Artificial Intelligence

Artificial Intelligence is an attempt to make a computer, a robot, or other piece of technology 'think' and process data in the same way as we humans do. AI therefore has to study how the human brain 'thinks', learns, and makes decisions when it tries to solve problems or execute a task.

What is Artificial Intelligence?

• The art of creating machines that perform functions that require intelligence when performed by people.

• The branch of computer science that is concerned with the automation of intelligent behaviour.

In today's world, technology is growing very fast, and we are getting in touch with different new technologies day by day.

Here, one of the booming technologies of computer science is Artificial Intelligence which is ready to create a new revolution in the world by making intelligent machines. The Artificial Intelligence is now all around us. It is currently working with a variety of subfields, ranging from general to specific, such as self-driving cars, playing chess, proving theorems, playing music, Painting, etc.

AI is one of the fascinating and universal fields of Computer science which has a great scope in future. AI holds a tendency to cause a machine to work as a human.

Artificial Intelligence is composed of two words **Artificial** and **Intelligence**, where Artificial defines *"man-made,"* and intelligence defines *"thinking power"*, hence AI means *"a man-made thinking power."*

So, we can define AI as:

"It is a branch of computer science by which we can create intelligent machines which can behave like a human, think like humans, and able to make decisions."

Artificial Intelligence exists when a machine can have human based skills such as learning, reasoning, and solving problems

With Artificial Intelligence you do not need to preprogram a machine to do some work, despite that you can create a machine with programmed algorithms which can work with own intelligence, and that is the awesomeness of AI.

Why Artificial Intelligence?

Before Learning about Artificial Intelligence, we should know that what is the importance of AI and why should we learn it. Following are some main reasons to learn about AI:

- o With the help of AI, you can create such software or devices which can solve real-world problems very easily and with accuracy such as health issues, marketing, traffic issues, etc.
- o With the help of AI, you can create your personal virtual Assistant, such as Cortana, Google Assistant, Siri, etc.
- o With the help of AI, you can build such Robots which can work in an environment where survival of humans can be at risk.
- o AI opens a path for other new technologies, new devices, and new Opportunities.

Advantages of Artificial Intelligence

Following are some main advantages of Artificial Intelligence:

- o **High Accuracy with less errors:** AI machines or systems are prone to less errors and high accuracy as it takes decisions as per pre-experience or information.
- o **High-Speed:** AI systems can be of very high-speed and fast-decision making, because of that AI systems can beat a chess champion in the Chess game.
- o **High reliability:** AI machines are highly reliable and can perform the same action multiple times with high accuracy.
- o **Useful for risky areas:** AI machines can be helpful in situations such as defusing a bomb, exploring the ocean floor, where to employ a human can be risky.
- o **Digital Assistant:** AI can be very useful to provide digital assistant to the users such as AI technology is currently used by various E-commerce websites to show the products as per customer requirement.
- o **Useful as a public utility:** AI can be very useful for public utilities such as a self-driving car which can make our journey safer and hassle-free, facial recognition for security purpose, Natural language processing to communicate with the human in human-language, etc.

Disadvantages of Artificial Intelligence

Every technology has some disadvantages, and the same goes for Artificial intelligence. Being so advantageous technology still, it has some disadvantages which we need to keep in our mind while creating an AI system. Following are the disadvantages of AI:

- **High Cost:** The hardware and software requirement of AI is very costly as it requires lots of maintenance to meet current world requirements.

- **Can't think out of the box:** Even we are making smarter machines with AI, but still they cannot work out of the box, as the robot will only do that work for which they are trained, or programmed.

- **No feelings and emotions:** AI machines can be an outstanding performer, but still it does not have the feeling so it cannot make any kind of emotional attachment with human, and may sometime be harmful for users if the proper care is not taken.

- **Increase dependency on machines:** With the increment of technology, people are getting more dependent on devices and hence they are losing their mental capabilities.

- **No Original Creativity:** As humans are so creative and can imagine some new ideas but still AI machines cannot beat this power of human intelligence and cannot be creative and imaginative.

• **Views of AI fall into four categories:**

- Systems that act like humans
- Systems that think like humans
- Systems that think rationally
- Systems that act rationally

1. **Acting humanly: The Turing Test**

• Turing Test, proposed by Alan Turing (1950), was designed to provide a satisfactory operational definition of intelligence

• Can machines behave intelligently? ⟹ Can machines think?

