UNIT I

INTRODUCTION

Introduction–Definition – Future of Artificial Intelligence – Characteristics of Intelligent Agents–Typical Intelligent Agents – Problem Solving Approach to Typical AI problems.

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1. 1 ARTIFICIAL INTELLIGENCE – AN INTRODUCTION

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. It is believed that AI is not a new technology, and some people says that as per Greek myth, there were Mechanical men in early days which can work and behave like humans.

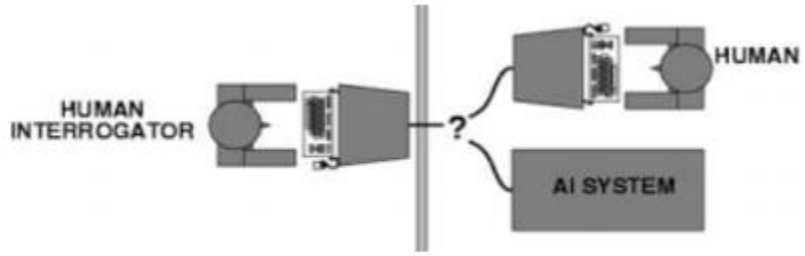
1.2 DEFINITIONS OF AI

AI definitions can be categorized into four, they are as follows:

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

1.2.1 Acting Humanly: *Turning Test Approach*

A Turing Test is a method of inquiry in artificial intelligence (AI) for determining whether or not a computer is capable of thinking like a human being. The test is named after Alan Turing, the founder of the Turning Test and an English computer scientist, cryptanalyst, mathematician and theoretical biologist. Turing proposed that a computer can be said to possess artificial intelligence if it can mimic human responses under specific conditions.



depicts Turning Test

The above figure Depicts Turning Test

1.2.2 Thinking Humanly: *The Cognitive Modeling Approach*

When program thinks like a human, it must have some way of determining how humans think. Two ways to get to know the actual workings of human minds namely:

- Through Introspection (Trying to catch one‟s own thoughts)
- Through Psychological Experiments.

1.2.3 Thinking Rationally

The Laws of Thought Approach Right thinking that is, irrefutable reasoning processes.

1.2.4 Acting Rationally

The Rational Agent Approach An agent is something that perceives and acts. AI is looked upon as a study that deals with the construction and study of the rational agents. Forming the right inferences is sometimes part of being a rational agent. One way to act rationally is to reason logically the conclusion that might achieve the goal and then only to act on the conclusion

1.3 IMPORTANCE AND PURPOSE OF 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:

- 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 Cortana, 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.

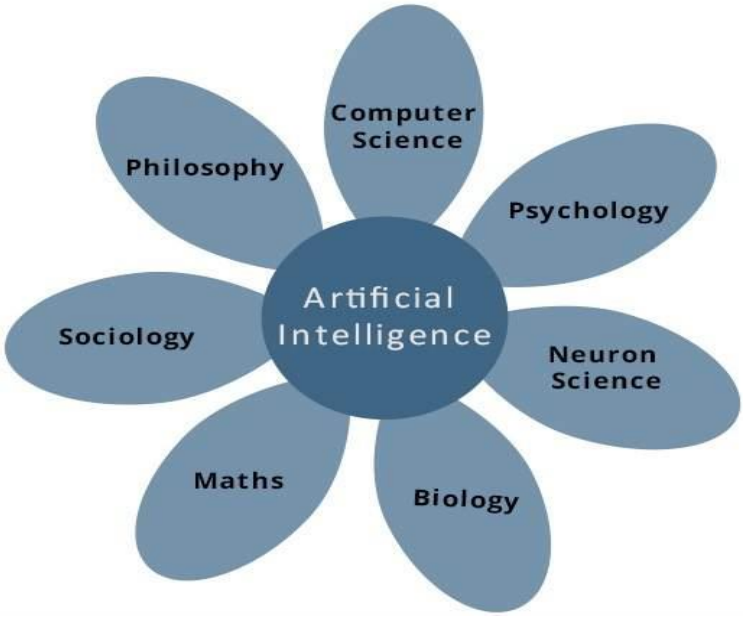
1.3.1 Goals of Artificial Intelligence

Following are the main goals of Artificial Intelligence:

1. Replicate human intelligence
2. Solve Knowledge-intensive tasks
3. An intelligent connection of perception and action
4. Building a machine which can perform tasks that requires human intelligence such as:
    - Proving a theorem
    - Playing chess
    - Plan some surgical operation
    - Driving a car in traffic
5. Creating some system which can exhibit intelligent behavior, learn new things by itself, demonstrate, explain, and can advise to its user.

