Module - 1

Introduction to Artificial Intelligence.

Artificial Intelligence (AI) refers to the science and Engineering of creating intelligent machines, especially computer programs, that can mimic human actions and cognitive functions such as thinking, learning, problem - solving, and decision - making.

- From a layman's view: AI enables machines to imitate human behavior.
- From a researcher's view: AI is a set of algorithms that produce results without explicit instructions allowing machines to think and act rationally.

example: AI is used in chess-playing computers, self-driving cars, and virtual assistants like Siri & Alexa.

How does AI work?

AI systems rely on three core cognitive processes:

1. learning processes:
   - acquire data and create rules (algorithms) to turn data into actionable information.
2. Reasoning Processes:
   - choose the right algorithm to achieve the desired outcome.

3. Self-Correction Processes:
- Continuously refine algorithms to improve accuracy.

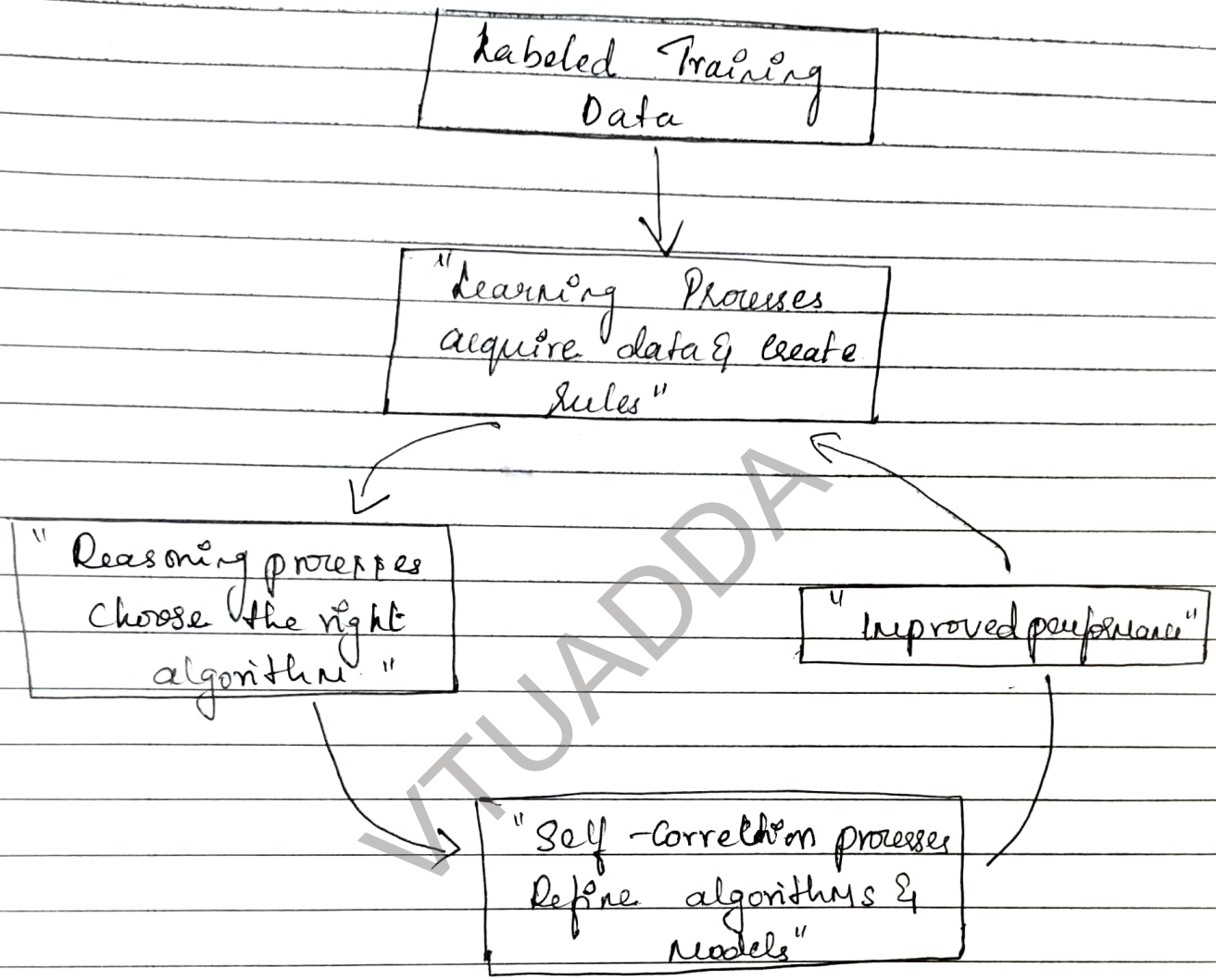
AI systems are trained using large amounts of labeled data to identify patterns and make predictions.
for example: a chatbot learns from text examples to converse with humans.

Advantages of AI.
1. Efficiency: Performs detailed data tasks quickly and accurately.
2. Speed: processes large volumes of data faster than humans.
3. Consistency: Delivers reliable and accurate results.
4. 24/7 availability: Operates continuously without fatigue.
5. Optimization: Better resource utilization and automation of complex processes.
6. Predictive Maintenance: Minimizes down time by predicting maintenance needs.
7. Innovation: Enables the creation of high-quality products and services.

