Artificial Intelligence

UNIT-1

Definition:- It is a machine based system that influences environments by producing outputs like, predictions recommendations, decisions derived from data patterns while emphasizing its responsible and ethical use across sectors guided by initiatives like India AI.

Definition:- It is a machine based system that for human defined objectives can make predictions, recommmendations or decisions and solve tasks requiring human like perception, cognition or learning and perform autonomously with minimum Human side.

Definition:- It is an interdisciplanary scientific and engineering field dedicated to building agents that can persive the environment through various sensors, extract relevant information, learn from experience, reason about actions and make decisions that help them to achieve specific goals or maximize their performance across a range of complex and dynamic environment.

Example :- Intelligent robot

AI focuses on building intelligent machines that can effectively and safely navigate novel situations.

There are 4 dimensions of AI

(i) Acting humanly :- The Turing test approach

(ii) thinking humanly :- The cognitive modeling approch.

(iii) thinking rationally :- the laws of taught approach

(iv) acting rationally :- the rational agent approach.

Acting humanly : the turning test approach

The turning test proposed by Alan turing (1950) was a thought expeiment
=) "Can machine think"

The computer would need the following capabalities :-

→ Natural language processing for human communication

→ Knowledge representation for information storage

→ Automated reasoning for answering questions and drawing conclusion

→ Machine learning for adaptation to new circumstances and to detect extrapolate patterns.

A human cannot tell respone other side of the wall are coming from the human or computer then the computer is intelligent, the verdit is turing test pass and the machine is human like.

The turing test consists of 3 participates, introgative, AI system and a AI Engineer.

A human evaluator will post question and asscess questions to determine which participate is human and which is artificial.

Ex:- A technical question relevant to manufacturing industry, Describe the optimization path of CNC router path for minimizing tool ware or aluminium alloy 7075.

Thinking rationally : the laws of thought approach.

A provided structure patterns for argument that given correct premisis would awalys yield correct conclusion this approach is known laas of cork approach and it assumes that intelligent Behavior can be achieved through the application of formal logical rules and formal principles

Aristotle codified the right thinking through Syllogisms.

Ex:- Socrids is a man, All men are are mortal thus Socrids is a mortal

Acting rationally :- for each possible percept sequence the rational agent is the one that acts maximizes performance measure on the basis of evidence perceived so far and built in knowledge.

To design a rational agent one specifies PEAS

An agent acts

Computer agents operate autonomsly, perceive their enviornment, persist over time, adapt and pursue goals.

A rational agents seeks the best outcome or the best expected outcome under uncertainty.

Foundations of AI

Mathematics

(i) formal logic :- It provides the framework for knowledge representation and automated reasoning in AI systems. It includes both propositional logic and predicate logic.

(ii) Probability & statistics :- It is the mathematical framework that allows AI to manage uncertainty and make decisions under incomplete information.

Algorithms :- They are precipe step by step procedures and process data.

Ex:- Tool path in the automated machine using shortest path algorithm to minimize the machine time.

Compute ability :- It explores the fundamental limits of what can be computed algorithmically.

Ex:- turing machine for binary addition has a binary numbers on tape, It follows transition nodes to add bit by bit and output is the sum written on the tape.

A problem is called intractable if the time required to solve instances of the problem grows exponentially with time.

Economics

Decision Theory :- It provides a formal and complete frame work made under uncertainty.

Game theory :- It is the condition of action where the action of one player can significantly effect the utility of the other plane.

multi agent system :- It is a system composed of multiple interacting intelligent agents.

Operations research

Markov - Desicion Process

Neuroscience

It is the study of the brain's nervous system.

The brain consists of nerve cells called Neurons.

Cognitive psychology views the brain as an information-processing device.

Intelligence augmentation (IA not AI) computers should augment human abilities rather than automate away human tasks.

Singularity :- It is a hypothetical future point when computer reaches a super human level of performance and rapidly improve themselves for that.

Optogenetics :- It uses light to control neurons leaving tissue if a gene is inserted with specific neurons it makes them responsive to particular colour of light then if a light is shine on that neurons it turns them on or off.

Brain machine interface :- It creates a direct connection path from brain to external device.

