Unit – I
INTRODUCTION & INTELLIGENT AGENTS

JNTUA SYLLABUS
Unit – I: **Introduction**: What is AI, Foundations of AI, History of AI, The State of Art.
Intelligent Agents: Agents and Environments, Good Behaviour : The Concept of Rationality, The Nature of Environments, The Structure of Agents

CONTENTS

S.No.	Name of the Topic	Page No.
1.1	ARTIFICIAL INTELLIGENCE	01
1.2	ELEMENTS OF AI/ SUBSETS OF AI/SUB AREAS OF AI	02
1.3	TYPES OF AI	04
1.4	FOUNDATIONS OF AI / FIELDS OF AI	06
1.5	HISTORY OF AI / EVOLUTION OF AI	07
1.6	PROGRAMMING LANGUAGES FOR AI	08
1.7	STATE OF THE ART IN AI/APPLICATIONS OF AI/USE CASES OF AI	09
1.8	AGENTS & ENVIRONMENTS	13
1.9	STRUCTURE OF AGENTS/ TYPES OF AGENT PROGRAM	15
	1.9.1. Simple reflex agent	16
	1.9.2. Model based Reflex Agent	17
	1.9.3. Goal based agent	18
	1.9.4. Utility based agent	19
	1.9.5. Learning agent	19
1.10	INTERACTING AGENTS/ DESIGN OF AGENTS	20
1.11	GOOD BEHAVIOUR: THE CONCEPT OF RATIONALITY	21
1.12	THE NATURE OF ENVIRONMENTS	21
	1.12.1 Specifying the Task Environment [PEAS]	21
	1.12.2 Properties of task environment/ Features of environment/Agents environment in AI	22

Unit –I
INTRODUCTION

1.1 ARTIFICIAL INTELLIGENCE (AI)

Intelligence

Artificial Intelligence

✓ Intelligence is the ability to create and apply right knowledge.

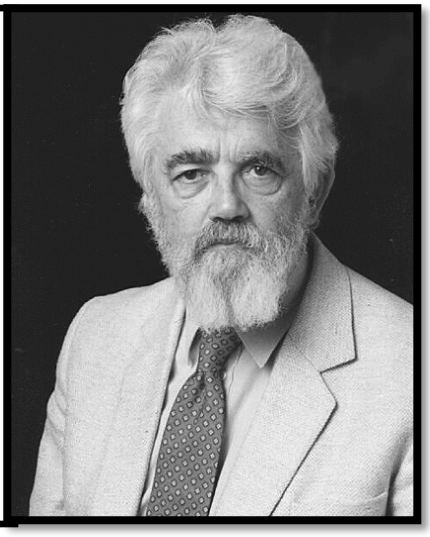
✓ A machine is said to be Artificially Intelligent, when it can create and apply right knowledge.

"Our Intelligence is what makes us human, and AI is an extension of that quality"

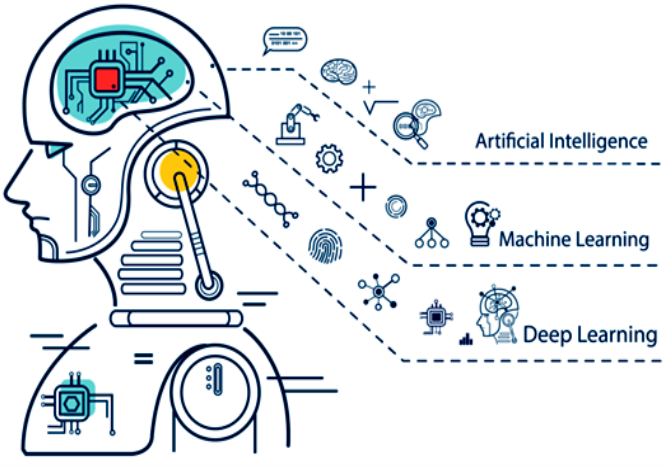
- AI is the Science and Engineering of making intelligent machines, especially intelligent computer programs.
- AI is the Science of building intelligent machines from large volumes of data and learning from experience to perform human like tasks.
- AI is a group of technologies working together to enable machines to sense, understand, act and learn.
- A technique which enables machines to mimic human behavior.
- AI is the simulation of human intelligence, processes by machines, especially computer systems.
- AI is the intelligence demonstrated by machines, as opposed to the natural intelligence displayed by humans or animals.
- AI is concerned with the design of intelligence in an artificial device.
- John McCarthy first coined the term AI in the year 1956.

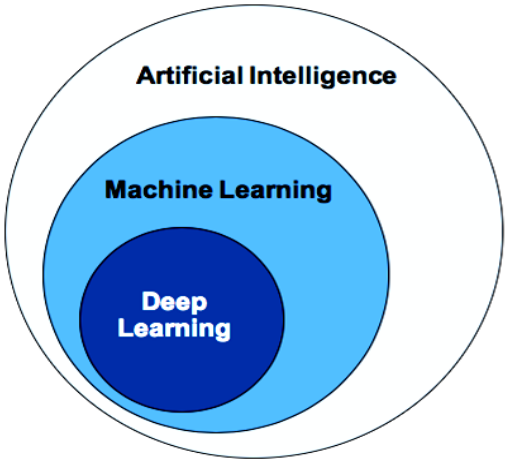
"Every feature of intelligence or learning aspects in principle can be so precisely described that a machine can be made to simulate it".

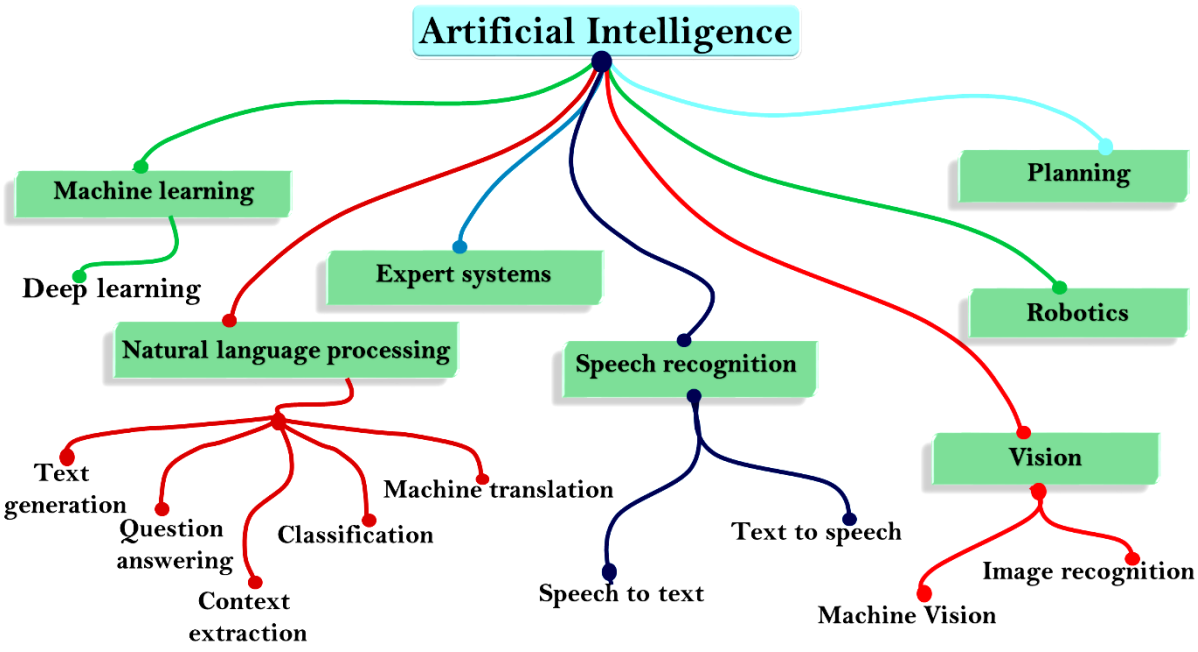
- John McCarthy
Father of AI
Professor
Standford University