• Operational test for intelligent behaviour: the Imitation Game

Turing Test: A computer passes the test if a human interrogator, after posing some written questions, cannot tell whether the written responses comes from a person or from computer.
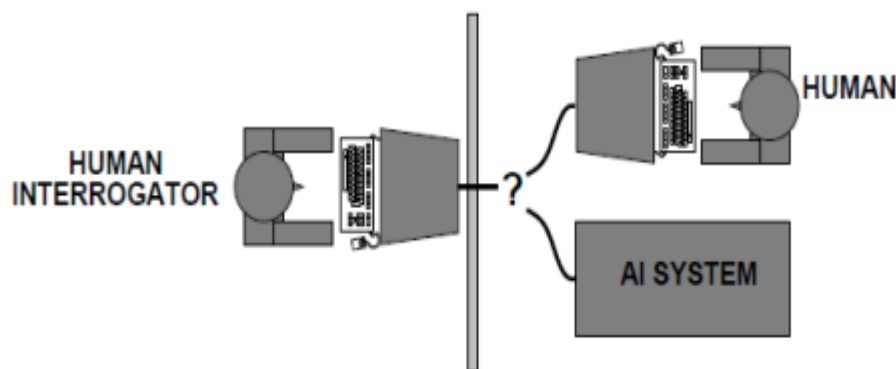
• Generally this test covers: knowledge representation, automated reasoning, natural language understanding, machine learning.

2. **<u>Thinking humanly: Cognitive Science</u>** (study of human brain/mind)

If it is required for machines to act like a human, it is necessary to go through the actual working of human minds.

• The field of cognitive science brings together computer models from AI and experimental techniques from psychology to construct precise and testable theories of the human mind.

• Requires scientific theories of internal activities of the brain

It can be achieved with:

1. Introspection: trying to catch thr thoughts
2. Psychological Experiments: observing a human doing some action.
3. Brain Imaging: observing brain and its actions.

This gains the "near to" similar theory of mind, hence becomes possible to convert human thoughts into computer program.

3. **<u>Thinking rationally: Laws of Thought</u> (Use of Logic)**

• What are correct arguments/thought processes?

• Development of various forms of logic:

> • Modelling Uncertainty

> • Dealing with complexity

• Main obstacles to this approach.

> • First, it is not easy to take informal knowledge and state it in the formal terms required by logical notation, particularly when the knowledge is less than 100% certain.

> • Second, there is a big difference between solving a problem "in principle" and solving it in practice.

4. **<u>Acting rationally: The rational agent approach</u>** (personal best performance)

Rational agents

• An agent is an entity that perceives and acts

• AI concentrates on general principles of rational agents and on components for constructing them.

• Abstractly, an agent is a function from percept histories to actions

• For any given class of environments and tasks, we seek the agent with the best performance.

 • Computational limitations can make perfect rationality unachievable

   ▪ Design best program for given machine resources

Approach:

 • An agent is just something that acts.

• A rational agent is one that acts so as to achieve the best outcome or, when there is uncertainty, the best expected outcome.

• Rational behaviour: doing the right thing

    • The right thing: that which is expected to maximize goal achievement, given the available information

Application of AI (State of Art)
Artificial Intelligence has various applications in today's society. It is becoming essential for today's time because it can solve complex problems with an efficient way in multiple industries, such as Healthcare, entertainment, finance, education, etc. AI is making our daily life more comfortable and fast.

Following are some sectors which have the application of Artificial Intelligence:
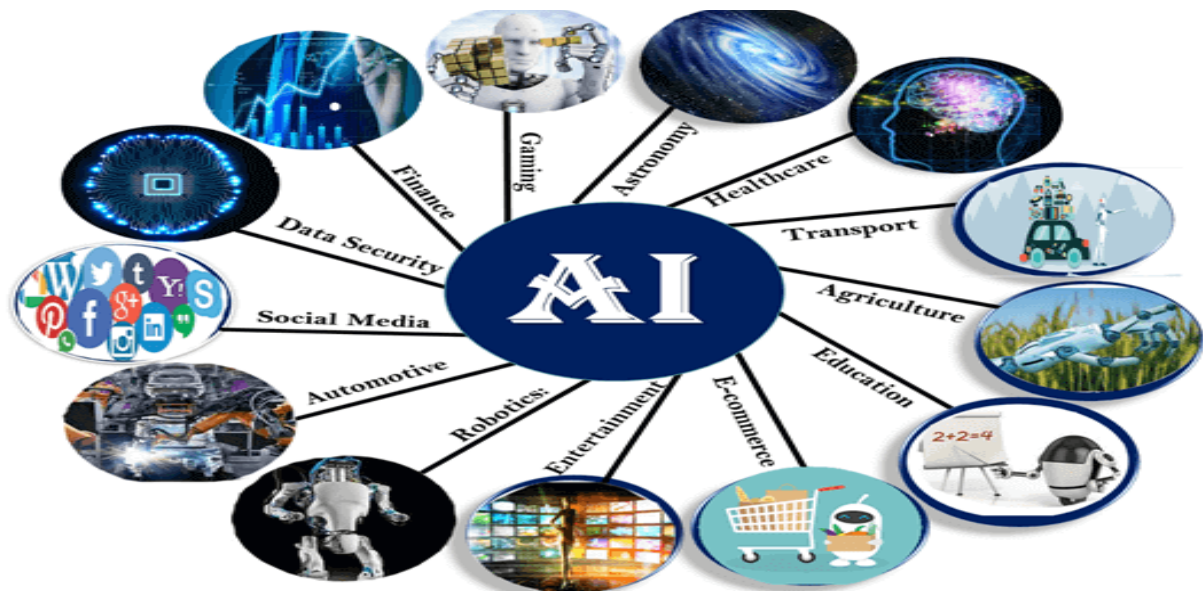
1. AI in Astronomy
   o Artificial Intelligence can be very useful to solve complex universe problems. AI technology can be helpful for understanding the universe such as how it works, origin, etc.