Psychology

(i) Behaviorism :- It is primarily shaped through environment through a process called conditioning the principles will focus on measurable Behaviors, learning occurs through environmental interactions shaped by Rewards and punishments

Cooperative psychology :- It uses the brain as an information device. The 3 steps stimulus must be translated into internal representation manipulated by cognitive process to derive new internal process. These are retranslated into back into action.

IA (Intelligence augmentation)

It means instead of replacing human intelligence enchancing and amplifying human mind through technology.

Computer Engineering

Increase in speed and capacity, and a decrease in price (Moore's law)

Hardware tuned for AI applications, such as the GPU, TPU, WSE (water scale engine)

Quantum computing tools holds out the promise of far greater accelerations

(i) GPU

(ii) TPU

(iii) WSE

(iv) Quantum computer.

Intelligent Agents

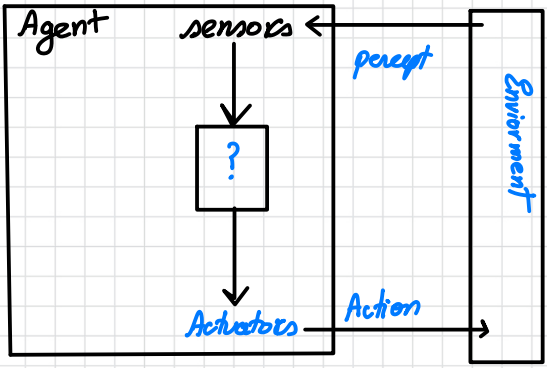
An agent is defined as something that sees through sensors and acts in an environment through actuators

Percept :- Is what the agent senses from environment

Percept sequence :- Complete history of sequence.

Agent function :- Maps percept sequence to action.

Agent program :- Is the implementation of the agent function.



percept sequence Vaccum-cleaner world

vaccum cleaner agent

The world consists of squares that can be either dirty or clean

is the agent intelligent?

Percept sequence	Action
[A. Clean]	Right
[A. Dirty]	Suck
[B. Clean]	left
[B. Dirty]	suck
[A. Clean] [A. Clean]	Right
[A. Dirty] [A. Dirty]	suck
[A. Clean] [B. Clean]	No operation
[B. Clean] [A. Clean]	No operation

If status = Dirty the return suck

If location = A then return right

If location = B then return left

The nature of environment

Specifying the task environment

→ PEAS (Performance, environment, actuators, sensors)

→ Before describing the agent, the PEAS description is the first step.

The PEAS description for social media recommendation system is as follows

→ Task :- Maximize user engagment

→ performance :- high click-through rate, dwell time, shares, comment

→ Environment :- user profiles, posts engagment data

→ Actuators :- Displaying recommended posts

→ Sensors :- user clicks, scroll, views

PEAS for AI Teacher bot

Performence :- high student test scores, low dropouts

Enviroment :- Student profiles, curriculum, content

Actuators :- Presenting lessons giving feedback, offering help

Sensors :- Student answers, interaction time, progress data, confusion signals

Types of enviroments

The types of enviroments are as follows:-

(i) non observable and overable

(ii) Deterministic & Stochastic

(iii) Episodic and sequential

(iv) Static and dynamic

(v) Discrete and continuous

(vi) Single agent and multi agent

identifing the enviroment in chess game

An agent has complete acesses to all the information nessacry to make the decisions through it's Sensors

An agent has limited information of the enviromented state.

Deterministic enviroment

The next state is determined by the current state and the agents action with no randomness involved.

Storchatic

Due to uncertinity the outcomes cannot be perfectly predicted.

Single agent Enviroment

It has one individual agent operating indepenrtly within the enviroment to achieve specific objectives.

Ex:- CNC machine

Multi agent enviroment

It has multiple intelligent agents which interact, co-ordinates to achieve the objectives

Ex:- Automated Guided vehicle

Episodic

here the agents experience is divided into individual episodes where the action in one does not effect the other.

Ex :- Part Quality inspection system

Current actions will effect the future states and long term conciquences must be conciclered.

It remains unchanged with no external changes occurring during the working of the agent.

Dynamic environment changes continiously requireing agents to adapt evloveing conditions & to make critical condition

Exc:- Mobile Robot

The action will vary based on the case.

The structure of agent

utility based agent

goal based agent

learning based agent

Simple Reflex Agent

function SIMPLE REFLEX AGENT (Percept) returns an action

It defines the agent, what it senses from the enviorment and returns the action performed

persistent: rules: a set of conditions, actions rules.