1.2 ELEMENTS OF AI/ SUBSETS OF AI / SUB AREAS OF AI







Following are the most common subsets of AI

1. Machine Learning
2. Deep Learning
3. Natural Language processing
4. Expert System
5. Robotics
6. Machine Vision
7. Speech Recognition

1. **Machine Learning [ML] –** Machine learning is the subset of AI which provides intelligence to machines with the ability to automatically learn with experiences without being explicitly programmed. Machine Learning is based on the idea that machines can learn from past data, identify patterns, and make decisions using algorithms. Machine learning algorithms are designed in such a way that they can learn and improve their performance automatically. Machine learning helps in discovering patterns in data. ML can be subdivided in to 3 main categories : ***Supervised learning, Unsupervised learning and Reinforcement learning***.
2. **Deep Learning [DL] –** Deep Learning is the Subset of Machine Learning in which Artificial Neural Networks (ANN) adapt and learn from vast amounts of data. Deep Learning provides the ability to machine to perform human-like tasks without human involvement. It provides the ability to an AI agent to mimic the human brain.
3. **Natural Language Processing [NLP]** - NLP is a subfield of computer science and AI. NLP enables a computer system to understand and process human language such as English, Hindi etc., We can easily ask Apple's Siri, OK Google, Amazon's Alexa or Microsoft's Cortana to help us in our language. Some of the applications include **Translation, Information extraction, Classification & Clustering.**
4. **Expert Systems –** In AI, expert systems are the computer programs that rely on obtaining the knowledge of human experts and programming that knowledge into a system. These systems are designed to solve the complex problem. One of the examples of an expert system is a Suggestion for the spelling error while typing in the **Google search box.**
5. **Robotics** - Robots are the programmed machines which can perform a series of actions automatically. AI can be applied to robots to make intelligent robots which can perform the task with their intelligence. AI algorithms are necessary to allow a robot to perform more complex tasks. Nowadays, AI and machine learning are being applied on robots to manufacture intelligent robots which can also interact socially like humans. One of the best examples of AI in robotics is **Sophia, a Humanoid robot**.
6. **Machine Vision** – This is an application of computer vision which enables a machine to recognize the object. Machine vision systems are programmed to perform narrowly defined tasks such as counting objects, reading the serial number, etc. Some of the applications include **Image recognition, Computer vision, , Robot vision.**
7. **Speech Recognition** - Speech recognition is a technology which enables a machine to understand the spoken language and translate into a machine-readable format.. It is a way to talk with a computer, and on the basis of that command, a computer can perform a specific task. It includes **Speech to text, Text to speech.**

1.3 TYPES OF AI

I. Based on Capabilities

1. Artificial Narrow Intelligence (ANI) or Weak AI
2. Artificial General Intelligence (AGI) or Strong AI
3. Artificial Super Intelligence (ASI) or Hypothetical AI

II. Based on Functionalities

4. Reactive machine AI
5. Limited memory AI
6. Theory of mind AI
7. Self awareness AI

1. Narrow AI or Weak AI

- This is the first stage of AI (***Machine Learning***)
- This is the only kind and most common form of AI that exists today.
- Narrow AI operates within a limited context.
- This is a simulation of human intelligence.
- Narrow AI is programmed to assist humans with a single task or a specific task.
- By definition, they have narrow capabilities like recommending a product in e-commerce websites like Amazon/ Flipkart or predicting weather etc.,
- Examples : Google search, Google Maps, Speech recognition, Image recognition on Facebook, Playing Chess in system, Personal digital assistants (Apple's Siri, OK google , Alexa), Autonomous Vehicles like TESLA Cars, Google's DeepMind, Sophia Robot.

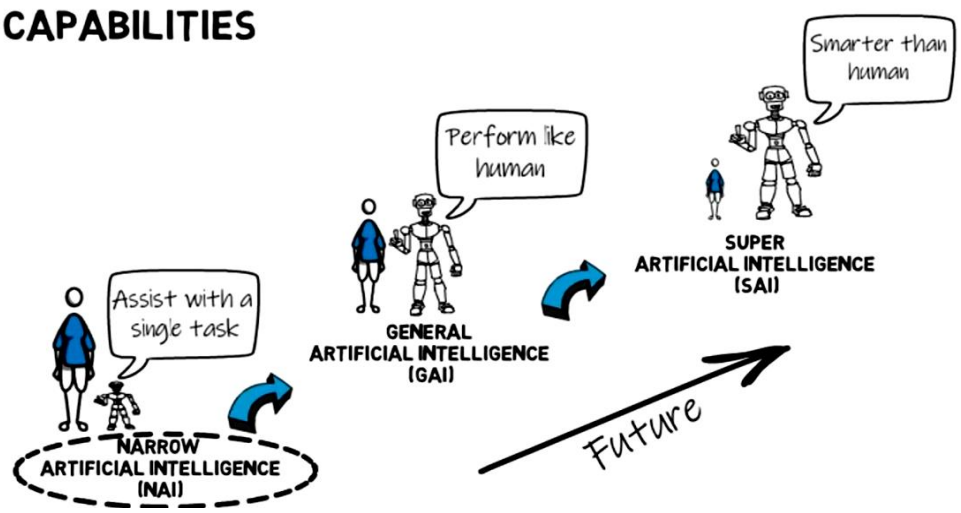
2. General AI or Strong AI

- This is the second stage of AI (***Machine Intelligence***)
- General AI is still a theoretical concept which is under research.
- General AI is a type of intelligence which could perform any intellectual task with efficiency like human. But presently there is no such system exists.
- It is defined as AI which has a human level of cognitive function such as reasoning.
- General AI has the ability of the programme to perform a different kind of tasks just like a humane does.
- Examples : Advanced Robotics (Expecting)

3. Super AI or Hypothetical AI

- This is the third stage of AI (***Machine Consciousness***)
- Super AI system would be able to surpass all human capabilities.

- This would include ability to think, decision making, taking rational decisions, make judgments, plan and even includes building emotional relationships.
- Development of this type of AI in real is still World changing task.
- This kind of AI we see in science fiction movies, like the robots from Star Wars or super computers in Terminator, Transformers, Matrix, I- robot etc.,



4.Reactive Machine AI

- Reactive Machines perform basic operations.
- This level of A.I. is the simplest.
- This system does not store memories or past experiences for future actions.
- These machines only focus on current scenarios and react on it as per possible best action.
- This kind of AI react to some input with some output.
- There is no learning occurs.
- Example : Spam filters in e-mail, IBM's Deep blue system, Google's AlphaGo

5. Limited Memory AI

- Limited memory machines can store past experiences or some data for a short period of time.
- These machines can use stored data for a limited time period only.
- This kind of AI has the ability to store previous data and use that data to make better predictions.