1.3.2 Discipline of Artificial Intelligence

To create the AI first we should know that how intelligence is composed, so the Intelligence is an intangible part of our brain which is a combination of **Reasoning, learning, problem-solving perception, language understanding, etc**. To achieve the above factors for a machine or software Artificial Intelligence requires the following discipline:



1.3.3 Advantages of Artificial Intelligence

Following are some main advantages of Artificial Intelligence:

- **High Accuracy with fewer 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.

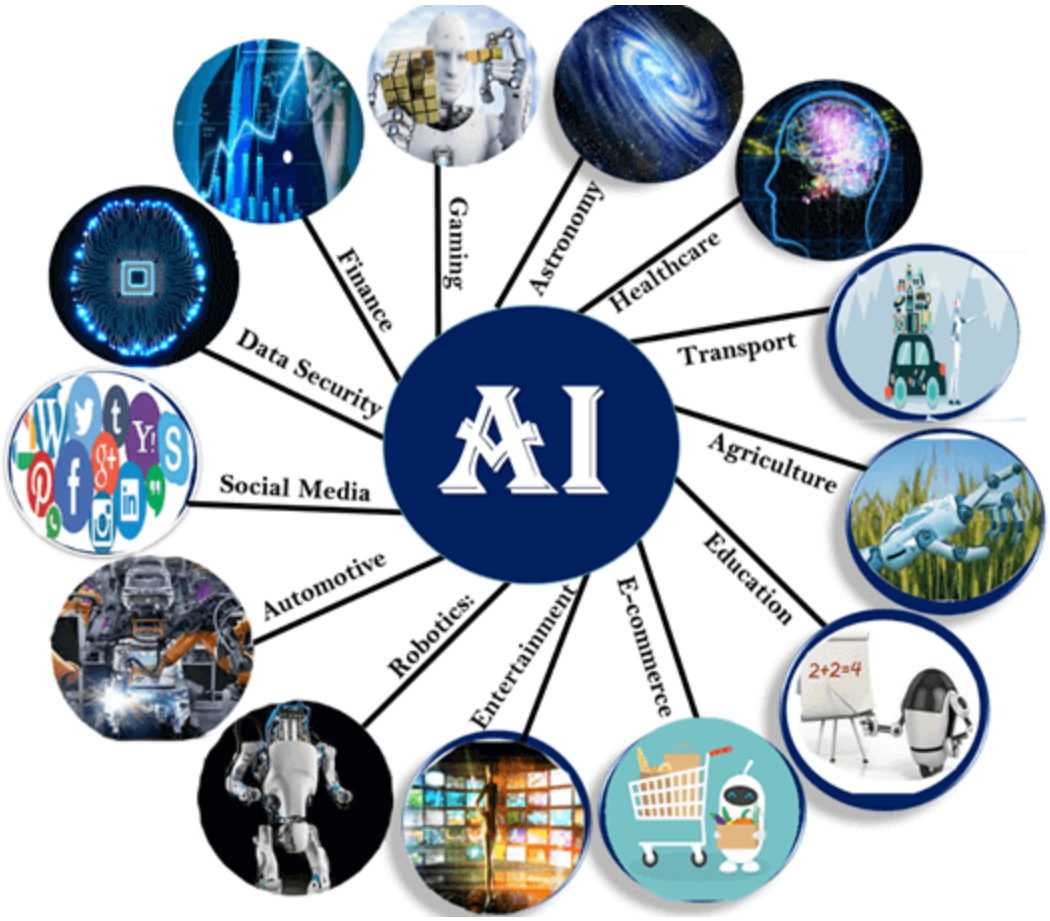
1.3.4 Disadvantages of Artificial Intelligence

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.

