Artificial Intelligence

Module – 1

Dr. SRIDHAR RAJ S, Asst. prof. (SCOPE)

What is Artificial Intelligence ?

- According to the father of Artificial Intelligence, John McCarthy, it is *"The science and engineering of making intelligent machines, especially intelligent computer programs".*
- **making a computer, a computer-controlled robot, or a software think intelligently**.
- AI is accomplished by studying how human brain thinks, and how humans learn, decide, and work while trying to solve a problem, and then using the outcomes of this study as a basis of developing intelligent software and systems.

Why AI?

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:

- 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.
- With the help of AI, you can create your personal virtual Assistant, such as Google Assistant, Siri, etc.
- With the help of AI, you can build such Robots which can work in an environment where survival of humans can be at risk.
- AI opens a path for other new technologies, new devices, and new Opportunities.

Importance of AI

Without AI	With AI
A computer program without AI can answer the **specific** questions it is meant to solve.	A computer program with AI can answer the **generic** questions it is meant to solve.
Modification in the program leads to change in its structure.	AI programs can absorb new modifications by putting highly independent pieces of information together. Hence you can modify even a minute piece of information of program without affecting its structure.
Modification is not quick and easy. It may lead to affecting the program adversely.	Quick and Easy program modification.

Evolution of AI

Year	Evolution
1923	Karel Čapek play named “Rossum's Universal Robots” (RUR) opens in London, first use of the word "robot" in English.
1943	Foundations for neural networks laid.
1945	Isaac Asimov, a Columbia University alumni, coined the term *Robotics*.
1950	Alan Turing introduced Turing Test for evaluation of intelligence and published *Computing Machinery and Intelligence.* Claude Shannon published *Detailed Analysis of Chess Playing* as a search.
1956	John McCarthy coined the term *Artificial Intelligence*. Demonstration of the first running AI program at Carnegie Mellon University.
1958	John McCarthy invents LISP programming language for AI.
1964	Danny Bobrow's dissertation at MIT showed that computers can understand natural language well enough to solve algebra word problems correctly.

Evolution of AI

Year	Evolution
1964	Danny Bobrow's dissertation at MIT showed that computers can understand natural language well enough to solve algebra word problems correctly.
1965	Joseph Weizenbaum at MIT built *ELIZA*, an interactive problem that carries on a dialogue in English.
1969	Scientists at Stanford Research Institute Developed *Shakey*, a robot, equipped with locomotion, perception, and problem solving.
1973	The Assembly Robotics group at Edinburgh University built *Freddy*, the Famous Scottish Robot, capable of using vision to locate and assemble models.
1979	The first computer-controlled autonomous vehicle, Stanford Cart, was built.
1985	Harold Cohen created and demonstrated the drawing program, *Aaron*.
1990	Major advances in all areas of AI − • Significant demonstrations in machine learning, Case-based reasoning, Multi-agent planning, Scheduling, Data mining, natural language understanding and translation, Vision, Virtual Reality, Games

Advantages

- **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.
- **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.
- **High reliability:** AI machines are highly reliable and can perform the same action multiple times with high accuracy.
- **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.
- **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.
- **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

- **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.

AI Applications

AI has been dominant in various fields such as −

- **Gaming** − AI plays crucial role in strategic games such as chess, poker, tic-tac-toe, etc., where machine can think of large number of possible positions based on heuristic knowledge.
- **Natural Language Processing** − It is possible to interact with the computer that understands natural language spoken by humans.
- **Expert Systems** − There are some applications which integrate machine, software, and special information to impart reasoning and advising. They provide explanation and advice to the users.