- Example: Self driving cars- These cars can store recent speed of nearby cars, the distance of the other cars, speed limit, and other information to navigate the road.
- Limited Memory A.I. works in two ways:
  - A team continuously trains a model on new data.
  - The A.I. environment is built in a way where models are automatically trained and renewed upon model usage and behavior.

6. Theory of Mind AI

- These are only in their beginning phases.
- This AI begins to interact with thoughts and emotions of humans.
- Fields of study tackling this issue include ***Artificial Emotional Intelligence*** and developments in the theory of decision making.
- Example: Sophia, a humanoid robot is able to see emotions and respond appropriately.

7. Self Awareness AI

- In some distant future, perhaps A.I. becomes self-aware.
- In this AI, machines are not only aware of emotions and mental status of others, but also their own sentiments.
- These machines will be smarter than human mind.
- This kind of A.I. exists only in story, and, as stories often do, instills both immense amounts of hope and fear into audiences.
- A self-aware intelligence beyond the human has an ***independent intelligence***.

1.4 FOUNDATIONS OF AI / FIELDS OF AI

1. **Philosophy**

   Logic, methods of reasoning, mind as physical system, foundations of learning, language, rationality.

   Foundational issues (can a machine think?), issues of knowledge and believe, mutual knowledge.

   - How does the mind arise from a physical brain?
   - Where does knowledge come from?
   - How does knowledge lead to action?

2. **Psychology/Cognitive Science**

   Problem solving skills, how do people behave, perceive, Process cognitive information, and represent knowledge.

   - How do humans and animals think and act?

3. **Mathematics & Statistics**

   Formal representation and proof, algorithms, computation,(un) decidability, (in) tractability, modeling uncertainty, learning from data.

- What are the formal rules to draw valid conclusions?
- What can be computed?
- How do we reason with uncertain information?

4. **Economics**
   Utility, decision theory, rational economic agents.
   - How should we make decisions ?
   - How should we do this?
5. **Neuroscience**
   Brain architecture, Neurons as information processing units.
   - How do brains process information?
6. **Computer Science & Engineering**
   Complexity theory, algorithms, logic and inference, programming languages, and system building,
   - How can we build fast and efficient computer?
7. **Control theory**
   Design system that maximize an objective function over time.
   - How can aircrafts operate under their own control?
8. **Linguistics**
   Knowledge representation, grammars, computational linguistics or natural language processing
   - How does language relate to thought?

1.5 HISTORY OF AI / EVOLUTION OF AI

1950 :**TURING TEST** - Mr.Alan Turing, a mathematician, developed Turing test as a measure of machine intelligence.
1956 :-**BIRTH OF AI** -John McCarthy introduced the term AI. First AI boom.
1959 : **AI LAB** – The first AI lab was established at MIT, Cambridge.
1966 :**ELIZA** - First chatbot, simulates conversation.
1970s:AI WINTER 1 - After the boom of early research, there was a pause.
1980 – 1990:Second AI boom.
1990s:AI WINTER 2 – Interest drops.
1997 :**DEEP BLUE** -Chess computer deep blue wins against chess World champion Garri Kasperov.
1999 :**Robot pet dog** – SONY launches the first robot pet dog AIBO.
2002 :**ROBOTIC VACUUM CLEANER** – The first robotic vacuum cleaner ROOMBA vacuums the floor while navigating and avoiding obstacles.
2005 :**HONDA'S ASIMO ROBOT** – An AI humanoid robot, is able to walk as fast as a human.

2009 :AUTONOMOUS CAR – Google builds WAYMO autonomous car

2010 :**APPLE'S SIRI** - Intelligent voice assistant is integrated into the iPhone 4s.

2011 :**IBM'S WATSON** – Question answering computer Watson wins first place on TV show jeopardy.

2014 :AMAZON'S ALEXA – Amazon launched Echo, which includes Alexa Virtual assistant.

2015 :TESLA AUTONOMOUS CAR –Tesla Motors announced its first version of Autopilot.

2016 :**SOPHIA HUMANOID ROBOT** – World's first ever robot citizen was developed by Hanson Robotics, Hong Kong.

2017 :**ALPHAGO** – Google's AlphaGo beats the World champion Lee Sedol in the game.

2018 :ALIBABA'S AI MODEL – Scored better than humans in reading and comprehension test at Standford University.

2019 :**ERICA ROBOT –** Robot created in Japan is set to become news anchor on national Television.

2020 :Microsoft introduced Turing Natural Language Generation, the largest language Model (16 billion parameters language model)

2021 :The Deep learning theory. (Virtual assistants, Autonomous cars, Service and Chat bots, Facial recognition, Shopping and Entertainment)

By 2024, AI will be the integral to every part of the business (25% of the overall spend on AI solutions)

1.6 PROGRAMMING LANGUAGES FOR AI

1. **Python** (1991) - one of the most popular languages for Artificial Intelligence/Machine Learning.This language is easy to learn with simple syntax and lot of frame works and libraries.
2. **Lisp** (1960) - List Processing is a programming language that was designed for easy manipulation of data strings. Developed in 1959 by John McCarthy(Father of AI).
3. **Prolog** (1973) – Programming in logic is a programming language specifically designed for AI development. Its applications include natural language understanding and expert systems
4. **R Programming** (1990) – Comprehensive statistical language that encourages the development of new ideas.
5. **Java** (1995) – Java is also be considered as a good choice for AI development.
6. **C++** (1985) - C++ language provides better handling for the AI model in production. And although C++ might not be the first choice for AI

engineers, it can't be ignored that many of the deep and machine learning libraries are written in C++.

7. **Julia** (2012) – Julia is a high level, high performance and dynamic programming language. Julia is one of the newer languages on the list which includes several features that directly apply to AI programming. Compared to Python, Julia is faster.