2. AI in Healthcare

- In the last, five to ten years, AI becoming more advantageous for the healthcare industry and going to have a significant impact on this industry.
- Healthcare Industries are applying AI to make a better and faster diagnosis than humans. AI can help doctors with diagnoses and can inform when patients are worsening so that medical help can reach to the patient before hospitalization.

3. AI in Gaming

- AI can be used for gaming purpose. The AI machines can play strategic games like chess, where the machine needs to think of a large number of possible places.

4. AI in Finance

- AI and finance industries are the best matches for each other. The finance industry is implementing automation, chatbot, adaptive intelligence, algorithm trading, and machine learning into financial processes.

5. AI in Data Security

- The security of data is crucial for every company and cyber-attacks are growing very rapidly in the digital world. AI can be used to make your data more safe and secure. Some examples such as AEG bot, AI2 Platform,are used to determine software bug and cyber-attacks in a better way.

6. AI in Social Media

- Social Media sites such as Facebook, Twitter, and Snapchat contain billions of user profiles, which need to be stored and managed in a very efficient way. AI can organize and manage massive amounts of data. AI can analyze lots of data to identify the latest trends, hashtag, and requirement of different users.

7. AI in Travel & Transport

- AI is becoming highly demanding for travel industries. AI is capable of doing various travel related works such as from making travel arrangement to suggesting the hotels, flights, and best routes to the customers. Travel industries are using AI-powered chat bots which can make human-like interaction with customers for better and fast response.

8. AI in Automotive Industry

- Some Automotive industries are using AI to provide virtual assistant to their user for better performance. Such as Tesla has introduced TeslaBot, an intelligent virtual assistant.

- o Various Industries are currently working for developing self-driven cars which can make your journey more safe and secure.

9. AI in Robotics:
- o Artificial Intelligence has a remarkable role in Robotics. Usually, general robots are programmed such that they can perform some repetitive task, but with the help of AI, we can create intelligent robots which can perform tasks with their own experiences without pre-programmed.
- o Humanoid Robots are best examples for AI in robotics, recently the intelligent Humanoid robot named as Erica and Sophia has been developed which can talk and behave like humans.

10. AI in Entertainment
- o We are currently using some AI based applications in our daily life with some entertainment services such as Netflix or Amazon. With the help of ML/AI algorithms, these services show the recommendations for programs or shows.

11. AI in Agriculture
- o Agriculture is an area which requires various resources, labor, money, and time for best result. Now a day's agriculture is becoming digital, and AI is emerging in this field. Agriculture is applying AI as agriculture robotics, solid and crop monitoring, predictive analysis. AI in agriculture can be very helpful for farmers.

12. AI in E-commerce
- o AI is providing a competitive edge to the e-commerce industry, and it is becoming more demanding in the e-commerce business. AI is helping shoppers to discover associated products with recommended size, color, or even brand.

13. AI in education:
- o AI can automate grading so that the tutor can have more time to teach. AI chatbot can communicate with students as a teaching assistant.
- o AI in the future can be work as a personal virtual tutor for students, which will be accessible easily at any time and any place.

Agent 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 an agent is present.

The environment is where agent lives, operate and provide the agent with something to sense and act upon it.

Features of Environment
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
7. Known vs Unknown
8. Accessible vs Inaccessible

1. Fully observable vs Partially Observable:
   o 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**.
   o A fully observable environment is easy as there is no need to maintain the internal state to keep track history of the world.
   o An agent with no sensors in all environments then such an environment is called as **unobservable**.

2. Deterministic vs Stochastic:
   o 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.
   o A stochastic environment is random in nature and cannot be determined completely by an agent.
   o In a deterministic, fully observable environment, agent does not need to worry about uncertainty.

3. Episodic vs Sequential:
   o In an episodic environment, there is a series of one-shot actions, and only the current percept is required for the action.
   o However, in Sequential environment, an agent requires memory of past actions to determine the next best actions.

4. Single-agent vs Multi-agent

- o If only one agent is involved in an environment, and operating by itself then such an environment is called single agent environment.
- o However, if multiple agents are operating in an environment, then such an environment is called a multi-agent environment.
- o The agent design problems in the multi-agent environment are different from single agent environment.

5. Static vs Dynamic:

- o 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.
- o Static environments are easy to deal because an agent does not need to continue looking at the world while deciding for an action.
- o However for dynamic environment, agents need to keep looking at the world at each action.
- o Taxi driving is an example of a dynamic environment whereas Crossword puzzles are an example of a static environment.

6. Discrete vs Continuous:

- o 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.
- o A chess gamecomes under discrete environment as there is a finite number of moves that can be performed.
- o A self-driving car is an example of a continuous environment.

7. Known vs Unknown

- o Known and unknown are not actually a feature of an environment, but it is an agent's state of knowledge to perform an action.
- o In a known environment, the results for all actions are known to the agent. While in unknown environment, agent needs to learn how it works in order to perform an action.
- o It is quite possible that a known environment to be partially observable and an Unknown environment to be fully observable.