Disadvantages of artificial Intelligence.
1. High Cost: Development and implementation are expensive.
2. Expertise Required: Needs skilled professionals to build and manage.
3. Data Dependency: Inaccurate or incomplete data can lead to errors.
4. Lack of Generalization: Struggles with tasks outside its training scope.
5. Job Displacement: May replace certain human roles.
6. Ethical Concerns: Raises issues around privacy, bias, and accountability.

How does AI Work?

1. Data Collection



Learning:

- AI Systems acquire data & generate rules (algorithms) to convert raw data into actionable insights.
- these rules guides the system in performing specific tasks.
- Ex: A chatbot learns how to respond by analyzing thousands of chat conversations

2. Reasoning:
- AI must select the most suitable algorithm to achieve a desire outcome.
- This involves logical decision-making & problem-solving.
- Ex: Choosing b/w a decision tree or neural networks for a classification task.

3. Self-correction:
- AI systems are designed to improve themselves over time.
- They refine their algorithms based on feedback and performance metrics.
- This ensure more accurate and reliable results in future tasks.

History of AI.

The foundational years (Pre-1956).

- 1943 : Warren McCulloch & Walter Pitts proposed the first mathematical model for building a neural n/w.
- 1950 : Alan Turing published "Computing Machinery & Intelligence", proposing the Turing Test.
- 1950 : Harvard undergraduates Marvin Minsky & Dean Edmonds built the first neural n/w computer.
- 1956 : the term Artificial Intelligence is coined at the Dartmouth conference.

this era is known as Early optimism & the first AI Winter.

Commercialization & the Second AI Winter (1980-1990s): the first commercial expert systems emerged, but ambitious govt projects failed, leading to a Second AI winter in the late 1980s.

1960s-70s : Development of early AI programs like ELIZA (natural language) & SHRDLU (robotic reasoning.

1980s : Rise of expert systems - AI programs that mimic decision-making of human experts.

Page Total

Modern Revival (1990 to present).

1990s to 2000s : ML gains traction : IBM's Deep Blue defeats chess champion Garry Kasparov.

2010s - present : Explosion of DL, neural n/w, & generative AI (eg. chatGDT, DALL-E).

Types of AI :

AI is categorized based on capability & functionality :

1. Based on capabilities :

a. Narrow AI (weak AI) : performs specific tasks
leg: voice assistants, Recommendation engines).

b. General AI (strong AI) : Hypothetical AI with human-like reasoning & adaptability

c. Super AI : A future concept where AI surpasses human intelligence in all aspects.

Weak vs strong AI.

features	Weak AI	Strong AI.
Scope	Task-specific	Broad, human-like.
learning	Limited	adaptive & flexible.
Ex :	Siri, Alexa.	None yet (still theoretical)
Consciousness	No.	Yes (hypothetical)

2. Based on functionality :

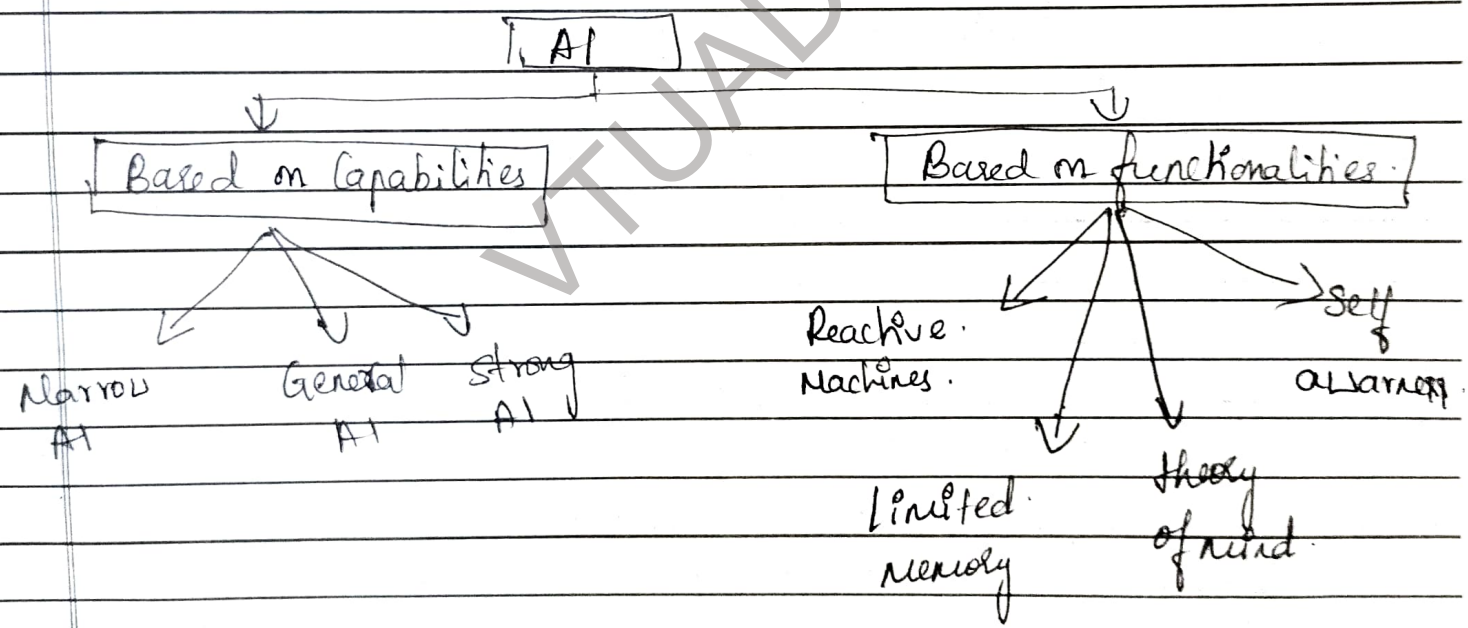
a. Reactive Machines : Respond to stimuli; no memory or learning leg: IBM's Deep Blue)
- Respond only to current i/ps
- Ex: Chess-playing programs.