1.7 STATE OF THE ART IN AI/APPLICATIONS OF AI/USE CASES OF AI

1. Google Products
2. Social Media
3. Entertainment
4. Speech Recognition
5. E-Commerce
6. Navigation systems
7. Smart Cars
8. Smart Home
9. Surveillance
10. Health care
11. Banking Sector
12. Finance Sector
13. Agriculture
14. Education
15. Space Exploration
16. Customer service chatbots
17. Game Playing
18. Video Games
19. Robotics
20. AI Autopilot

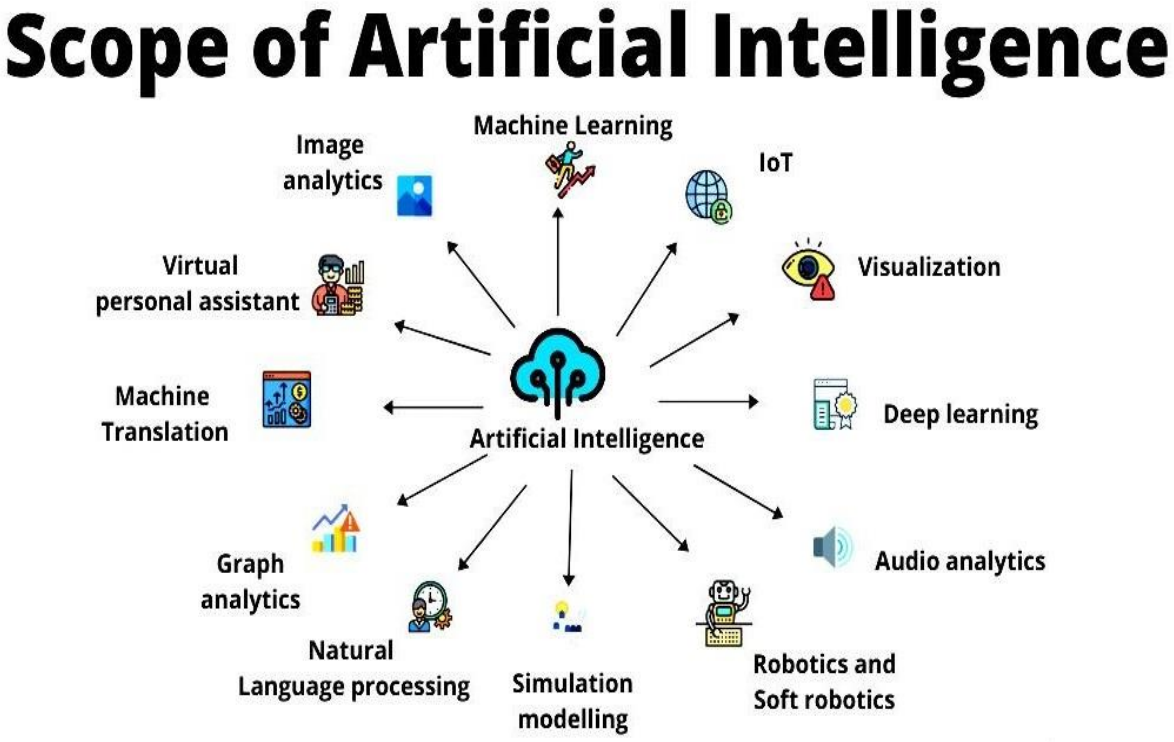
1. **Google Products** – Google search engine is able to give accurate search results and makes recommendations. Few more AI applications include Google lens, Google Maps, Google Cloud Google Photos, Google drive, Google calendar, Google translate, Google chrome, Google news, Gmail(Email spam and Malware filtering), Google assistant, Google conversation (Speech to Text , Text to Speech) Youtube etc.,
2. **Social Media** – **Facebook** and **Instagram** pushes the news feed content as per the user's interest. Face Recognition is also used on Facebook. Concepts like Machine learning and Deep Learning are used to detect facial attributes. **Twitter's** AI identifies hate speech and terroristic languages in tweets. It uses Machine Learning, Deep Learning and Natural Language Processing. **Snapchat** has facial filter lenses. This filter tracks the facial movement of the user to add an animated effect or digital mask and adjust as per the user face.
3. **Entertainment** - **Netflix** and **Amazon Prime**, relies heavily on the info collected by the users. Netflix, Youtube produce a list of preferred movies or content as per the user's interest.
4. **Speech Recognition** - Virtual Personal Assistants like Amazon's Alexa , Apple's Siri, Microsoft's Cortana and OK Google assistance systems helps

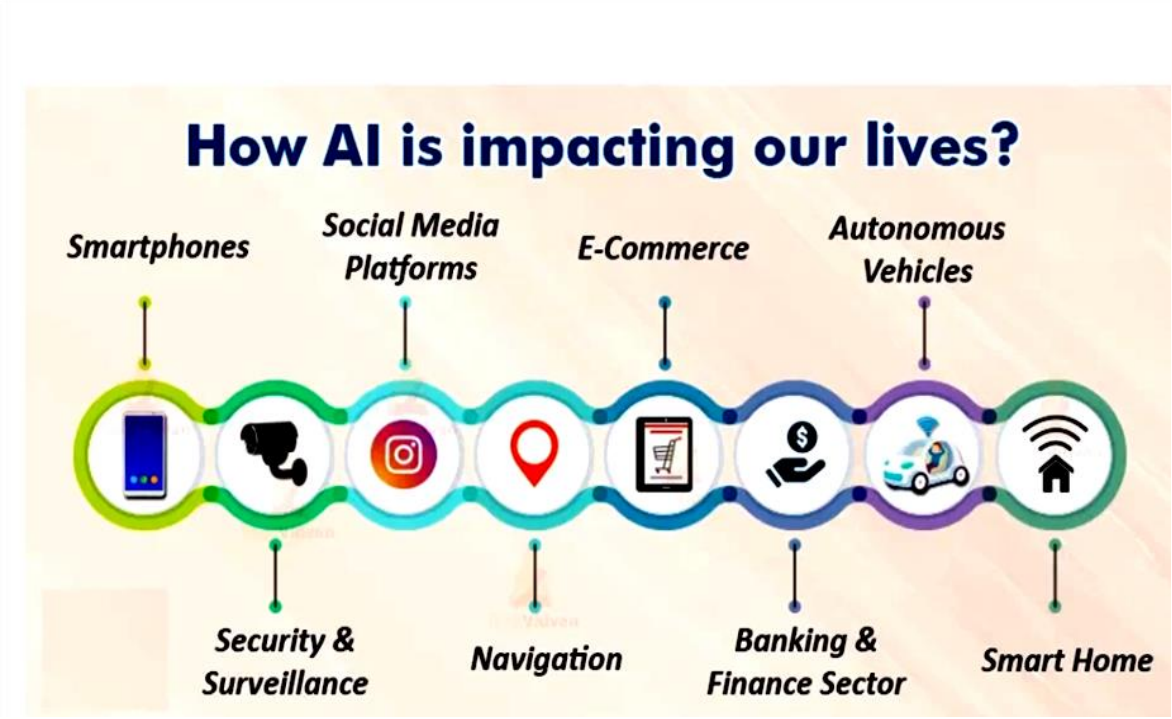
the user to simplify their tasks. These devices use **speech recognition and NLP** to perform a wide range of tasks on our command. These devices can be used to control the devices at the house, play music, book cabs, make phone calls, order favorite food, check the weather conditions, and so on.

