the first people to change the name of the United States in the United States. They were the first people to change the flag of the United States in the United States. They were the first people to change the capital of the United States in the United States. They were the first people to change the date of the United States in the United States. They were the first people to change the color of the United States in the United States. They were the first people to change the shape of the United States in the United States. They were the first people to change the size of the United States in the United States. They were the first people to change the location of the United States in the United States.

Post Bell to the left of the shortest ball to the right of the

Leptotheca

4. Large space can be used for different things.

* Completeness of Diffusion:

$E + \sqrt{10}dV$

$F = \text{number of states (nodes)}$
 $E = \text{number of edges (edges)}$

2290001 2000000 1000000 1000000

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 3. authors of the papers.
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 172. The fifty-eighth part is a
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 174. authors of the papers.
 175. The fifty-ninth part is a
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 178. The sixtieth part is a
 179. list of the subjects of the
 180. papers.
 181. The sixty-first part is a
 182. list of the names of the
 183. authors of the papers.
 184. The sixty-second part is a
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 188. list of the subjects of the
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 190. The sixty-fourth part is a
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 192. authors of the papers.
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 237. authors of the papers.
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 241. The eighty-first part is a
 242. list of the subjects of the
 243. papers.
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 265. The eighty-ninth part is a
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 267. papers.
 268. The ninetieth part is a
 269. list of the subjects of the
 270. papers.
 271. The ninety-first part is a
 272. list of the names of the
 273. authors of the papers.
 274. The ninety-second part is a
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 277. The ninety-third part is a
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 282. authors of the papers.
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 289. The ninety-seventh part is a
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 291. authors of the papers.
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 295. The ninety-ninth part is a
 296. list of the subjects of the
 297. papers.
 298. The hundredth part is a
 299. list of the names of the
 300. authors of the papers.
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 304. The hundred-second part is a
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 322. The hundred-eighth part is a
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 325. The hundred-ninth part is a
 326. list of the names of the
 327. authors of the papers.
 328. The hundred-tenth part is a
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 330. papers.
 331. The hundred-eleventh part is a
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 333. papers.
 334. The hundred-twelfth part is a
 335. list of the names of the
 336. authors of the papers.
 337. The hundred-thirteenth part is a
 338. list of the titles of the
 339. papers.
 340. The hundred-fourteenth part is a
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 342. papers.
 343. The hundred-fifteenth part is a
 344. list of the names of the
 345. authors of the

TOPIC NAME : _____

DAY : _____

TIME : _____

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Finding the optimal solution:

Approach:

- * Build the state space graph.
- * Use a search algorithm (Dijkstra's shortest path) to find the lowest cost path to the goal.

Challenge:

- * State space can be huge, making search difficult.

- * Complexity of Dijkstra's:

$$O(E + V \log V)$$

where,

E = number of actions (edges)

V = number of states (nodes)

General Search Process:

- * Start at the initial node state.
- * Expand it — list all possible successor states.

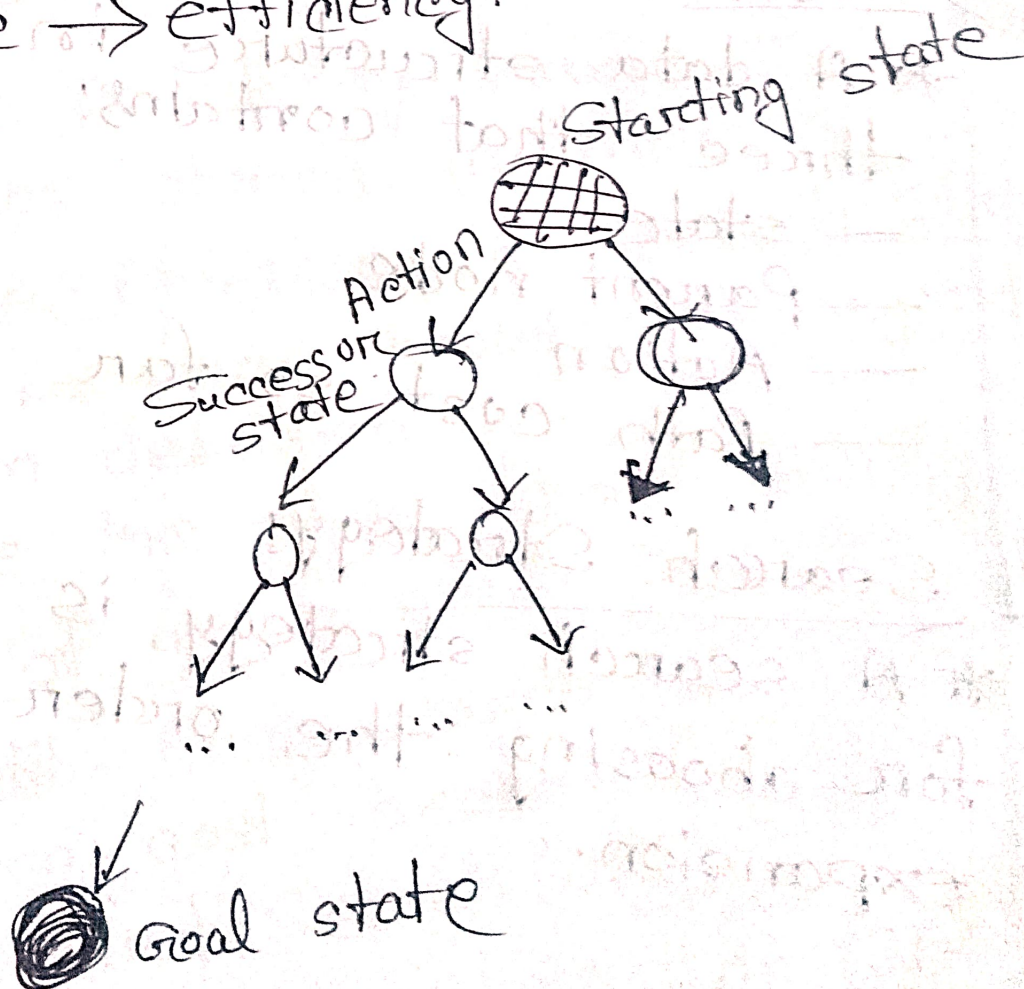
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- * Maintain a Fringe (Frontier): List of unexpanded states.
- * At each step:
 - pick 1 state from fringe:
 - expand it (generate successors)
- * Continue until the goal state is reached
- * Aim to expand as few state as possible $\rightarrow$ efficiency.



Nodes vs States:

⇒ State

* A description of a physical configuration of the environment.

* Example: In the Romania problem 'being in Arad' is a state.

⇒ Node:

* A data structure in the search tree that contains:

- state.
- parent node
- Action
- path cost so far

Search Strategy:

* A search strategy is the rule for choosing the order of node expansion.

⇒ Evaluation Dimensions:

- * Completeness: Will it always find a solution if one exists?
- * Optimality: Will it always find the least-cost solution?
- * Time complexity: Number of nodes generated.
- * Space complexity: Maximum number of nodes stored in memory.

III Uninformed Search Strategies:

- * Use no extra knowledge beyond the problem definition.
- * Explore the state space blindly.

Types of uninformed Search:

- 1) Breadth-First Search (BFS)
- 2) Uniform cost search (UCS)
- 3) Depth-first Search (DFS)
- 4) Iterative Deepening Search (IDS)