Page Total

b. Limited Memory:
- Can learn from historical data.
- Used in autonomous vehicles, fraud detection.

c. Theory of Mind:
- future goal: AI that understands human emotions & social cues.
- Not yet achieved.

d. Self-awareness:
- Most advanced & hypothetical form.
- AI would possess consciousness and self-reflection.



Page Total

Is AI same as augmented Intelligence & Cognitive Computing, ML & DL.

AI : the grand Goal :

the science & engineering of making intelligent machines". It's the broadest term, encompassing any techniques that allows a machine to mimic human-like intelligence (problem-solving, learning, reasoning, perception etc)

- analogy : the concept of "Transportation" its goal is to get from A to B.
- Subfields : Includes ML, Robotics, Computer vision, NLP, Expert Systems & more.

Augmented Intelligence :

~~a design~~ is a subfield of AI that emphasizes human AI collaboration. It's designed to enhance human decision-making, not replace it.

Goal : To make human decision-making better, faster & more data-driven.

Ex : - a doctor using an AI tools to analyze medical scans. the AI highlights potential tumors, but the final diagnosis is made by the doctor.

- Business dashboards that automatically highlight virtual information & trends for an analyst.

Cognitive Computing :

a subfield of AI that aims to mimic & simulate human thought processes in a computerized model. It focuses on reasoning, understanding context, & learning from interactions.

Cognitive Computing overlaps with AI but focuses on simulating human thought processes using self-learning systems.

Goal : To create systems that can interact with humans naturally & solve complex problems in human-like ways.

Page Total

Ex: IBM Watson analyzing legal documents or Medical records.

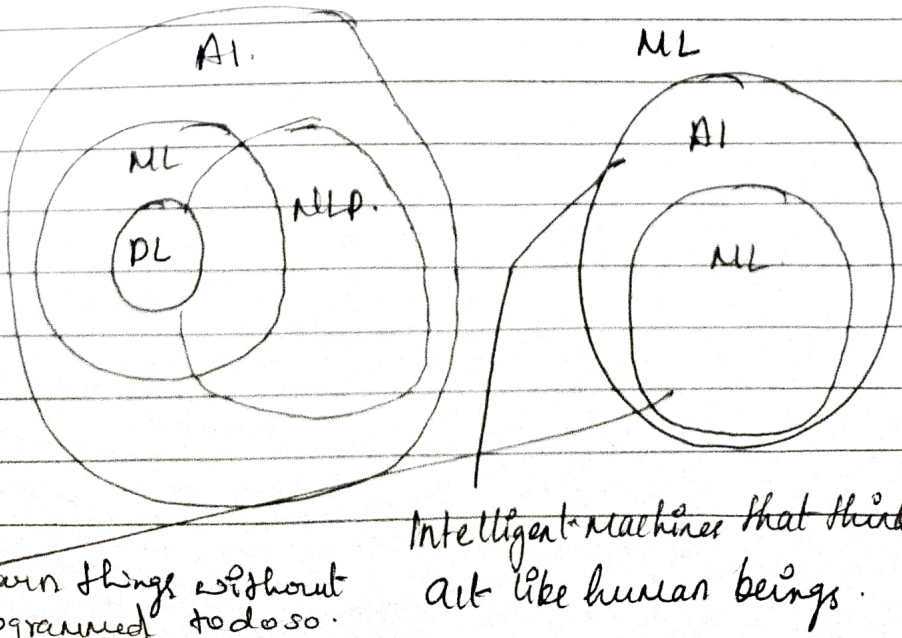
ML - key Method:
a subset of AI. It's a "branch of computer Science that analyses data and identifies patterns to teach a machine to deduce results and make decisions without any human intervention".

Goal: Identify patterns and make predictions
Ex: Email spam filters that learn from user behavior.

DL - the advanced Technique:
Subset of ML that uses neural nets with many layers to learn from large amounts of data.

Goal: Handle complex tasks like image recognition, Speech processing, & language translation

Ex: face recognition in smartphones.



System learn things without being programmed to do so.

Intelligent machines that think & act like human beings.

Machine Learning:

ML is a subfield of AI that focuses on giving machines the ability to think, learn & make decisions similar to human intelligence.

It includes studying how intelligence works in humans & applying those principles to computers or machines so they can perform tasks like understanding, reasoning, learning and problem-solving.

1. Defining Intelligence:

Intelligence refers to the ability to learn, understand, & apply knowledge to adapt to new situations, solve problems & make decisions.