5. **E-Commerce/ Retail Business** – Amazon, Flipkart makes right product recommendations based on user preferences.
6. **Navigation systems -** GPS technology can provide users with accurate, timely, and detailed information to improve safety. AI is heavily used by Uber, OLA and many logistics companies to improve operational efficiency, analyze road traffic, and optimize routes..
7. **Smart Cars –** Self-driving cars have been a buzz-term in the AI industry. The development of such autonomous vehicles like TESLA Autopilot, Google's WAYMO vehicles will definitely overtake the transport system.
8. **Smart Home -** Various devices like smart locks, smart switches, ect., are increasingly becoming compatible with various devices. Thermostats and building management systems can help automate building heating and cooling, for instance. In effect, they learn and can predict when to turn our TV, A/C. Geyser, Fan on or off for optimal comfort
9. **Surveillance** – Face recognition tools for security purposes, AI based CCTV camera surveillance are automated and works 24/7 providing real time information.
10. **Health care** – Health care devices like Fitbit or iWatch collects a lot of data like heart rate, oxygen levels , calories burnt etc which can help with early detection, disease diagnosis. This artificial human mind gives personalized medicine and X-ray, CT Scan readings accurately. Personal health care APPS can act as life trainers, reminding about tablets ,exercises or healthy food.
11. **Banking Sector –** AI provides customer support, digital payments virtual assistant chatbots, detect credit card frauds. HDFC Bank has developed an AI based chatbot called EVA (Electronic Virtual Assistant) and IRA (Intelligent Robotic Assistant).
12. **Finance Sector** - Stock market trading is mainly dependent upon the ability to predict the future very accurately. Intelligent systems can gather a huge amount of data in a short span. Machines can learn how to observe patterns in past data and predict how these predicted patterns might repeat in the future.
13. **Agriculture** – AI in agriculture is used for predictive analysis, crop and soil monitoring. Drones are also used for spraying pesticides. AI and Robotics help farmers in finding more efficient ways and strategies to

protect their crops from weeds and floods. **Blue River Technology** developed a robot called **See & Spray,** utilizes computer vision technologies like object detection to observe and spray on plants.

14. **Education** –Automated marking software, easy tracking of information like progress, attendance, activities is possible with AI..This can help the teachers to monitor not just the academic but also the psychological, mental and physical **condition** of the students but also their all-round development.
15. **Space Exploration** - Unmanned space exploration missions like the Mars Rover, which is already present on the red planet. The rover robot is working on autonomous targeting of cameras to perform investigations on Mars planet.
16. **Customer service chatbots -** The more advanced customer service chatbots are able to extract information from the site and present the information to the user. This uses Natural Language Understanding (NLU), Natural Language Processing(NLP).
17. **Game Playing** – Game Playing is an important domain of AI. Games don't require much knowledge; the only knowledge needed is to provide the rules, legal moves and the conditions of winning or losing the game. **IBM's DEEP BLUE** became the first chess computer program to defeat the world champion Garry Kasparov in a chess match. **IBM WATSON** is a robust cloud-powered, AI-based platform; won the game of Jeopardy. **Google's AlphaGo** beats the World champion Lee Sedol in the game.
18. **Video Games** – Human like intelligence in video games serves to enhance the game-player experience. The actions taken by the opposite person are unexpected as the game is designed in such a way that the opponents are enough trained and never repeat the same mistakes.
19. **Robotics** -Robots are designed to perform repetitive tasks with increased speed in an efficient manner. Robots with AI technology can be used for Carrying goods in hospitals, factories, and warehouses, Cleaning offices(Robot Vacuum cleaner) and large equipment etc.,Sophia, a humanoid robot is the best example of AI technology.
20. **AI Autopilot –** This is one of the early use cases of AI technology. As per the reports, the average flight of an Aeroplane involves 5-7 minutes of human steering during take-off and landing of the plane. The remaining operation is in autopilot mode.


Scope of Artificial Intelligence
Machine Learning
Image analytics
IoT
Virtual personal assistant
Visualization
Machine Translation
Artificial Intelligence
Deep learning
Graph analytics
Audio analytics
Natural Language processing
Simulation modelling
Robotics and Soft robotics


How AI is impacting our lives?
Smartphones
Social Media Platforms
E-Commerce
Autonomous Vehicles
Security & Surveillance
Navigation
Banking & Finance Sector
Smart Home

INTELLIGENT AGENTS

1.8 AGENTS & ENVIRONMENTS

An AI system can be defined as the study of the rational agent and its environment. The agents sense the environment through sensors and act on their environment through actuators.

Definition: "An intelligent agent can be anything which perceives its environment through sensors and act upon that environment through actuators or effectors".

In simple, an agent senses the environment and takes actions autonomously in order to achieve goals.

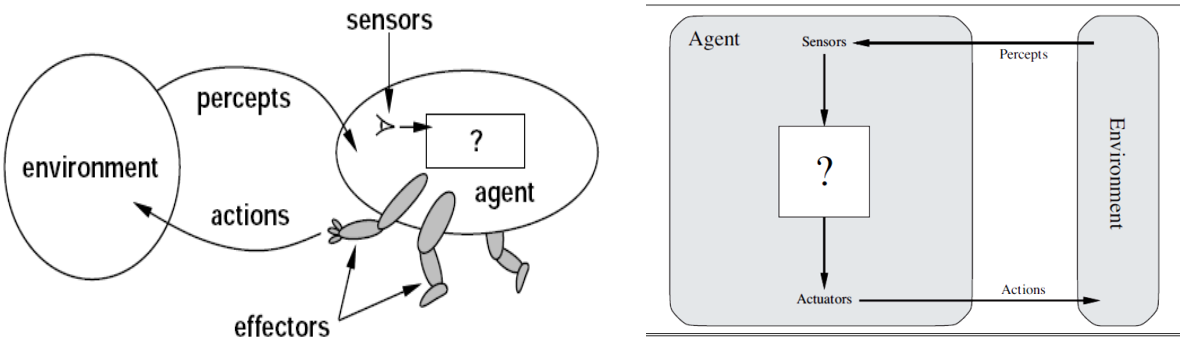
An agent runs in the cycle of **perceiving, thinking and acting**.

An Agent can be a human agent or robot agent or software agent.

- **Human-Agent:** A human agent has eyes, ears, skin, taste buds and other organs for sensors and hand, legs, vocal tract work for actuators.
- **Robotic Agent:** A robotic agent can have cameras, infrared range finder, NLP for sensors and various motors , grippers, wheels, lights, speakers for actuators.
- **Software Agent:** Software agent can have keystrokes, file contents, network packet as sensory input and act on those inputs and display output on the screen.

Hence the world around us is full of agents such as thermostat, cellphone, camera, and even we are also agents.

Examples : AI assistants like **Ok Google, Amazon's Alexa Apple's Siri** use sensors to perceive a request made by the user and the automatically collect data from the internet without the user's help. They can be used to gather information about its perceived environment such as weather and time.



Sensor: Sensor is a device which detects the change in the environment and sends the information to other electronic devices. An agent observes its environment through sensors. A Sensor can be IR sensor, Voice sensor etc.,

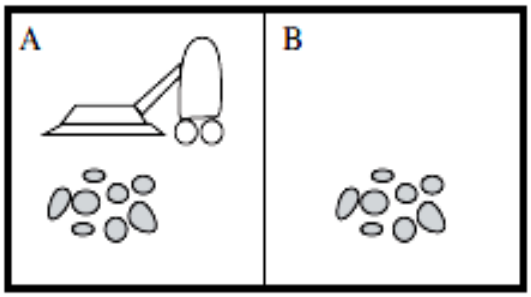
Actuators: Actuators are the component of machines that converts energy into motion. The actuators are only responsible for moving and controlling a system. An actuator can be an electric motor, gears, rails, etc.