8. Accessible vs Inaccessible

- o If an agent can obtain complete and accurate information about the state's environment, then such an environment is called an Accessible environment else it is called inaccessible.

- An empty room whose state can be defined by its temperature is an example of an accessible environment.
- Information about an event on earth is an example of Inaccessible environment.

Rational Agent:

A rational agent is an agent which has clear preference, models uncertainty, and acts in a way to maximize its performance measure with all possible actions.

A rational agent is said to perform the right things. AI is about creating rational agents to use for game theory and decision theory for various real-world scenarios.

For an AI agent, the rational action is most important because in AI reinforcement learning algorithm, for each best possible action, agent gets the positive reward and for each wrong action, an agent gets a negative reward.

Rationality:
The rationality of an agent is measured by its performance measure. Rationality can be judged on the basis of following points:

- Performance measure which defines the success criterion.
- Agent prior knowledge of its environment.
- Best possible actions that an agent can perform.
- The sequence of precepts.

Nature of Environment:

- ❖ Types of Artificial Intelligence:
  Artificial Intelligence can be divided in various types, there are mainly two types of main categorization which are based on capabilities and based on functionally of AI.
- 1) Type-1: Based on Capabilities:
  - ➢ Weak AI or Narrow AI
  - ➢ General AI
  - ➢ Super AI

Weak AI or Narrow AI:

Narrow AI is a type of AI which is able to perform a dedicated task with intelligence. The most common and currently available AI is Narrow AI in the world of Artificial Intelligence.

Apple Siriis a good example of Narrow AI, but it operates with a limited pre-defined range of function.

General AI:

General AI is a type of intelligence which could perform any intellectual task with efficiency like a human.

The idea behind the general AI to make such a system which could be smarter and think like a human by its own.

Currently, there is no such system exist which could come under general AI and can perform any task as perfect as a human.

Super AI:

Super AI is a level of Intelligence of System at which machines could surpass human intelligence, and can perform any task better than human with cognitive properties. It is an outcome of general AI.

2) Type-2 : Based on functionality:
   ➢ Reactive Machines
   ➢ Limited Memory
   ➢ Theory of Mind
   ➢ Self-Awareness

Reactive Machine:

Purely reactive machines are the most basic types of Artificial Intelligence.

Such AI systems do 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.

Limited Memory:

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.

Theory of Mind:

Theory of Mind AI should understand the human emotions, people, beliefs, and be able to interact socially like humans. These types of AI machines are still not developed, but researchers are making lots of efforts and improvement for developing such AI machines.

Self-Awareness:

Self-awareness AI is the future of Artificial Intelligence. These machines will be super intelligent, and will have their own consciousness, sentiments, and self-awareness. These machines will be smarter than human mind.

Structure of Agents:

Agents in Artificial Intelligence

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. An AI agent can have mental properties such as knowledge, belief, intention, etc.

What is an Agent?

An agent can be anything that perceive its environment through sensors and act upon that environment through actuators. An Agent runs in the cycle of **perceiving**, **thinking**, and **acting**. An agent can be:

- o **Human-Agent:** A human agent has eyes, ears, and other organs which work for sensors and hand, legs, vocal tract work for actuators.

- o **Robotic Agent:** A robotic agent can have cameras, infrared range finder, NLP for sensors and various motors for actuators.

- o **Software Agent:** Software agent can have keystrokes, file contents 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, cell phone, camera, and even we are also agents.

Before moving forward, we should first know about sensors, effectors, and actuators.

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.

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.
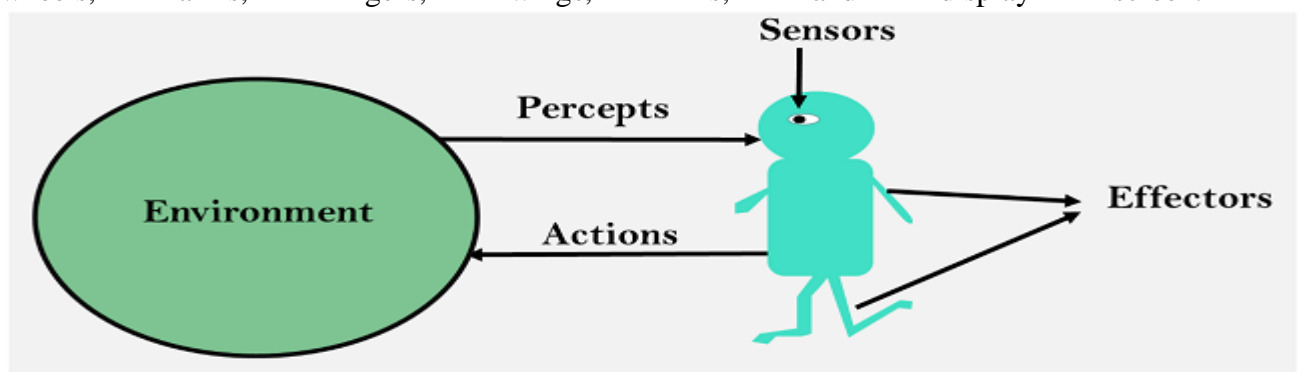
Intelligent Agents:

An intelligent agent is an autonomous entity which act upon an environment using sensors and actuators for achieving goals. An intelligent agent may learn from the environment to achieve their goals. A thermostat is an example of an intelligent agent.