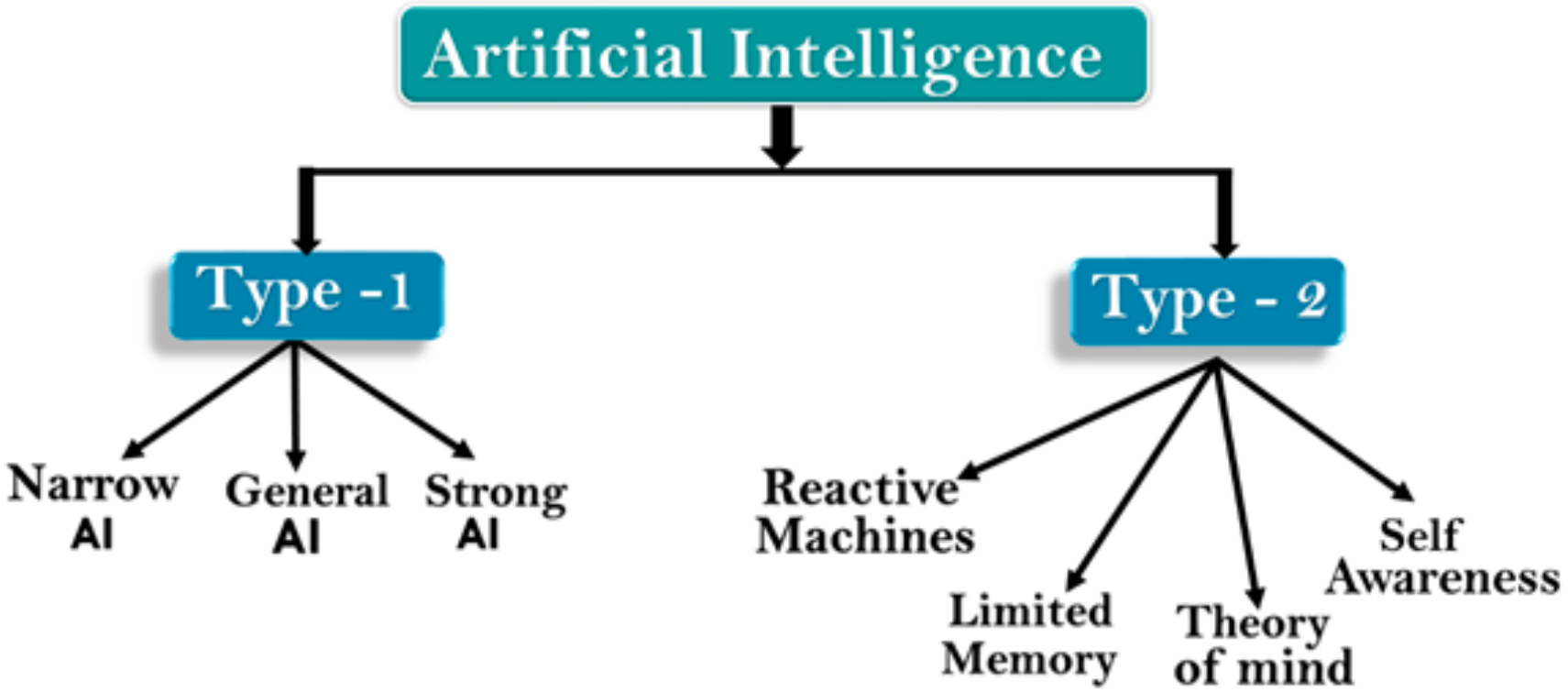
AI Applications

- **Vision Systems** − These systems understand, interpret, and comprehend visual input on the computer. For example,
  - A spying aeroplane takes photographs, which are used to figure out spatial information or map of the areas.
  - Doctors use clinical expert system to diagnose the patient.
  - Police use computer software that can recognize the face of criminal with the stored portrait made by forensic artist.
- **Speech Recognition** − Some intelligent systems are capable of hearing and comprehending the language in terms of sentences and their meanings while a human talks to it. It can handle different accents, slang words, noise in the background, change in human's noise due to cold, etc.

AI Applications

- **Handwriting Recognition** – The handwriting recognition software reads the text written on paper by a pen or on screen by a stylus. It can recognize the shapes of the letters and convert it into editable text.
- **Intelligent Robots** – Robots are able to perform the tasks given by a human. They have sensors to detect physical data from the real world such as light, heat, temperature, movement, sound, bump, and pressure. They have efficient processors, multiple sensors and huge memory, to exhibit intelligence. In addition, they are capable of learning from their mistakes and they can adapt to the new environment.

Types of AI


Artificial Intelligence
Type -1
Type - 2
Narrow AI
General AI
Strong AI
Reactive Machines
Limited Memory
Theory of mind
Self Awareness

AI Type 1 : Based on capabilities

Weak AI or Narrow AI:

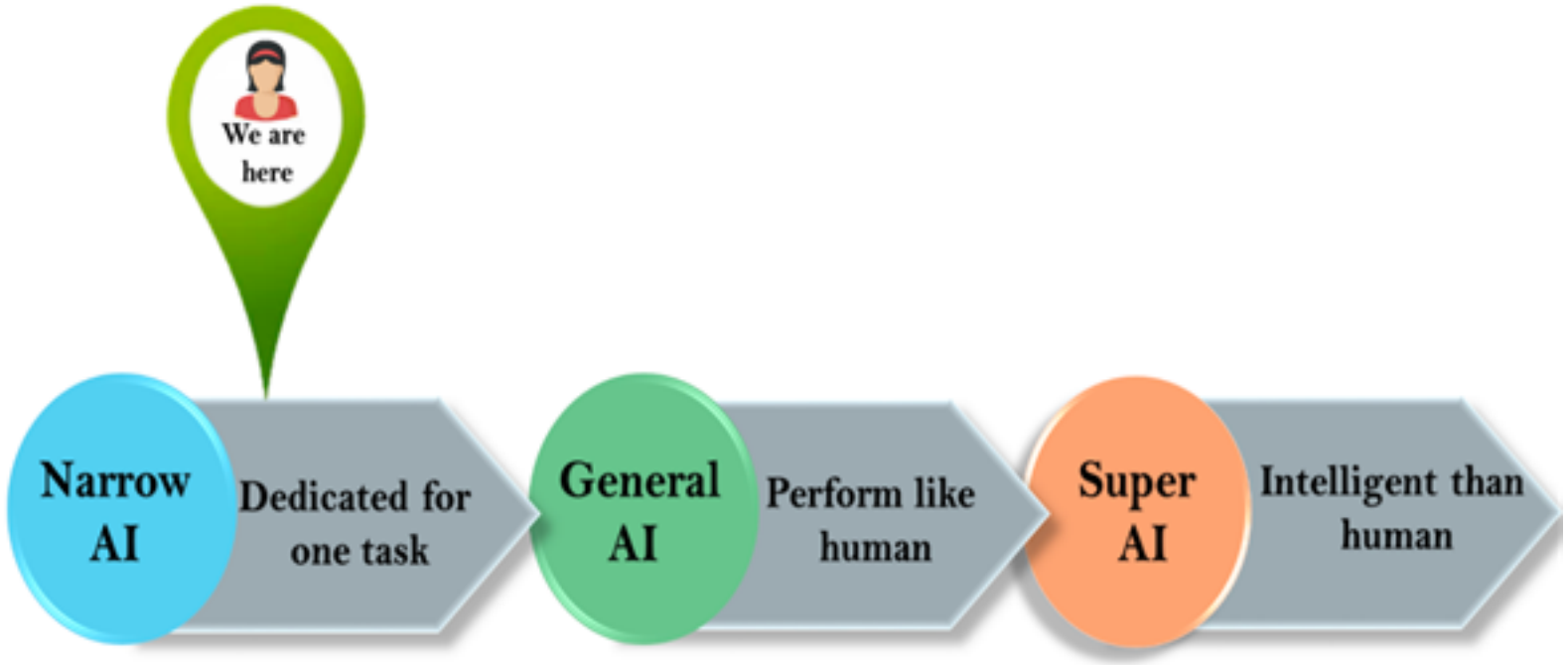
- Narrow AI is a type of AI which is able to **perform a dedicated task** with intelligence.The most common and currently available AI is Narrow AI in the world of Artificial Intelligence.
- Narrow AI **cannot perform beyond its field or limitations**, as it is only trained for one specific task. Hence it is also termed as weak AI. Narrow AI can fail in unpredictable ways if it goes beyond its limits.
- Apple Siriis a good example of Narrow AI, but it operates with a limited pre-defined range of functions.
- IBM's Watson supercomputer also comes under Narrow AI, as it uses an Expert system approach combined with Machine learning and natural language processing.
- Some Examples of Narrow AI are playing chess, purchasing suggestions on e-commerce site, self-driving cars, speech recognition, and image recognition.

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.
- The worldwide researchers are now focused on developing machines with General AI.
- As systems with general AI are still under research, and it will take lots of efforts and time to develop such systems.

Super AI

- Super AI is a level of Intelligence of Systems 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.
- Some key characteristics of strong AI include capability include the ability to think, to reason, solve the puzzle, make judgments, plan, learn, and communicate by its own.
- Super AI is still a hypothetical concept of Artificial Intelligence. Development of such systems in real is still world changing task.


We are here
Narrow AI
Dedicated for one task
General AI
Perform like human
Super AI
Intelligent than human

Artificial Intelligence type-2: Based on functionality

1. Reactive Machines

- 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.
- IBM's Deep Blue system is an example of reactive machines.
- Google's AlphaGo is also an example of reactive machines.

2. 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.
- Self-driving cars are one of the best examples of Limited Memory systems. These cars can store recent speed of nearby cars, the distance of other cars, speed limit, and other information to navigate the road

3. Theory of Mind

- Theory of Mind AI should **understand the human emotions**, people, beliefs, and be able to interact socially like humans.

- This type of AI machines are still not developed, but researchers are making lots of efforts and improvement for developing such AI machines.