Effectors: Effectors are the devices which affect the environment. Effectors can be legs, wheels, arms, fingers, wings, fins, and display screen.

Example : Vacuum cleaner world with just two locations

Percepts : Location (A or B)
Status (clean, dirty)
Actions : Left, Right, Suck, NoOp
function Vacuum –Agent([location, status]) returns an action

- *if* status = dirty *then* return suck
- *else if* location =A *then* return Right
- *else if* location = B *then* return Left



A vacuum-cleaner world with just two locations.

Percept sequence	Action
[A, Clean]	Right
[A, Dirty]	Suck
[B, Clean]	Left
[B, Dirty]	Suck
[A, Clean], [A, Clean]	Right
[A, Clean], [A, Dirty]	Suck
⋮	⋮
[A, Clean], [A, Clean], [A, Clean]	Right
[A, Clean], [A, Clean], [A, Dirty]	Suck
⋮	⋮

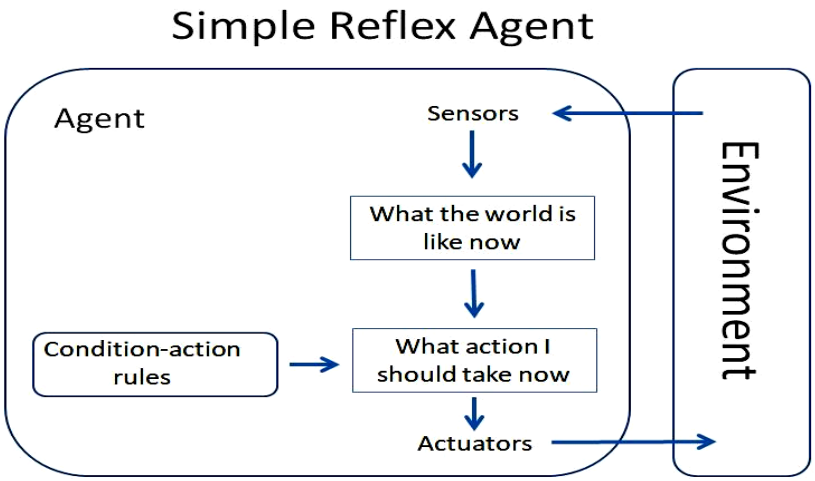
Partial tabulation of a simple agent function for the vacuum-cleaner world

1.9 STRUCTURE OF AGENTS/ TYPES OF AGENT PROGRAM

- The job of AI is to design an agent program that implements the **agent function " f "**
- The agent function maps from percept histories to actions.
  - **[$f: P^* \rightarrow A$]**
- The structure of an intelligent agent is a combination of architecture and agent program. It can be viewed as
  - ***Agent = Architecture + Program***
- The agent program runs on the physical architecture to produce " f "
- The architecture is the combination of sensors & actuators.
- If the program is going to recommend actions like "walk", the architecture should have "legs".
- Following are the main three terms involved in the structure of an AI agent:
  - **Architecture:** Architecture is machinery that an AI agent executes on.
  - **Agent Function:** Agent function is used to map a percept to an action.
  - **Agent program:** Agent program is an implementation of agent function. An agent program executes on the physical architecture to produce function
- Intelligent agents are grouped in to five classes based on their degree of perceived intelligence and capability. All these agents can improve their performance and generate better action over the time.
- Types of Agent Program
  1. Simple reflex agent
  2. Model based reflex agent
  3. Goal based agent
  4. Utility based agent
  5. Learning agent

1.9.1. Simple reflex agent

- The Simple reflex agents are the simplest agents.
- These agents take decisions on the basis of the current percepts and ignore the rest of the percept history.
- These agents only succeed in the **fully observable environment.**
- The Simple reflex agent does not consider any part of percepts history during their decision and action process.
- The agent works on **Condition-action rule (if-then rule)** i**.e., if the condition is true then action is taken else not.**
- Examples : A Room Cleaner agent works only if there is dirt in the room.
  In a room, **if** it is dark. **then** turn on lights.
  In a room ,**if** temperature is high , **then** switch on A/C.
  If car-in- front is braking, **then** initiate braking.(after receiving the visual input, some processing is done to establish action)
  If it is cloudy**, then** take umbrella or rain coat



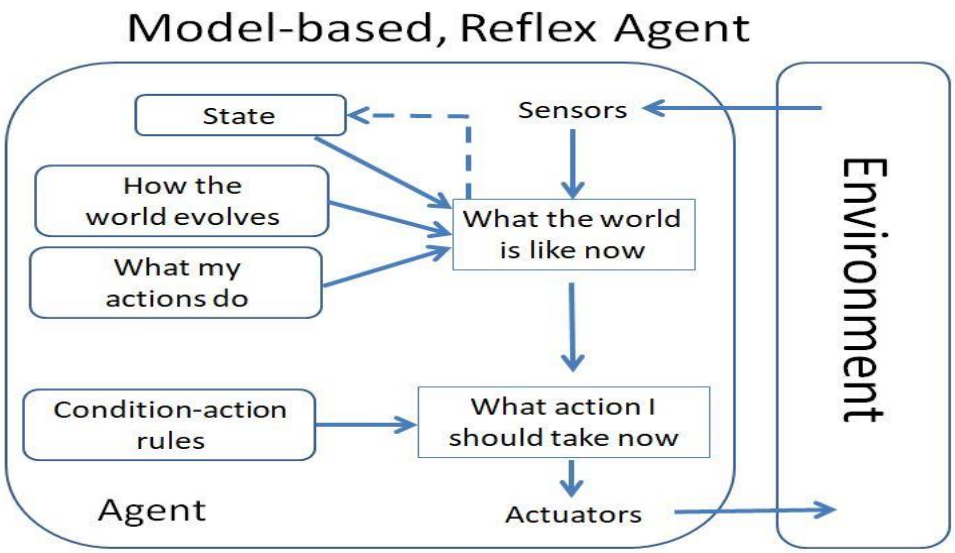

```
Function SIMPLE-REFLEX-AGENT(percept ) returns an action
    persistent: rules, a set of condition–action rules

    state←INTERPRET-INPUT(percept )
    rule←RULE-MATCH(state, rules)
    action ←rule.ACTION
    return action
```

- Problems for the simple reflex agent design approach:
  - They have very limited intelligence
  - Mostly rules are too big to generate and to store.
  - If there is any change in environment, the whole set of rules should be updated.