These are multiple form of intelligence seen in humans, as identified by Howard Gardener's theory of Multiple Intelligence:

1. Linguistic Intelligence:-
the ability to speak, understand & use language effectively.
Ex: Narrators, Writers, or Orators.

2. Musical Intelligence:-
the ability to create and understand music, rhythms & pitches.
example: Mathematicians & Scientists.

3. logical -Mathematical Intelligence:
~~the ability to create and understand~~
the ability to think logically & solve Mathematical or Scientific problems.
Ex: Mathematicians & Scientists.

4. Spatial Intelligence:
the ability to visualize and manipulate objects or spaces mentally.
Ex: Artists, designers, astronauts.

5. Bodily - kinesthetic Intelligence:-
the ability to control body movements to solve problems.
Ex: Athletes, dancers, Surgeons.

6. Intrapersonal Intelligence:-
the ability to understand one's own thoughts, emotions, & motivations.
Ex: philosophers, Spiritual leaders.

7. Interpersonal Intelligence:-
the ability to understand other people's feelings, emotions & intentions.
ex: Teachers, Counselors, interviewers.

2. Components of Intelligence:

Intelligence - whether human or artificial - is built from several key components. In AI systems, these components are used to simulate intelligent behavior.

a) Reasoning:
- the process of making decisions & predictions based on facts or evidence.
- Two types:-
  - i) Inductive Reasoning: Drawing general conclusions from specific examples
    ex: Seeing many white swans → assuming all swans are white.
  - ii) Deductive Reasoning: Drawing specific conclusions from general rules.
    ex: All swans are birds → A swan is a bird.

b) Learning:
- the process of acquiring new knowledge & improving skills through experience.
- Types of Learning:
  1. auditory learning: learning by hearing (eg: Lectures).
  2. Episodic Learning: Learning through experiences or sequences (eg: remembering a story)
  3. Motor learning: Learning through movement (eg: sports skills)
  4. Observational learning: Learning by watching others.
  5. Perceptual learning: Recognizing objects or patterns seen before.
  6. Relational learning: Understanding relationship b/w things.
  7. Spatial learning: Learning through maps, colors, & visuals.
  8. Stimulus - Response learning: Learning to react to specific stimuli (eg: avoiding hot surfaces).

c) Problem solving:
Identifying problems and finding suitable soln.

Steps include:
- Identifying the issue.
- Exploring possible soln.
- Selecting & applying the best soln.

d) Perception:
- the ability to sense and ~~interpret~~ interpret information from environment
  - Humans use sensory organs (eyes, ears etc).
  - AI uses sensors (Cameras, microphones, etc.) to gather data.

e) Linguistic Intelligence:
- the capability to use and comprehend verbal & written language effectively.

- In AI, this is seen in systems that understand and generate natural language, such as chatbots & voice assistants (eg. Siri, ChatGPT).

Difference b/w human & NI

Aspects	Human Intelligence	Machine Intelligence
Origin	Naturally developed through biological evolution.	Artificially created by human through programming & algorithms.
Learning ability	Learning from experiences, emotions & understanding.	Learns from data using algorithms (ML)
perception	Perceives using human senses (sight, hearing, touch, etc). & interprets patterns.	Perceives data using sensors (Cameras, microphones, etc) and predefined rules.
Memory & Recall	Recalls information based on associative memory (linked by experience & emotion).	Retrives stored data using search algorithms or databases.
Decision Making.	Considers logic, intuition, emotions & others.	Makes decision purely based on logic, data & programmed rules.
Creativity	Highly creative & capable of imagination, innovations & abstract thinking.	Lacks true creativity; can only mimic patterns learned from data.
Memory & Recall	Recalls information by patterns.	Uses search algorithms to find information.
Handling missing information	Can deduce missing or distorted information accurately.	Struggles with incomplete data, less accurate

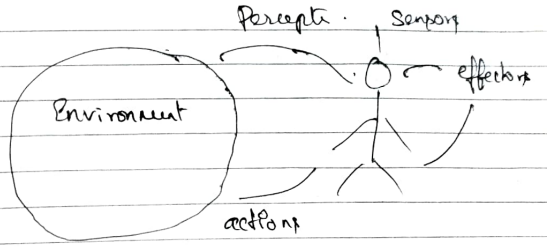
Agent & Environment :-

AI agents act in the their environment, which may include other agents.
- they perceive their environment using sensors.
- they act upon the env. using effectors.

In Simple terms :-
An AI agent takes i/p from its surroundings → make a decision → performs an action.

Definition of an Agent :
an agent is anything that can perceive its environment through sensors & act upon that environment using effectors (Actuators) to achieve goals.

Environment:
the Environment is everything outside the agent that it interacts with or reacts to.
- it provides i/p (percept) to the agent.
- it receives o/p (actions) from the agent.