It includes programed set of rules which is stored in the memory. Each rule will link a condition to action

state ⟷ INTERPRET-INPUT (Percept)

rule ⟷ RULE-MATCH (state, rules)
Action.

return action.

The agent takes the sensor data and interprets it to state.
Ex:- raw pixels of a camera might be interpreted as obstacle detected.

Agent searches the list of rules to find the condition that matches the current state.

Once a matching rule is found the agent selects the action associated with that rule.
Exc:- If the state is obstacle detected then stop or turn left

The agent outputs the selected action which is performed by actuators like Motors or wheels.

Model Based Agents

Function :-

Persistence: a: state: the agent current conception of the situation.
b: transitional model: description of how the next state depends on the current state of action.
c: sensor model: A description of how the current state is reflected in the agent percept.
d: rules: A set of conditions & actions
e: Action: the most recent action

State ← UPDATE-STATE

rule ← RULE-MATCH

action ← ruleAction

return Action

Here the agent updates the internal state based on the new information It combines the old internal state, action it just took, new sensory information etc

Consider welding on a car assembly line

step 1:- Let the agent be a simple reflex agent it will be having only 1 sensor that is a proximity sensor. The agent follows one rule

IF car chassis is detected
THEN execute program welding sequence at fixed location
ELSE remain idle.

This agent has a limitation that if the part is misalligned welding will take place at wrong location resulting in the defective product. Since it has no understanding of the process.

Step 2:- The robotic agent has a cameras agent and an internal process model. The agent can understand the sequence of the assembly line as follows:-

The camera sees the chassis, the agent updates the internal state

Internal State } Station_Empty / To chassis_present }

The next event is the placement of side panels. When the internal state is panel ready which is confirmed by the camera the build is initiated.

This agent improves from simple reflex agent by understanding the sequence so that welding happens only after the side panel is attached to the chassis.

Step 3:-
The agent is given a goal of welding the side panel Securely to the chassis according to 3D-CAD

When the path is ready the agent does not run a fixed program instead it checks with the design and trys to match accordingly.

If the camera detects a small clamp obstructing the weld path the agent plans a new sequence of moments for welding to achive the gold.

The limitation of this agent if there are multiple paths to achive the goal the agent will not be able to decide.

Step 4:- Utility based welding agent should be able to consider not just the goal but also the quality of the weld and efficiency.

The agent maximizes the score based on weld quantity, energy consumption time per job, wear on components.

If there are 2 welding paths the agent calculates the utility

Path A:- might be faster but uses more energy and creates more stress

Path B:- Might be slower but results in high quality weld Consuming less energy.

The agent now chooses PATH B based on higer utility code.

Step 5:-

The learning agent has the ability to learn and adapt. It contains

(i) Performance

(ii) Critic

(iii) Learning elements

(iv) Problem generation

Performs the welding task using utility based logic, 3D scanners and thermal sensors inspect the finished belt the feedback is compared with a CAD model if the critic tells the weld at cordinate (x, y) is 2% weaker than the standered due to insufficient heat, the learning element increases the welder voltage by 0.5% to eliminate this it then updates the decision model for future jobs

The problem generator might occationally try diffrent weld speed or angle as a safe experiment

Fairness :-
principles of responsible AI: It is a requirement that individuals are treated similar to other individuals regardless of the class. Other factors are fairness through unawareness, Demographic parity (male, female) group fairness, well qualified, less qualified, equal opportunity, equal impact.

Safety :-

It is priciceles aligned with true human values a safe AI agent should not have unintended side effects.
Esc:- Robot fetching a coffee.
safety measures by RBI
(i) Free AI Committee
(ii) Mule Hunter AI

Explainabity, transferability :-

A good explanation should be understandable and convincible to the user and accurately reasonable to the system. A machine is explainable if it is able to give a story of task done by it.

Privacy and security :-

It requires that the AI systems protect the user data against the breaches and attacks.

Inclusiveness :-

Write yourself

Accountability :-

write yourself

ISO 42001 international Standard provides a framework for AI management systems covering the entire AI life cycle. It offers the structured guidance AI governance and practices and is internationally recognized.