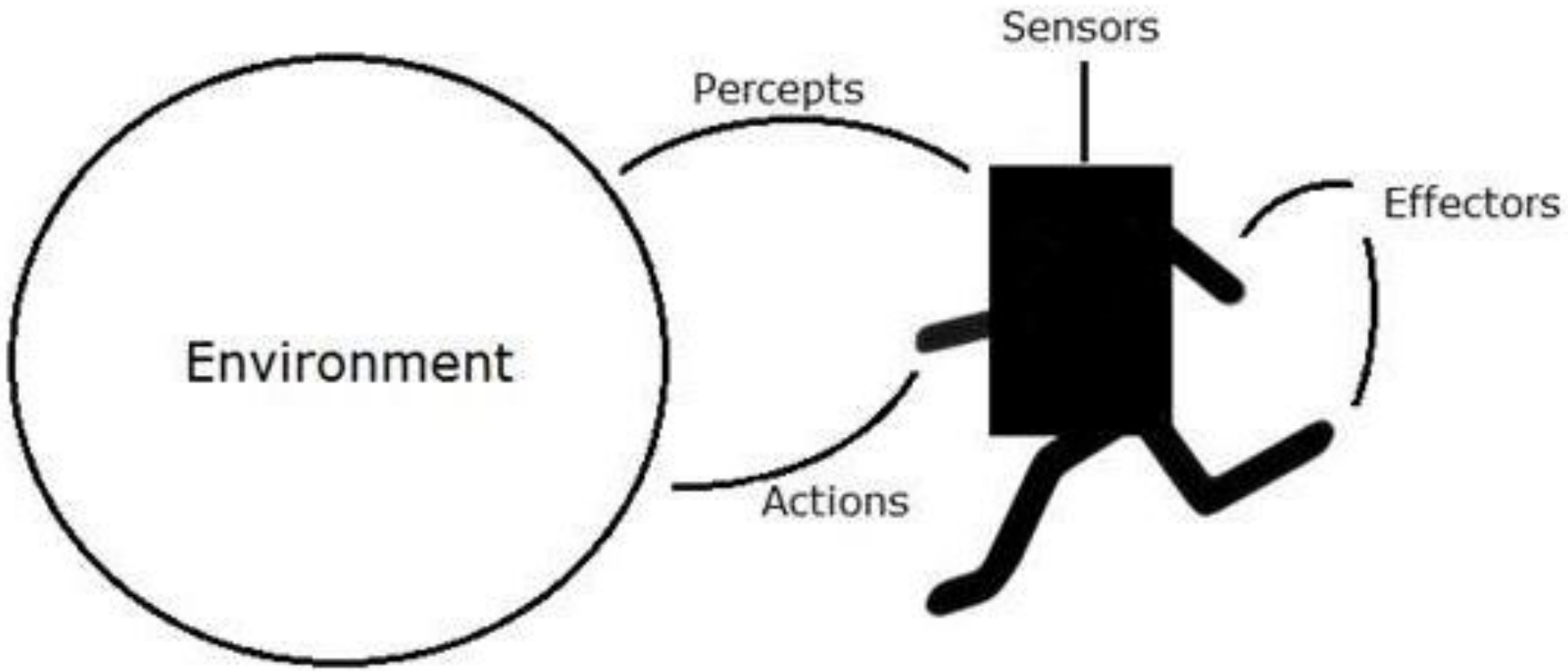
4. Self-Awareness

- 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.
- Self-Awareness AI does not exist in reality still and it is a hypothetical concept.

Agents

- An AI system is composed of an agent and its environment. The agents act in their environment. The environment may contain other agents.
- An **agent** is anything that can perceive its environment through **sensors** and acts upon that environment through **effectors.**
- A **human agent** has sensory organs such as eyes, ears, nose, tongue and skin parallel to the sensors, and other organs such as hands, legs, mouth, for effectors.
- A **robotic agent** replaces cameras and infrared range finders for the sensors, and various motors and actuators for effectors

Agent and Environment



How do agents interact?

- **Sensor**: A sensor can be defined as an object that detects environmental changes and relays this information to the device. It is used for observing the surroundings.
- **Actuator**: Actuators move and control a system. Essentially, they convert energy into motion. Examples of actuators include gears and electric motors.
- **Effector**: Effectors are the parts through which action takes place in the environment. For example, an effector can be wheels, arms, display screens, or legs.

How do agents interact?

- **Perception**: In this phase, the agent learns and understands its environment. They gather information from the surrounding without making any changes to them. When the sensors receive information, it is known as perception.
- **Action**: As the name suggests, this is when the agent makes a change to its environment. It is a proactive contact and is done through actuators.

Rules of Agent

An agent is an individual entity that acts based on the inputs received from its surroundings. However, there are **four** rules that an AI agent follows. These rules include the following.

- Rule 1: An agent should be able to perceive the environment.
- Rule 2: The observations made from the environment must be used for decision-making.
- Rule 3: The decision taken must result in an action.
- Rule 4: The action must be rational.

Ideal Rational Agent

Rationality of an agent depends on the following −

- The **performance measures**, which determine the degree of success.
- Agent's **Percept Sequence** till now.
- The agent's **prior knowledge about the environment**.
- The **actions** that the agent can carry out.

Structure of Agents

An intelligent agent's structure is a blend of architecture and an agent program. It can be represented as follows.

Agent = Architecture + Agent program

Let us discuss what these three terms mean.

- Architecture: This refers to the machinery/platform on which the intelligent agent is executed.
- Agent Function: This map a precept to an action.
- Agent Program: Implementing the agent function is called an agent program. It is executed on the physical architecture.