Following are the main four rules for an AI agent:

- o **Rule 1:** An AI agent must have the ability to perceive the environment.
- o **Rule 2:** The observation must be used to make decisions.
- o **Rule 3:** Decision should result in an action.
- o **Rule 4:** The action taken by an AI agent must be a rational action.

Structure of an AI Agent

The task of AI is to design an agent program which implements the agent function. The structure of an intelligent agent is a combination of architecture and agent program. It can be viewed as:

Agent = Architecture + Agent program

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 f.
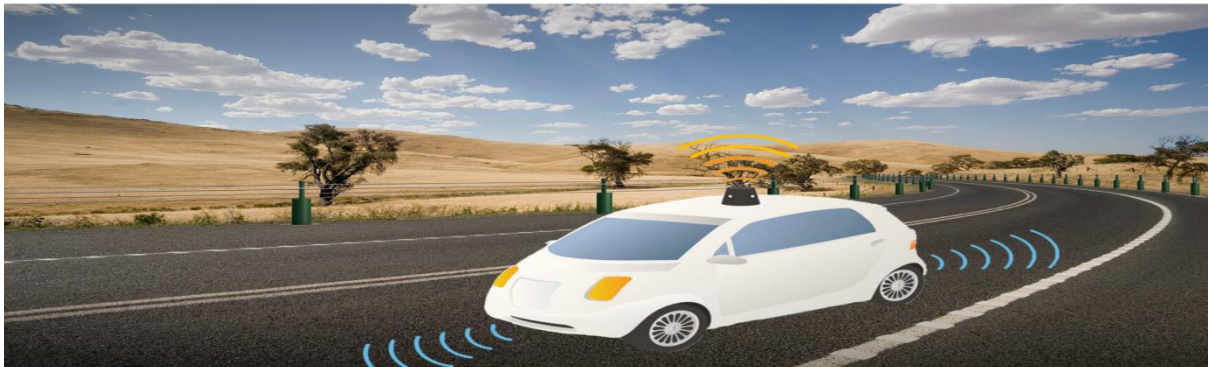
PEAS Representation

PEAS is a type of model on which an AI agent works upon. When we define an AI agent or rational agent, then we can group its properties under PEAS representation model. It is made up of four words:

- o **P:** Performance measure
- o **E:** Environment
- o **A:** Actuators
- o **S:** Sensors

Here performance measure is the objective for the success of an agent's behaviour.

PEAS for self-driving cars:

Let's suppose a self-driving car then PEAS representation will be:

Performance: Safety, time, legal drive, comfort

Environment: Roads, other vehicles, road signs, pedestrian

Actuators: Steering, accelerator, brake, signal, horn

**Sensors:** Camera, GPS, speedometer, odometer, accelerometer, sonar.

Types of AI Agents

Agents can be grouped into 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. These are given below:

- o   Simple Reflex Agent
- o   Model-based reflex agent
- o   Goal-based agents
- o   Utility-based agent
- o   Learning agent

1. Simple Reflex agent:

- o 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.

- o These agents only succeed in the fully observable environment.

- o The Simple reflex agent does not consider any part of percepts history during their decision and action process.

- o The Simple reflex agent works on Condition-action rule, which means it maps the current state to action. Such as a Room Cleaner agent, it works only if there is dirt in the room.

- o Problems for the simple reflex agent design approach:

    - o They have very limited intelligence

    - o They do not have knowledge of non-perceptual parts of the current state

    - o Mostly too big to generate and to store.