Problem solving agents

A problem solving agent is an intelligent agent specifically designed to solve complex problems or achive specific goals in the environment. There are 5 steps in the problem solving agent

Step 1 :- Goal formulation

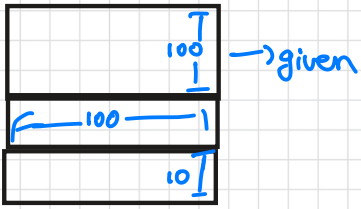
Step 2 :- Problem formulation

Step 3 :- Searching

Step 4 :- Solving

Step 5 :- Execution

Esc :- CNC machining optimization



Goal :- minimizing the production while maintaing the production accuracy within 0.1mm tolerance for the given path.

problem formulation :- Define the machining environment like geometry of the work piece, available tools, spindle speed, feed rates, coolant options the initial state represents the raw material and the goal state is the finished component.

Search :- Evaluate the different tool path, cutting parameters and the sequence of machining. factors to be considered are tool wore, surface finish and material removal rate.

Solution :- Genrate the CNC Program with tool Suggestion, feed and other commands that minimize the cycle time.

Execution :- Execute the program on the machining sector with the machine following the pre-determined path to produce the finished component

Ex :- google maps, robot path plan spam flattering agent, smart irrigation systems, chess, puzzels.

Water Jug Problem

There are 2 jugs A and B where A can hold 4L and B can hold 3L the goal is to get 2L in jug A from the start state (0,0) it has to reach the goal state (2,n)

All possible states (x,y)

$x \in \{0,1,2,3,4\}$, $y \in \{0,1,2,3\}$
x is liters in Jug A, y liters in Jug 3

Step 3 :- fill A
(0,0) → (4,0)
pour water A to B
(4,0) → (1,3)
empty jub B
(1,3) → (1,0)
pour A to B
(1,0) → (0,1)
fill Jug A
(0,1) → (4,1)
pour. A to B
(4,1) → (2,3)

This sequence uses 7 actions and achieves the goal state (2,3)

Execution :- the above action is performed in the listed order so that jug A contains satisfying the goal

Missionary - Carnival Problem

The objective is to transport goatmen, tiger, goat & grass from the left bank to right bank of the lake without leaving the tiger alone with the goat or the goat alone with the grass or either back.

Search Problem and solutions

Steps in search problem

Step 1:- Defining state space

Step 2:- Defining starting state

Step 3:- Defining goal state

Step 4:- Defining actions

Step 5:- Transition model

Step 6:- Action cost

The state space defines all possible configurations of the relevant objects. The initial state specifies one or more state within that space as a possible solution from which the problem solving can start.

The goal state specifies one or more state that will be acceptable as the solution to the problem.

ACTION(s) returns a finite set of actions that can be executed in s

Transition model:- It describes what the action does. with the following command

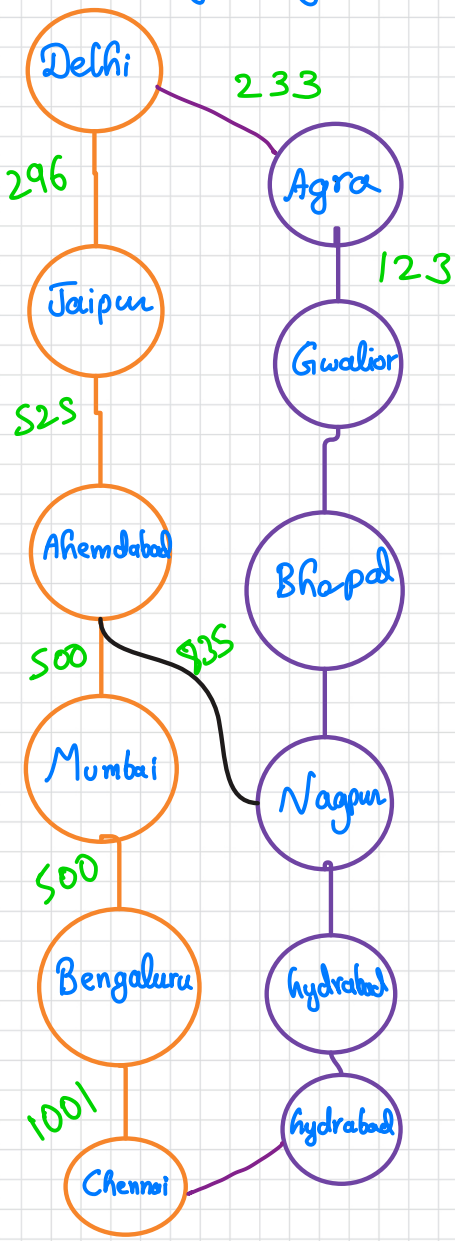
RESULT(s,a)

It returns the state that results from doing action a as s.