PEAS

Intelligent agents typically make use of the PEAS model. PEAS stands for Performance Measure, Environment, Actuators, and Sensors. Let's understand this with an example of a medical diagnosis system.

- Performance measure: Minimized costs, healthy patients.
- Environment: Hospital, staff, patient.
- Actuators: Screen display including tests, treatments, and questions.

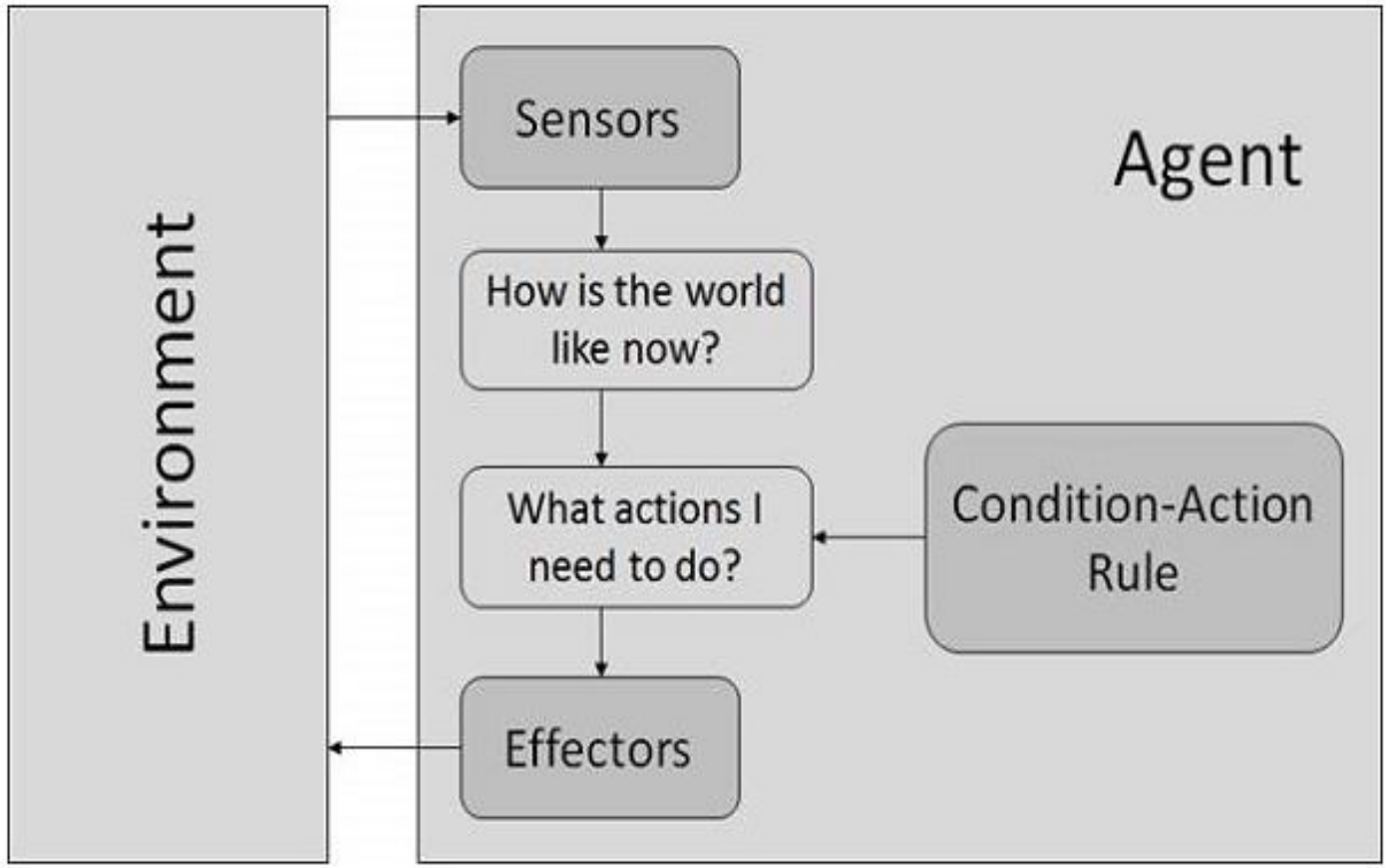
Property of Agents

An intelligent agent in AI has multiple properties. They are discussed as follows.

- Environment: The intelligent agent is in some kind of environment.
- Autonomy: The agent **doesn't require direct interference from humans** or other software to do its work; it controls its activities and internal environment.
- Social Ability: To achieve its goals and get information, the agent must have the **ability to interact with other agents** and people in a complex manner. This is referred to as social ability.
- Reactivity: The agent must have the **ability to recognize the changes in its environment**, decide independently when to act, and respond to those changes on time.
- Proactiveness: Apart from reacting to changes, the agent must also be **able to respond to any anticipated future actions**. This means it should be able to identify opportunities and take the initiative independently.
- Temporal Continuity: The agent **runs continuously**.
- Mobility: The agent can actuate in its environment.
- Veracity: An agent **will not communicate false information**.
- Benevolence: All actions performed by the agent must be for the **benefit of others**. It will always do what is asked of it.
- Rationality, Learning, Versatility (can have several goals).
- Coordination: The agent comes with the ability to manage various resources.