   - o Not adaptive to changes in the environment.
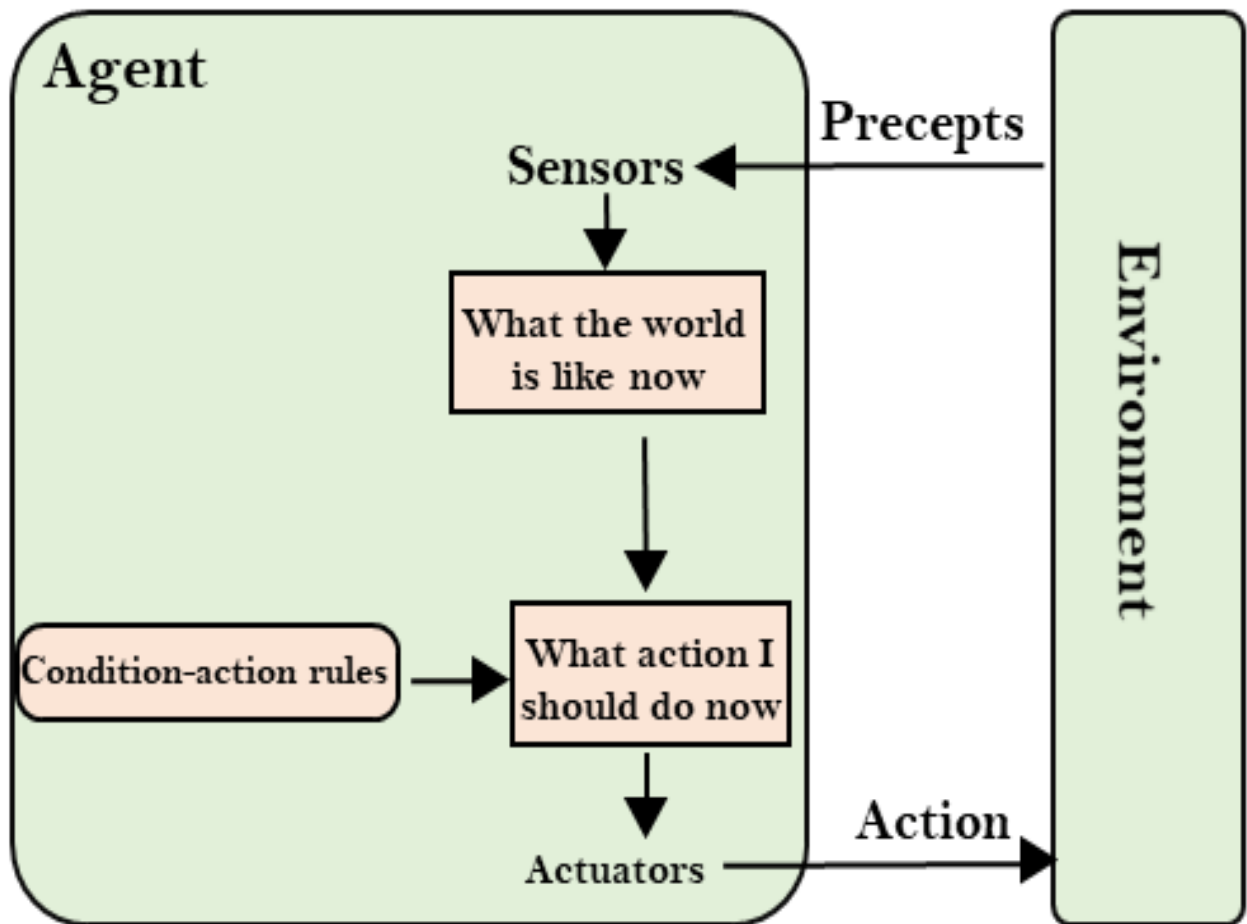
2. Model-based reflex agent

- o The Model-based agent can work in a partially observable environment, and track the situation.
- o A model-based agent has two important factors:
    - o **Model:** It is knowledge about "how things happen in the world," so it is called a Model-based agent.
    - o **Internal State:** It is a representation of the current state based on percept history.
- o These agents have the model, "which is knowledge of the world" and based on the model they perform actions.
- o Updating the agent state requires information about:
    - a. How the world evolves
   - b. How the agent's action affects the world.
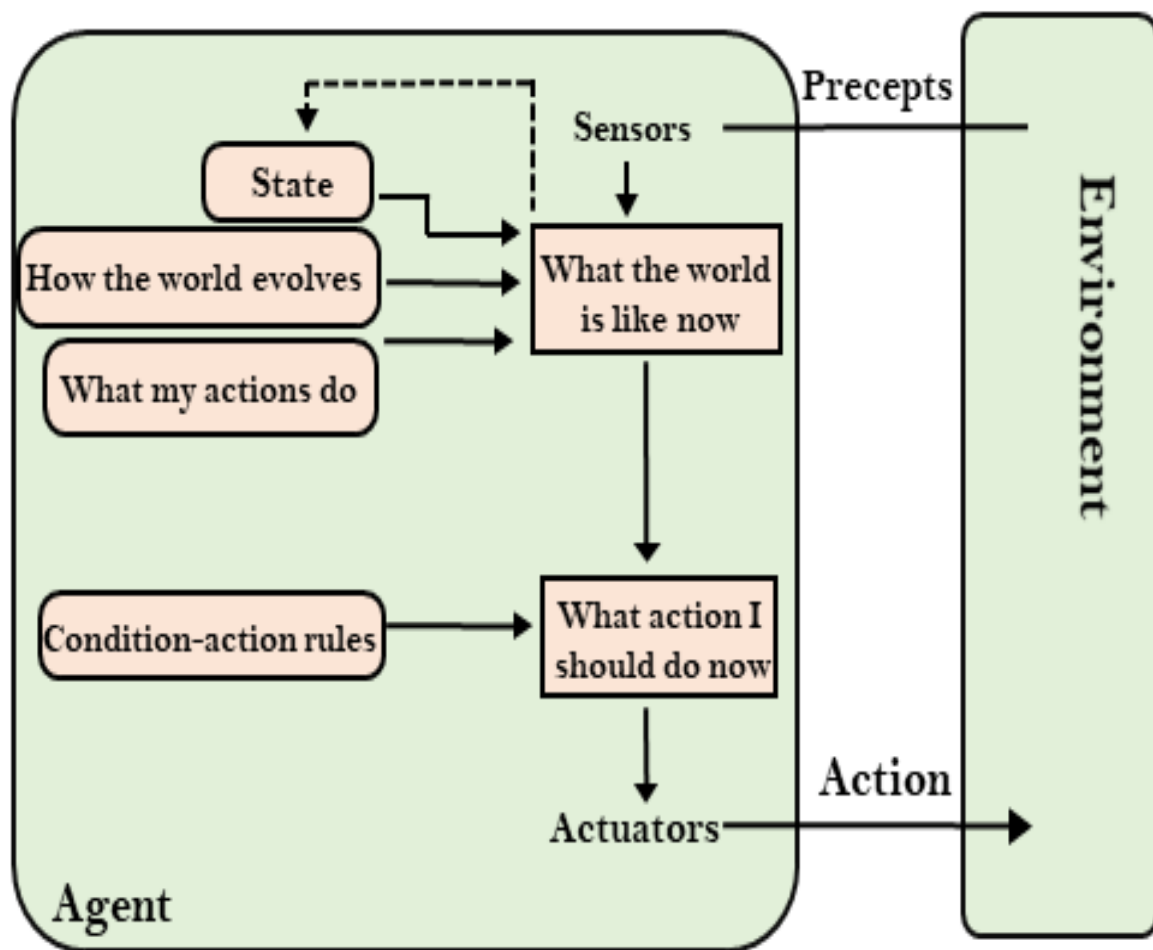
3. Goal-based agents