1.9. 2.Model based Reflex Agent

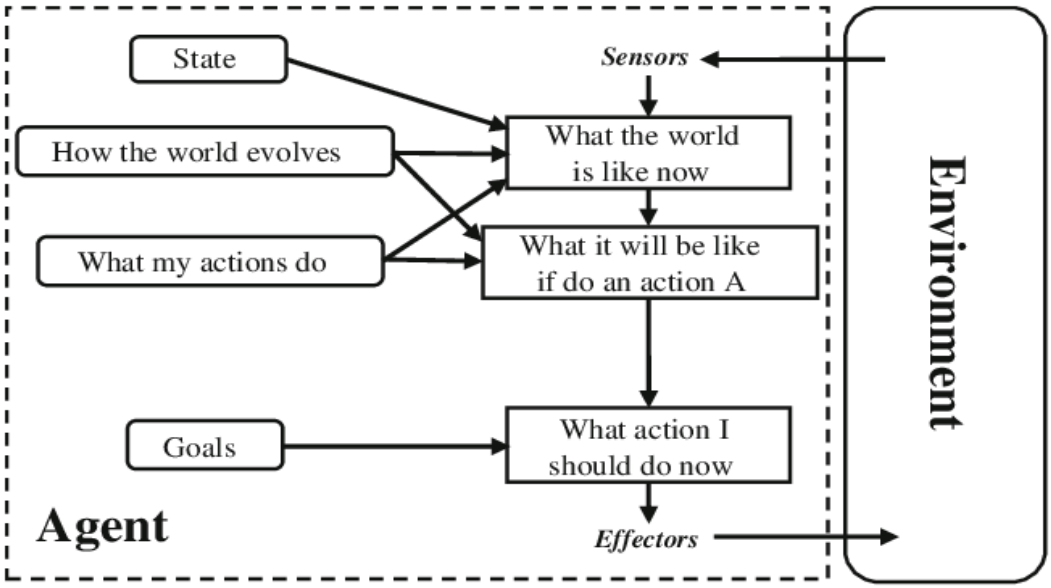
- It can handle **partially observable environment**, & track the situation.
- It works by finding a rule whose condition matches the current situation.
- This agent does not take the actions immediately. It check the history.
- A model-based agent has two important factors:
  - **Model:** It is knowledge about "how things happen in the world," so it is called a Model-based agent.
  - **Internal State:** It is a representation of the current state based on percept history.
- These agents have the model, "which is knowledge of the world" and based on the model they perform actions.
- Updating the agent state requires information about:
  - How the world evolves
  - How the agent's action affects the world.



function MODEL-BASED-REFLEX-AGENT(percept) **returns** an action
persistent: state, the agent's current conception of the world state
model , a description of how the next state depends on current state and action
rules, a set of condition–action rules
action, the most recent action, initially none

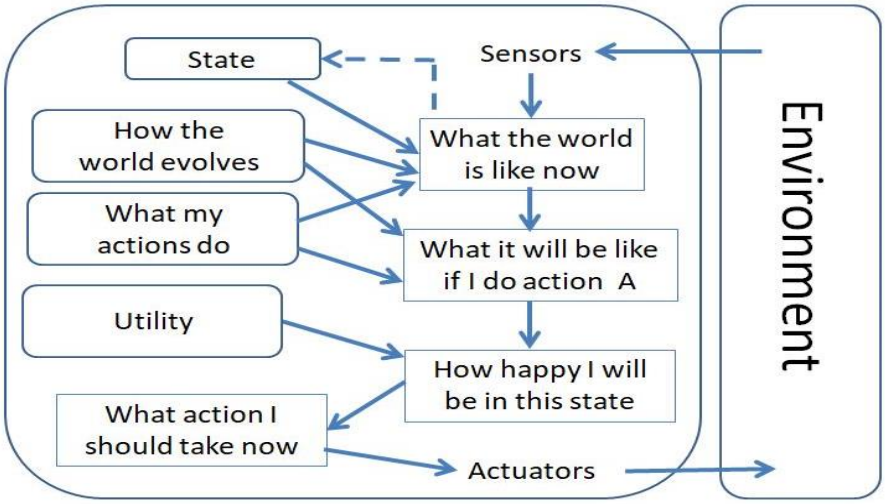
state←UPDATE-STATE(state, action, percept ,model)
rule←RULE-MATCH(state, rules)
action ←rule.ACTION
return action

1.9.3. Goal based agent



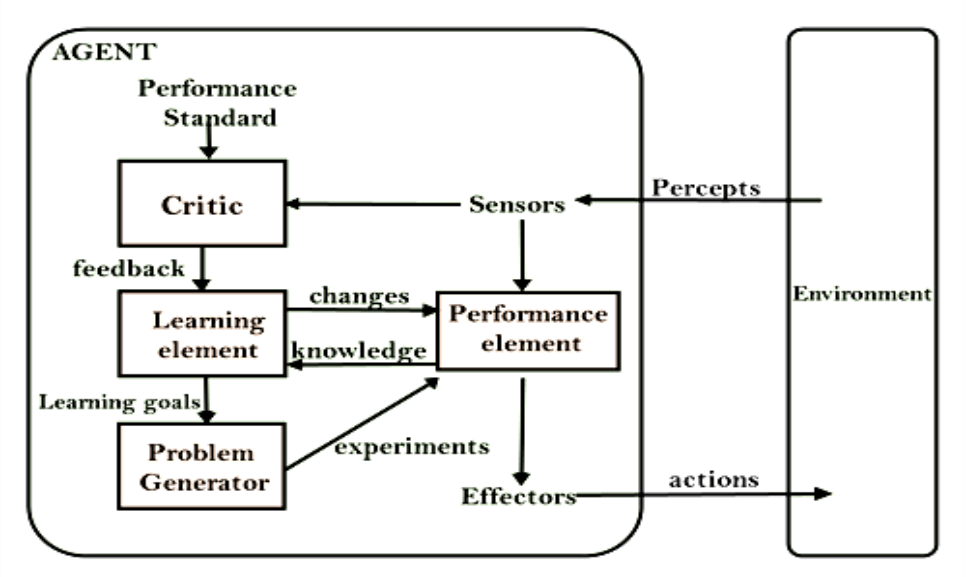
- This agent is expansion of model based agent with " goal" information.
- This is the example of supervised learning.
- Knowing something about the current state of the environment is not always enough to decide what to do.
- For example, at a road junction, the taxi can turn left, turn right, or go straight on. The correct decision depends on where the taxi is trying to reach the destination i.e., goal.
- These kinds of agents take decisions based on how far they are currently from their **goal** (which describes **desirable situations**).
- They choose an action, so that they can achieve the goal.
- Their every action is intended to reduce its distance from the goal.
- This allows the agent a way to choose among multiple possibilities, selecting the one which reaches a goal state.
- These agents may have to consider a long sequence of possible actions before deciding whether the goal is achieved or not.
- These considerations of different scenario are called **searching and planning**, which makes an agent proactive.
- The goal-based agent's behavior can easily be changed.

1.9. 4. Utility based agent



- These agents are similar to the goal-based agent but provide an extra component of utility measurement which makes them different by providing a measure of success at a given state.
- Utility-based agent act based not only goals but also the best way to achieve the goal.
- The Utility-based agent is useful when there are multiple possible alternatives, and an agent has to choose in order to perform the best action.
- The utility function maps each state to a real number to check how efficiently each action achieves the goals.

1.9. 5. Learning agent



- A learning agent in AI is the most advanced type of agent which can learn from its past experiences, or it has learning capabilities.
- It starts to act with basic knowledge and then able to act and adapt automatically through learning.
- A learning agent has mainly four conceptual components, which are:
    a. **Learning element (When to do What?) :** It is responsible for making improvements by learning from environment
    b. **Critic (Try to reduce errors) :** Learning element takes feedback from critic which describes that how well the agent is doing with respect to a fixed performance standard.
    c. **Performance element (How to do everything?):** It is responsible for selecting external action
    d. **Problem generator:** This component is responsible for suggesting actions that will lead to new and informative experiences.
- Hence, learning agents are able to learn, analyze performance, and look for new ways to improve the performance.