Simple reflex agent

- The simple reflex agents **take action based on current perceptions**.
- Simple reflex agents **cannot solve complex problems.**
- This agent operates under the **condition-action rule** enabling the agent to convert the present state into action. For **example**, a room cleaner can only work when a place is dirty. Therefore, if the condition is true, the agent will take action.



Simple Reflex Agents

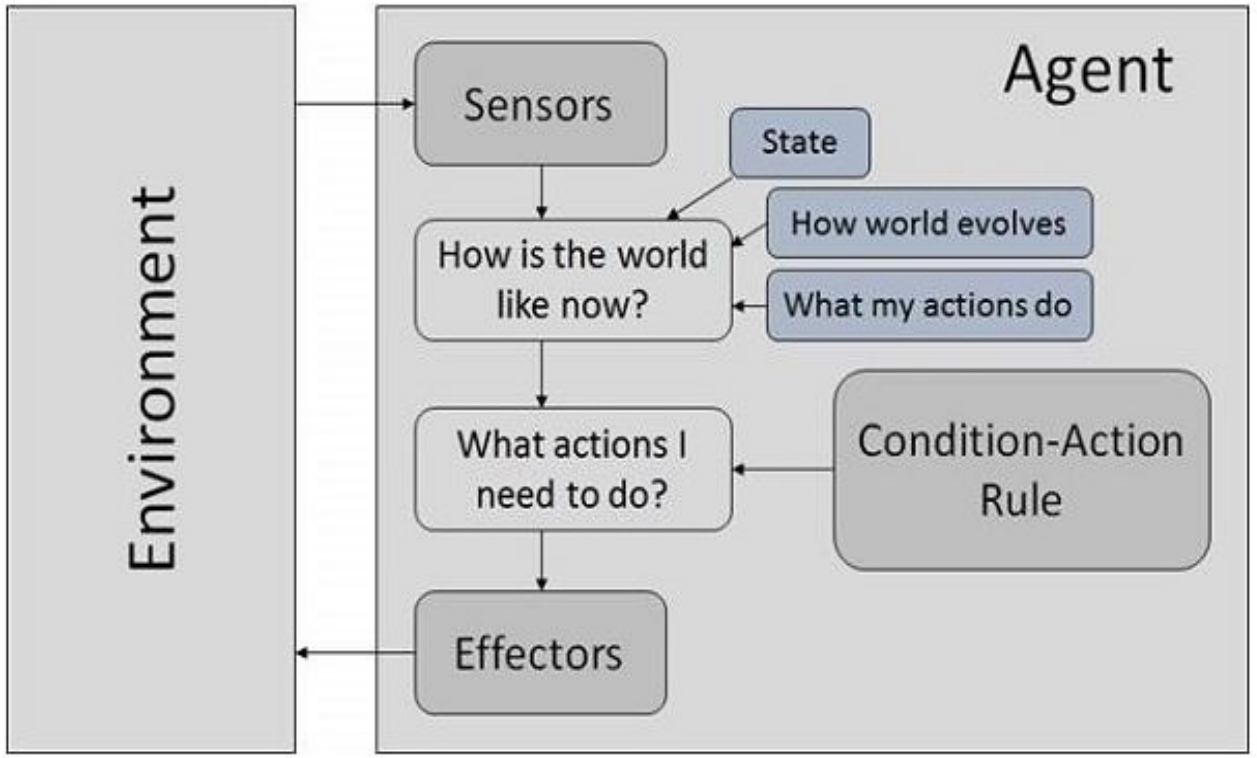
- This agent can function only when the environment can be **fully observed**.
- The agent **may get stuck in infinite loops** if the environment cannot be fully observed.

Some of the **disadvantages** of Simple Reflex agents include the following.

- They have extremely **limited intelligence**.
- They are too **big** to **generate** and **store**.
- They **cannot adjust to changes** in their environment. If the environment is changed, the agent must be updated with new rules.