- o   The knowledge of the current state environment is not always sufficient to decide for an agent to what to do.
- o   The agent needs to know its goal which describes desirable situations.
- o   Goal-based agents expand the capabilities of the model-based agent by having the "goal" information.
- o   They choose an action, so that they can achieve the goal.
- o   These agents may have to consider a long sequence of possible actions before deciding whether the goal is achieved or not. Such considerations of different scenario are called searching and planning, which makes an agent proactive.
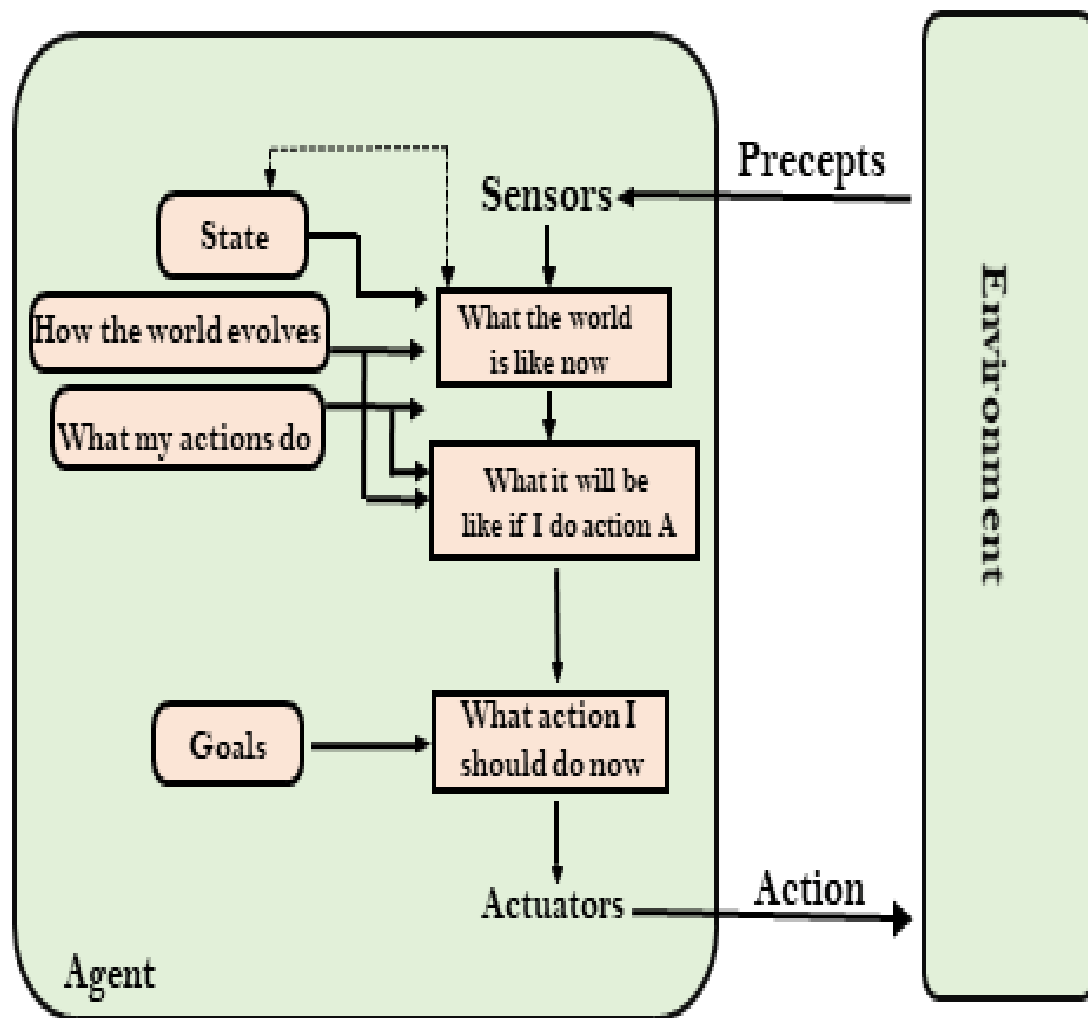
4. Utility-based agents

- o 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.