ACTION-COST c(s,a,s') It gives the numeric cost of applying action in state S to reach state s'. A problem solving agent user cost function that reflects its own performance measure.

Illustration of agent:- Consider an agent currently in delhi and has to reach Chennai.

The agent sees that there are 2 roads leading out of Delhi



Step 2:-
Delhi is the agent's starting location.

Step 3:- Goal state is Chennai which is the target destination which the agent must reach.

ACTIONS(Delhi)

{ To(Jaipur), To(agra)}

ACTIONS(Agra)

={ To(Delhi),

Step 5:- Transition model

RESULT(Delhi, To(Agra) = Agra

RESULT(Delhi, To(Gwalior))

Each city has actions corresponding to travel for directly connected cities.

Step 6:- Action cost functions

The agent explores all possible routes from Delhi to chennai as follows:-

ACTION-COST(Delhi, To(Agra), Agra)
= 230

ACTION-COST(cf Agra, To(Gwalior)
Gwalior) = 123

Path 1 = 2530 Km

Path 2 = 2667 km

The total cost is the sum of individual action cost as calculated above. An optimum solution has the lowest path cost sum of all the solutions.

Obstruction in formulating a problem include road quality, wheather conditions, driving speed, radio program and etc.

Rules for sokoban puzzle problem

The enviorment is a rectangular grid of walls and floor squares. The floor square maybe empty or may contain boxes or target or they may be a wall inbetween. The objective of the player is to push each box onto the goal square so that every target is covered and no box is remained

The player can move 1 square at a time in any of the directions if the square is empty the player must not pass though walls or boxes.

If the player is in the adjecent square of the box it can be pushed but once the box is pushed it cannot be reverse.

Pushing the box diagonally, pushing the box, pulling the box is not allowed.

If the box cannot be retrieved from its position and remains stuck, it is a deadlock situation & the puzzle cannot be solved.

The puzzle is considered sort when each box has been moved to a distinct core position.

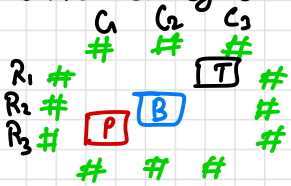
If there are n non-obstacle squares and 6 boxes then the no. of states can be calculated as

$$(n-6) \times \frac{n!}{6!(n-6)!}$$

Ex:- for a 2x2 grid with 4 squares & 1 box

$$(4-1) \times \frac{4}{1!(4-1)!}$$

Formulation of a sukoban Problem



Consider a sukoban problem with palyer one box and a tauget whose coordinates as shown.

Step 1:- state representation

It contains the current position of the player as coordinates (x, y) as position of the box (x, y) where x is row no. & y is column no.

$S = (Player\_position, \{Box1\_pos, Box2\_pos...\})$

The initial state of the above problem is represented as $\{(3,1),(2,2)\}$.

Step 2:- Actions

The allowed actions from any given state is to shift the position to any adjacent empty square, syntax:-

$ACTION(s) = \{MoveLeft/MoveRight/MoveUp/MoveDown\}$

It defines the result of each action to a given state.

Step 3:- Transition Mode

Syntax:-

$RESULT(s, a) = S$

result:-

step 2:-

result

$((3,1),(2,2), Move\ Right) = \{(3,2),(2,2)\}$

step 2:-

$RESULT((3,2),(2,2), Move\ Up) = [(2,2),(1,2)]$

Step 4:- Action cost

This is the metric for evaluating the cost of taking action a in status to reach the new state s'. for a simple move the cost is considered as 1 and for a push the cost is taken as 2. Syntax:-

$ACTION\_COST((3,1),(2,2)), Move\ Right\ ((3,2),(2,2)) = 1$

since it is a simple move

goal test

It compares the current position of the box with the fixed position of the target every target square must be occupied by a box. The goal test is true if and only if

Bpos and Tpos are identical

For the above problem Bpos = (1, 3) & Tpos = (1, 3) hence it passes the gold test.