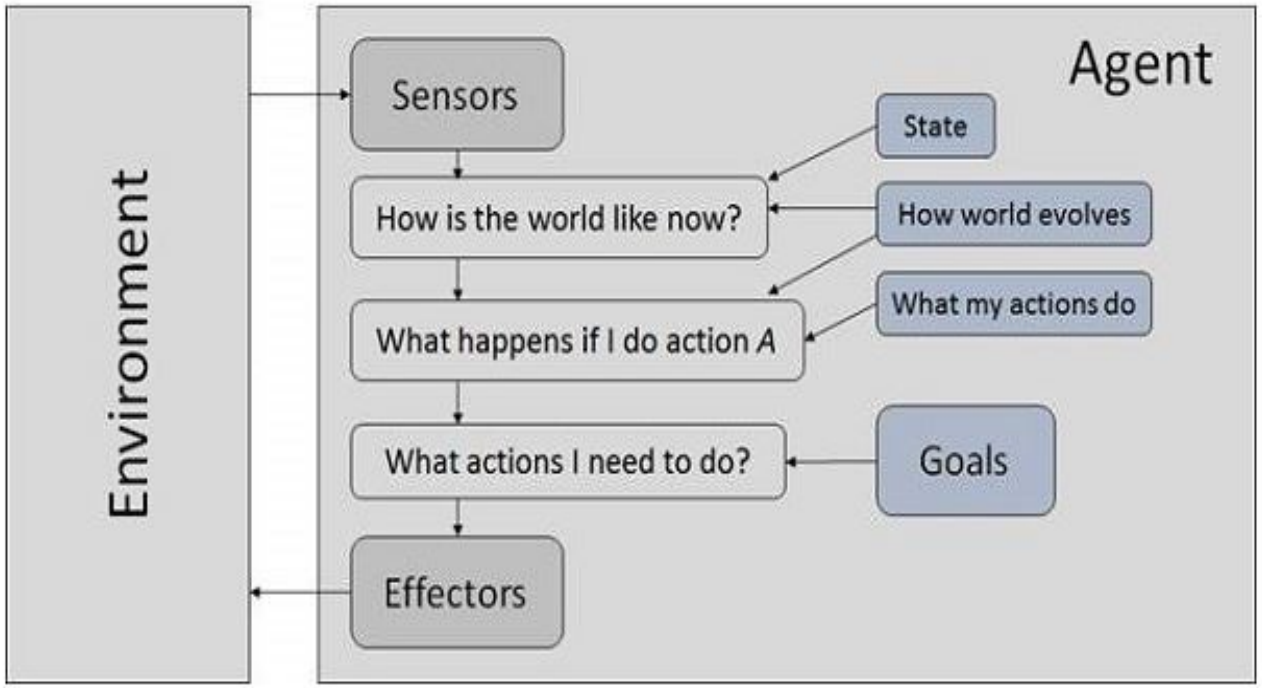
Model based reflex agents

- Model-based reflex agents **can function in partially observable environments.**
- The **model** means these agents know how things function in the world.
- The agent's **internal state** adjusts with each percept, and its depiction of existing conditions happens based on the percept history.
- The model-based reflex agents **identify a rule which matches the present condition by using the model of the world** to function in a partially observable environment.
- This type of agent stores the current condition inside itself, helping maintain a **rough structure that defines the invisible part** of the environment.



Goal based reflex

- Goal-based agents make decisions **based on their distance from their goal.**
- Goal-based agents are **more adaptable** than reflex agents as the **knowledge required** for their decisions is **clear** and can be modified easily.
- The goal-based agents are smarter and more intelligent than simple reflex agents as they can **think beyond what is happening in the present moment** and decide the best possible action.
- One of the **limitations** of these agents is that they **become inflexible once their goal is set**.