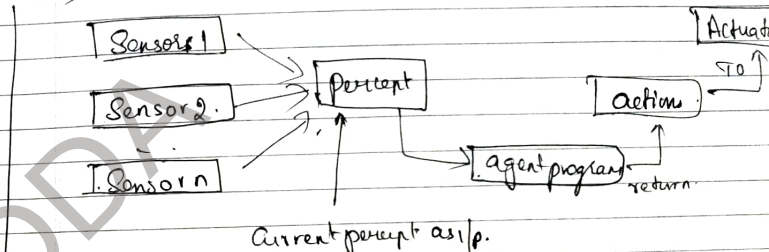
Types of Agents in an AI System:

1. Human Agent:
   - Sensors: Sensory organs like eyes, ears, nose, skin etc.
   - effectors: Hands, legs, mouth for taking actions.
   ex: a cricket player (sees the ball → decides → hits it)
2. Robotic agent:
   - Sensors: ~~Sensory organs like eye~~ Cameras, infrared range finders.
   - effectors: Motors, actuators to perform actions.

Vacuum cleaning robot (Roomba) → Senses dust → moves cleans.

3. SIS agent:
   Sensors: User bit strings as its program
   effectors: Executes programmed actions based on those bit strings.

Spam filters → reads → email header → decides → moves email to spam folder.

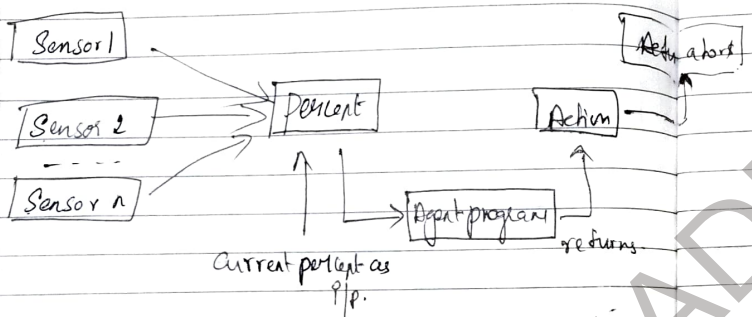


3.4.1 Key Terminology:

- performance Measures of Agent:
  It helps determine how successful an agent is based on its actions.
- Behaviour of Agent:-
  the action performed by an agent after receiving a percept (i/p)
- Percept:
  perceptual i/p received by an agent at a specific moment in time.
- percept Sequence:
  a list of all percepts an agent has received up until now.

agent function :-
• a map that converts the percept sequence to an action performed by the agent.

3.4.2 Rationality :



- Rationality is the ability to make reasonable and sensible decision.
- A rational agent makes decisions that maximize its performance based on:
  a. Performance measure (how successful the agent is).
  b. Percept sequence (the i/p it has received).
  c. Prior knowledge (what the agent already knows about the environment.
  d. Possible actions (what the agent can do).
- rational agent always performs the right action to maximize its performance.
- Problem solved by Agent (PEAS):
  - Performance measure, Environment,

Actuators & Sensors are used to define a problem that an agent will solve.

Types of Agents :

1. Simple Reflex Agent :
   acts only on current percept using "if - then" rules ; no memory.
   Ex: Automatic door sensor.

2. Model - Based Reflex Agent :
   Maintains an internal model of the world (has some memory).
   Ex: Self-driving car tracking objects.

3. Goal - Based Agent :
   acts to achieve a specific goal.
   Ex: GPS navigation system.

4. Utility - Based Agent :
   chooses the best action based on utility (preference or satisfaction).
   Ex: Online recommendation system.

5. Learning Agent :
   learns and improves from experience.
   Ex: chatGPT, stock market prediction AI

Types of Environment :-

- Observable / Partially observable :
  full or partial information available
  ex: chess (observable), Poker (partial)

- Deterministic / non deterministic :
  Same or unpredictable outcomes for actions.
  ex: chess (deterministic), Ludo (non-deterministic).

- Static / Dynamic :
  changes while acting or not.
  ex: Crossword (Static), Self-driving car (dynamic)

- Discrete / Continuous : finite or infinite possible states.
  ex: chess (discrete), Driving (continuous)

- Single Agent / multi-Agent :-
  One or many agents
  ex: Vacuum cleaner (Single), soccer match (multi)

- accessible / Inaccessible :
  Complete or incomplete environment data.
  ex: Empty room (accessible), Global weather (Inaccessible)

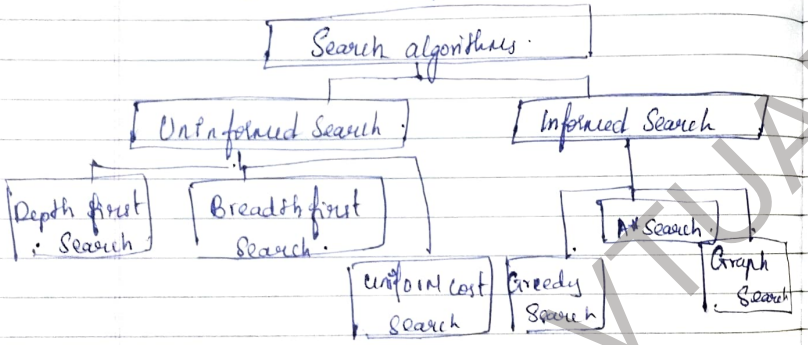
- Episodic / non-episodic : Each episode independent or dependent
  ex: Simple task (episodic), Driving (non-episodic).

Search:

Search is the method an AI system uses to navigate through a problem space to find a soln. It involves:

- State: Different configuration of situations.
- action: Moves of transition b/w states.
- Goal: the desired end state.
- Path: A sequence of actions leading from the start state to the goal.