- o Utility-based agent act based not only goals but also the best way to achieve the goal.

- o 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.

- o The utility function maps each state to a real number to check how efficiently each action achieves the goals.
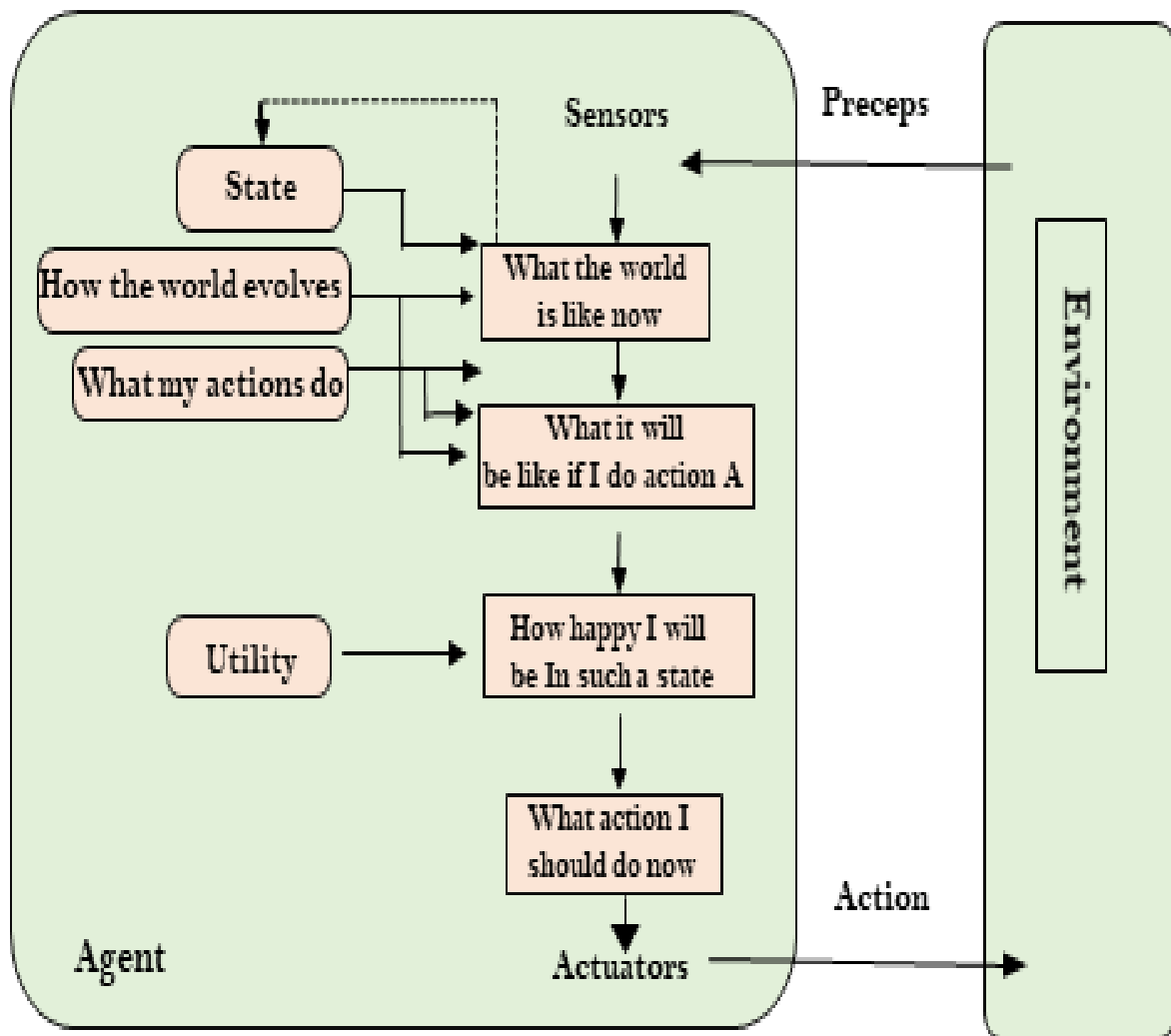
5. Learning Agents

- o A learning agent in AI is the type of agent which can learn from its past experiences, or it has learning capabilities.
- o It starts to act with basic knowledge and then able to act and adapt automatically through learning.
- o A learning agent has mainly four conceptual components, which are:
  - a. **Learning element:** It is responsible for making improvements by learning from environment
  - b. **Critic:** 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:** 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.