1.10 INTERACTING AGENTS/ DESIGN OF AGENTS

Example 1: How do we design an agent that can wipe the windshield of a car when needed?

1) Goals – Keep windshield clean & maintain visibility
2) Percepts – Raining, Dirty
3) Sensor – Camera (moist. dirt sensor)
4) Effectors – Wiper (left, right, back)
5) Actions – Off, slow, medium, fast
6) Environment – Inner city, highways, weather.

Example 2: How do we design Collision Avoidance Agent in a vehicle (CAA)

1) Goals – Avoid running into obstacles
2) Percepts – Obstacle distance, velocity, trajectory
3) Sensor – Vision, proximity sensor
4) Effectors – Steering wheel, accelerator, brakes, horn, headlights.
5) Actions – Steer, speed up, brake, blow horn, signal(lights)
6) Environment – Highway

Example 3 :How do we design Lane Keeping Agent in a vehicle (LKA)

1) Goals – Stay in current lane
2) Percepts – Lane centre, lane bourndaries
3) Sensor – Vision
4) Effectors – Steering wheel, accelerator, brakes
5) Actions – Steer, speed up, brake
6) Environment – Highway

1.11 GOOD BEHAVIOUR: THE CONCEPT OF RATIONALITY

- Intelligent agents must SENSE, must ACT, must be AUTONOMOUS and must be RATIONAL.
- Following are the main four rules for an AI agent:
  - **Rule 1:** An AI agent must have the ability to perceive the environment.
  - **Rule 2:** The observation must be used to make decisions.
  - **Rule 3:** Decision should result in an action.
  - **Rule 4:** The action taken by an AI agent must be a rational action.
- AI is about developing/building rational agents.
- A **rational agent** is one that does the right thing.
- **Definition** : For each possible percept sequence, a rational agent should select an action that is expected to maximize its performance measure, given the evidence provided by the percept sequence and whatever built-in knowledge the agent has.
- Example **–** In an exam, maximize marks based on the questions on the paper & your knowledge.
- **Rationality** at a given time depends on four things
  1. The performance measure defining the criterion of success.
  2. The agent's prior knowledge of the environment.
  3. The actions that the agent can perform.
  4. The agent's percept sequence up to now.

1.12 THE NATURE OF ENVIRONMENTS

1.12.1 Specifying the Task Environment [PEAS]

- In designing an agent, the first step must always be to specify the task environment as fully as possible.
- Task environments are the problems, while the rational agents are the solutions.
- **PEAS** (Performance measure, Environment, Actions, Sensors) is used to describe the task environment.
- **Example 1: For an autonomous car agent type**
  - ✓ **Performance Measure** – Correct destination, Minimum fuel consumption, minimum trip time and cost, zero violation of traffic rules, maximum safety and comfort trip.
  - ✓ **Environment** – Variety of roads, traffic lights, other vehicles, pedestrians, animals, road works, interaction with the customers.
  - ✓ **Actions/Actuators (outputs)** - Steering, Braking, accelerator, gear shifting, signal, horn, wind shield wiper, display to communicate with the customers.

- ✓ **Sensors (inputs)** - Cameras, GPS, sonar (sound navigation and ranging) speedometer, odometer, detect other vehicles, road condition, engine sensors.

- **Example 2: For an iRobot Roomba Vacuum Cleaner,**
  - ✓ **Performance Measure** – Cleanliness, Efficiency, Low noise, More battery life, Less electricity consumption, Security, Fast cleaning,
  - ✓ **Environment** – Room, Table, Carpet, Tiles floor, Wooden floor
  - ✓ **Actions/Actuators (outputs)** – Wheels, Different brushes for cleaning, Vacuum extractor.
  - ✓ **Sensors (inputs)** – Camera, Dirt sensor, Location sensor,Bump sensor ,IR wall sensor, Cliff sensor(to identify stairs or steep drops or balcony)

1.12.2 Properties of task environment/ Features of environment/Agents environment in AI

- An environment is everything in the World which surrounds the agent but it is not a part of an agent itself.
- An environment can be described as a situation in which agent is present.
- An environment can have various features from the point of view of an agent.
  1. Fully observable vs. Partially Observable
  2. Static vs. Dynamic
  3. Discrete vs. Continuous
  4. Deterministic vs. Stochastic
  5. Single-agent vs. Multi-agent
  6. Episodic vs. sequential

1. Fully observable vs Partially Observable

- If an agent sensor can sense or access the complete state of an environment at each point of time then it is **a fully observable** environment, else it is **partially observable**.
- A fully observable environment is easy as there is no need to maintain the internal state to keep track history of the world.
- An agent with no sensors in all environments then such an environment is called as **unobservable**.
- Example : Fully observable – vacuum cleaner with dirt & location sensors, chess with a clock, Crossword puzzle.
  Partially observable – Taxi driving.vaccum cleaner with single sensor.

2. Deterministic vs Stochastic

- If an agent's current state and selected action can completely determine the next state of the environment, then such environment is called a deterministic environment.
- A stochastic environment is random in nature and cannot be determined completely by an agent.

- In a deterministic, fully observable environment, agent does not need to worry about uncertainty. -
- Example : Deterministic – Image Analysis Crossword puzzle, Chess with a clock.
  Stochastic – Taxi driving, Medical diagnosis.

3. Episodic vs Sequential

- In an episodic environment, there is a series of one-shot actions, and only the current percept is required for the action.
- However, in Sequential environment, an agent requires memory of past actions to determine the next best actions.
- Example: Episodic – Part picking robot, Image analysis
  Sequential – Crossword puzzle, Chess game with a clock,Taxi driving, Medical diagnosis.

4. Single-agent vs Multi-agent

- If only one agent is involved in an environment, and operating by itself then such an environment is called single agent environment.
- However, if multiple agents are operating in an environment, then such an environment is called a multi-agent environment.
- The agent design problems in the multi-agent environment are different from single agent environment.
- Example: Single agent –Crossword puzzle, Image analysis, Part picking Robot.
  Multi-agent – Chess game, Taxi driving

5. Static vs Dynamic

- If the environment can change itself while an agent is deliberating then such environment is called a dynamic environment else it is called a static environment.
- Static environments are easy to deal because an agent does not need to continue looking at the world while deciding for an action.
- However for dynamic environment, agents need to keep looking at the world at each action.
- Example: Static – Crossword puzzle
  Dynamic – Taxi driving

6. Discrete vs Continuous

- If in an environment there are a finite number of percepts and actions that can be performed within it, then such an environment is called a discrete environment else it is called continuous environment.
- Example: Discrete –Crossword puzzle, Chess game
  Continuous –Taxi driving.

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"Artificial Intelligence will reach human levels by around 2029. Follow that out further to, say, 2045, we will have multiplied the intelligence, the human biological machine intelligence of our civilization a billion-fold. " – Raymond Kurzweil, **Director of Engineering, Google.**