Types of Search algorithms.



properties:

- Completeness: a search algorithm is complete if it guarantees at least one soln for a given i/p.
- Optimality: a search algorithm is optimal if it provides the best soln with the lowest path cost.
- Time & Space Complexity:
  - Time complexity: the amount of time an algorithm take to complete a task.
  - Space Complexity: the amount of memory required for the search process.

- a good search algorithm should use less time & space.

Uninformed Search algorithms

These algorithms have no additional information about the goal state beyond what is provided in the problem definition. They explore the search space blindly based on how close they are to the goal.

Characteristics:

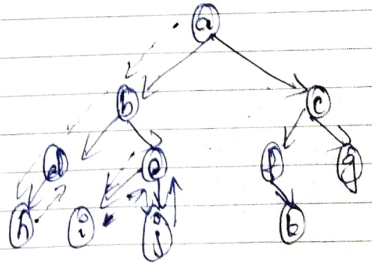
- Systematically explore all possible paths.
- Guaranteed to find a soln if one exists.
- Can be inefficient for large search spaces.

Types:

1. Depth - F S.
2. Breadth FS
3. Uniform Cost Search (UCS)
4. Depth - Limited Search (DLS)
5. Iterative Deepening DFS (IDDFS)
6. Bidirectional Search.

1. Depth first Search:-

It's a simple search algorithm used to explore a tree or graph by starting from the root node & exploring as far as possible along each branch before backtracking.



LIFO → last in first out.

Steps:-

1. Start from root node.
2. Move to first child node, then it further continuing deep.
3. When reaching a leaf node (no more children) backtrack to last node with unexplored branches.
4. Repeat until goal is found or all nodes visited.

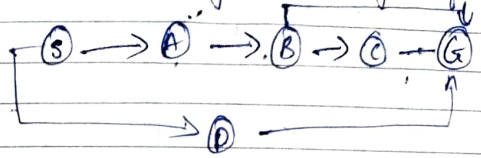
S → A → B → C → G.

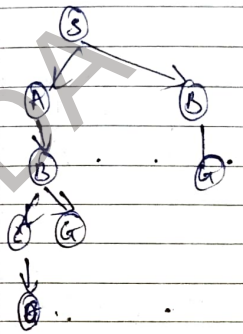
advt: → less memory usage - only stores nodes along current path.
→ faster for deep soln: may find goal quicker than BFS.

disdvt:
→ May get stuck in infinite loops in infinite spaces.
→ Not optimal → doesn't guarantee shortest path.
→ May not find soln if it chooses wrong branch first.

BFS:
- explores all nodes at current depth level before moving to next level.
- Uses a Queue (FIFO) datastructure.
- Explores wide before going deep.

Steps:
1- Start from root node (level 0)
- visit all the nodes at level 1
- Move to level 2. visit all nodes.
- Continue level by level until goal found.





advt: • Complete
• Optimal - finds shortest path
• Never gets stuck in infinite loops

disadvt:
- High memory usage
- Slower for deep soln.

Uniform Cost Search (UCS)

- Expands node with lowest path cost from start node
- Uses a priority Queue ordered by cumulative cost.
- Not depth - based or breadth - based - purely cost based.

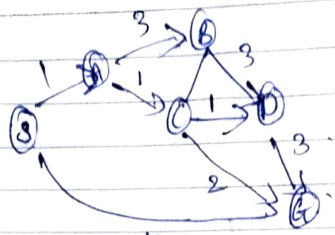
g(n) = cumulative cost from start to node n.
always expands node with smallest g(n) first.

S → G Shortest path.
path: S → A → B → G.
total cost = 5.

advt: optimal - always finds cheapest path.

Complete: guaranteed to find soln

disdvt : Cantbestop → Memory intensive



Depth Limited Search (DLS)

- DFS with predetermined depth limit (L)
- Stops exploring when reaches depth limit.
- Treats nodes at depth L as leaf nodes.

Termination Condition:

1. Standard failure : no soln exists.
2. Cut off failure : Soln beyond depth limit.
3. Success : Soln found within limit.

Searching for node H with depth limit = 2:

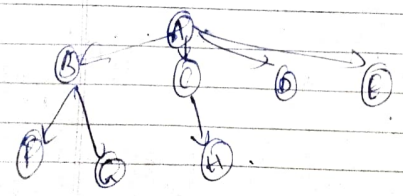
A → B → (children checked) → backtrack.
A → C → H (goal found).

advt:

avoids infinite loops of DFS.
Memory efficient like DFS.

Disdvt.

- Incomplete if soln beyond depth limit.
- Need to choose appropriate depth limit.



Iterative Deepening DFS (IDDFS).

- Combines benefits of DFS & BFS.
- performs DFS repeatedly with increasing depth limits.
- Starts with depth limit 0, increases by 1 each iteration.

Steps:

- perform DFS with depth limit = 0.
- if goal not found, depth limit = 1, repeat DFS.
- Continue increasing depth limit until goal found.