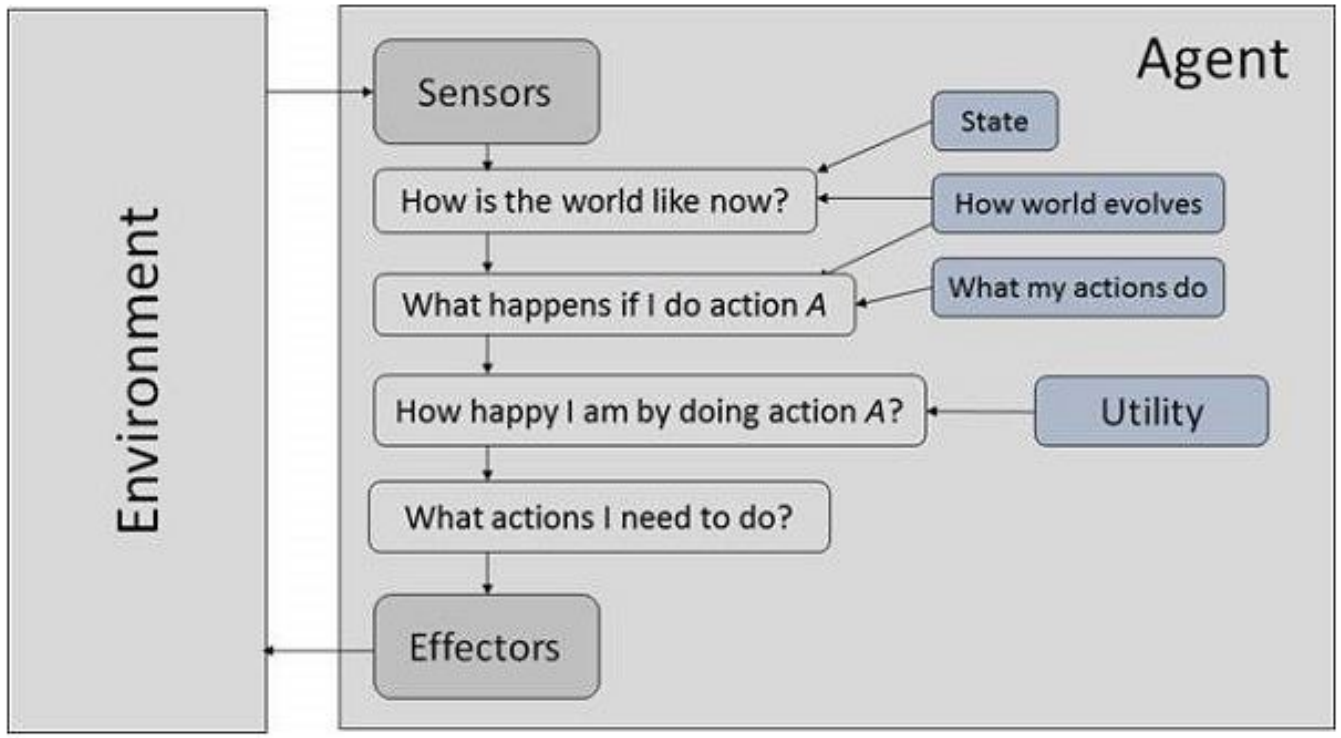


Utility based reflex agents

Utility-based agents look for a **quick, cost-effective, and secure way** of achieving goals.

For eg., If you want to travel from Delhi to Rajasthan, a goal-based agent will set the goal as Rajasthan and take you there through the right path. A utility-based agent will instead analyze other possible routes and **select the option that achieves the maximum utility.**

Therefore this type of agent is **preferred when there are multiple alternatives** and the agent has to decide between them to ensure maximum utility.



Environment properties

An environment in artificial intelligence is the surrounding of the agent. The agent takes input from the environment through sensors and delivers the output to the environment through actuators. There are several types of environments:

- Fully Observable vs Partially Observable
- Deterministic vs Stochastic
- Competitive vs Collaborative
- Single-agent vs Multi-agent
- Static vs Dynamic
- Discrete vs Continuous
- Accessible vs Inaccessible
- Episodic vs sequential

Fully Observable vs Partially Observable

- When an agent sensor is capable to sense or access the complete state of an agent at each point in time, it is said to be a fully observable environment else it is partially observable.
- An environment is called **unobservable** when he agent has no sensors in all environments.
- **Examples:**
  - **Chess –** the board is fully observable, so are the opponent's moves
  - **Driving –** the environment is partially observable because what's around the corner is not know.

Deterministic vs Stochastic

- When a uniqueness in the agent's current state completely determines the next state of the agent, the environment is said to be deterministic.
- The stochastic environment is random in nature which is **not unique** and cannot be completely determined by the agent.
- **Example:**
  Chess – there would be only a few possible moves for a coin at the current state and these moves can be determined
  Self Driving Cars – the actions of a self-driving car are not unique, it varies time to time

Competitive vs Collaborative

- An agent is said to be in a competitive environment when it competes against another agent to optimize the output.
  - The game of chess is competitive as the agents compete with each other to win the game which is the output.
- An agent is said to be in a collaborative environment when multiple agents cooperate to produce the desired output.
  - When multiple self-driving cars are found on the roads, they cooperate with each other to avoid collisions and reach their destination which is the output desired.

Single-agent vs Multi-agent

- An environment consisting of only one agent is said to be a single-agent environment.
  - A person left alone in a maze is an example of the single-agent system.
- An environment involving more than one agent is a multi-agent environment.
  - The game of football is multi-agent as it involves 11 players in each team.

Dynamic vs Static

- An environment that **keeps constantly changing itself** when the agent is up with some action is said to be dynamic.
  - A roller coaster ride is dynamic as it is set in motion and the environment keeps changing every instant.
- An idle environment with **no change in its state** is called a static environment.
  - An empty house is static as there's no change in the surroundings when an agent enters.

Discrete vs Continuous

- If an environment consists of a finite number of actions that can be deliberated in the environment to obtain the output, it is said to be a discrete environment.
  - The game of chess is discrete as it has only a finite number of moves. The number of moves might vary with every game, but still, it's finite.
- The environment in which the actions performed cannot be numbered i.e. is not discrete, is said to be continuous.
  - Self-driving cars are an example of continuous environments as their actions are driving, parking, etc. which cannot be numbered.

Accessible vs Inaccessible

- 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.

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.