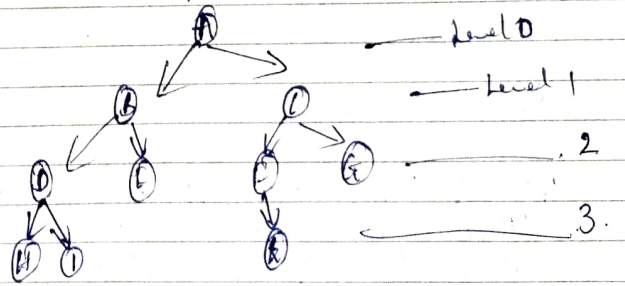
Iteration 1 (Depth 0) : Explore A.
— " 2 — " 1 : Explore B, C.
— " 3 — " 2 : — " D, E, F, G.
— " 4 — " 3 : — " H (goal found)

advt:

- Complete.
- optimal (Shortest path)
- Memory efficiency

disdvt

- Repeated work.
- Time Complexity.



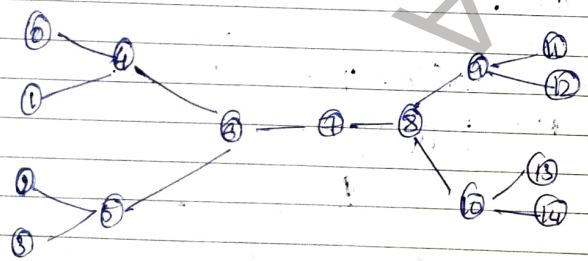
Bidirectional Search:

- Runs two simultaneous searches:
  - forward search: from start node towards goal
  - Backward search: from goal node towards start
- Stops when two searches meet at common node

Steps:
- Initialize forward search from start.
- — " : backward — " — from goal.
- Expand both search alternately.
- Stop when a node is common to both frontiers

adv:
- Must faster
- Memory efficiency.
- Complete & optimal.

disadv:
- Not always applicable
- More complex to implement
- Needs efficient way to check intersection



Informed Search Algorithms (Heuristic Search)

These algorithms use EXTRA INFORMATION about the search space to find the goal more efficiently.

Characteristics:
- Uses heuristic func. $h(n)$ to estimate distance to goal.
- Explore fewer nodes than uninformed search.
- faster for larger search spaces.
- May not always find the optimal path.

1. Pure Heuristic Search:

a type of informed search that expands nodes based solely on their heuristic value $h(n)$.

How it work:-

1. Maintains two lists:
   - open list: nodes yet to be expanded.
   - Closed list: Nodes already expanded.

2. Process:
   - always expands the node with the lowest heuristic value $h(n)$ first.
   - applies heuristic to child nodes.
   - adds child nodes to open list based on heuristic value
   - keeps shortest paths, discards longer ones.
   - Repeats until goal state is reached.

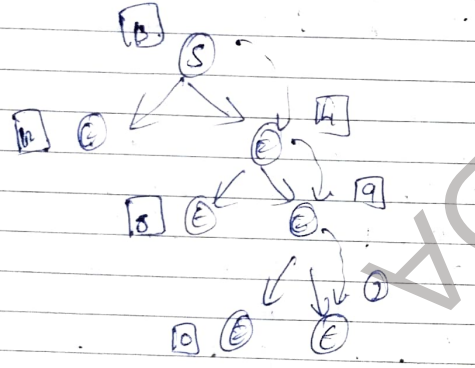
BFS (Greedy Search).

a specific implementation of pure heuristic search that always chooses the most "promising" path at each step.

How it work:-

Insert the start node in the Open list.
If open list is empty, Stop (goal not found)

- Remove the node with lowest heuristic value h(n) from open.
- add this node to closed list.
- Expand this node with lowest heuristic value h(n) from open.
- add this node to closed list.
- Expand this node to closed list.
- ~~Expand~~ if any successor is the goal, stop & return success.
- if a successor is not in open or closed, add it to open list.
- Repeat from step 2 until goal is found.



Introduction to knowledge Representation:-

is a fundamental area of AI that deals with how to store & manipulate knowledge to enable intelligence decision-making.

- It involves representing information about the world in a form that a computer system can utilize to solve complex tasks.

- KR acts as a bridge b/w raw data & intelligent behavior, allowing AI systems to reason about and draw conclusions.

knowledge: Information about the world that an AI system uses to make decisions.

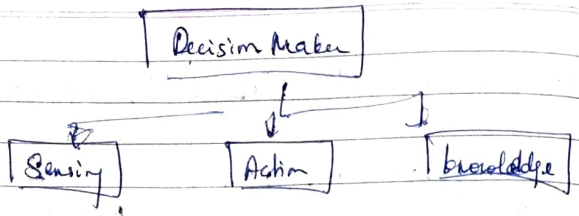
logic: a formal language used to represent knowledge & facilitate reasoning.

Cycle of knowledge Representation:-

1. Perception: acquire information from the environment.
2. knowledge based update: incorporate new knowledge.
3. Reasoning: Use existing knowledge to infer new facts.
4. action: Execute decision based on reasoning

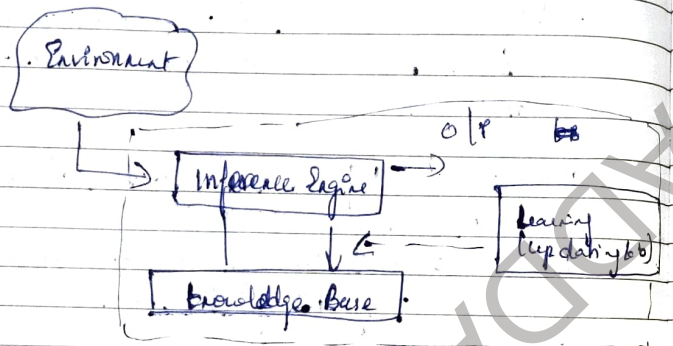
knowledge Representation Requirements:

- Expressiveness: ability to represent a wide range of knowledge
- Efficiency: Storage & retrieval.
- Inference Support: must support reasoning & inferences



Knowledge - Based Agent (KBA)

a knowledge - based agent is an AI agent that maintains an internal knowledge base & uses it to make decision.



architecture of KBA
- Knowledge Base: Stores facts & rules.
- Inference Engine: Applies logical rule to deduce new information.

Operations of KBA:-
TELL: add new knowledge to the KB.
ask: Query the KB to retrieve i/p.

Levels of a KBA.
1- knowledge level: Describes what the agent knows.
2. logical level: Represents knowledge using formal logic.
3. Implementation level: How knowledge is stored & processed.

Types of knowledge:

1. Declarative knowledge: facts & statements (eg: "the sky is blue").
2. Procedural ~~-k~~ : Step by step processes or algorithms (eg: how to ride a bike)
3. Meta ~~-kk~~ : knowledge about knowledge (eg: knowing what you know or don't know)
4. heuristic knowledge: Rule-to-thumb knowledge used for problem-solving.
5. Structural ~~-k~~ : Relationships b/w concepts (eg: hierarchies, IsA's).

Techniques of KR.

1. logical Representation:-
- uses formal logic (eg. propositional logic, first-order logic).
Ex: if it is raining, then the ground is wet.

2. Semantic nets:-
- Represent knowledge as nodes (concepts) & edges (relationships).
- Ex: Bird -> is a -> Animal.

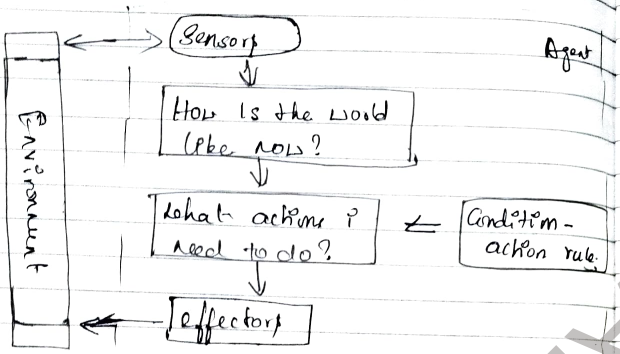
3. Frame Representation:-
- Uses data structures (frames) with slots and fillers to represent stereotypical situations.
- Ex: A "car" frame with slots for color, model etc.

4. Production Rules:
- Uses "IF-THEN" rules to represent knowledge.
- Ex: IF temperature > 100 THEN alert = 'fever'

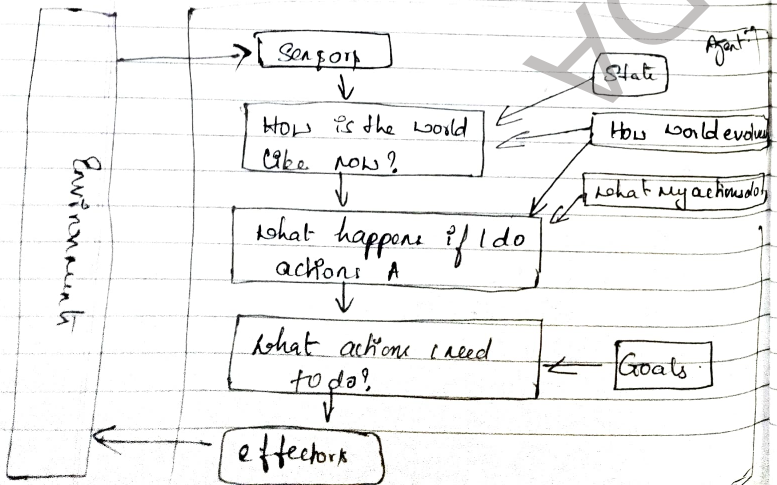
5. Ontologies:
- formal definitions of concepts & relationships in a domain.

Types of Environments :-

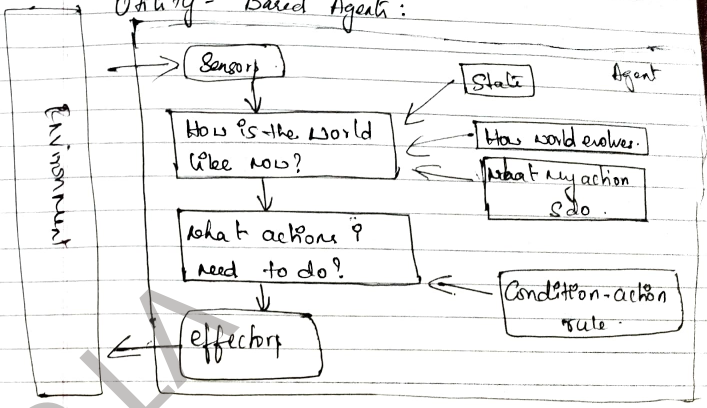
Model - Based Reflex Agent :



Goal - Based Agent :-



Utility - Based Agent :



Learning Agent :