1.3.5 Application of AI

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:



AI in Astronomy

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.

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.

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.

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.

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.

AI in Social Media

- Social Media sites such as Facebook, Twitter, and Snap chat 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, hash tag, and requirement of different users.

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 chatbots which can make human-like interaction with customers for better and fast response.

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

AI in Robotics

- 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.

- 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.

AI in Entertainment

- 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.

AI in Agriculture

- 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.

AI in E-commerce

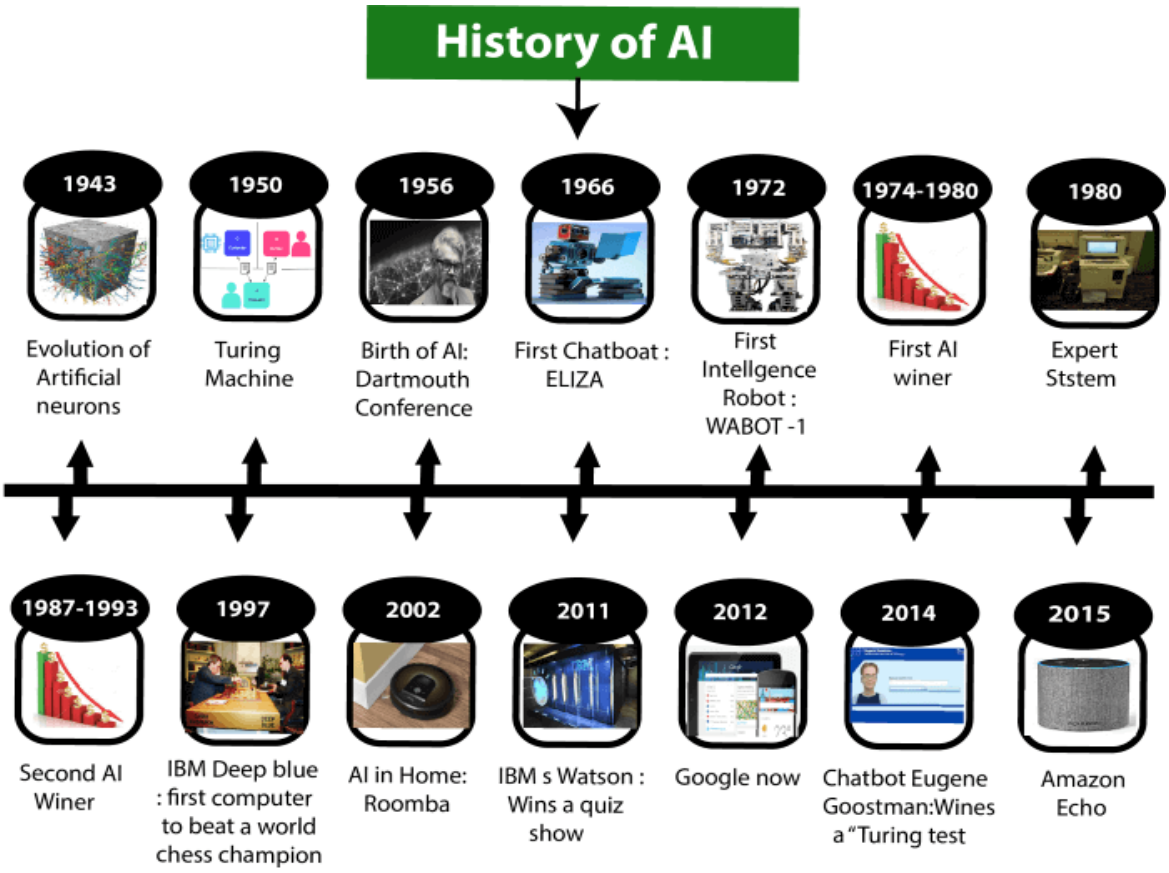
- AI is providing a competitive edge to the e-commerce industry, and it is becoming more demanding in the e-commerce business. AI is helping shoppers to discover associated products with recommended size, color, or even brand.

AI in education

- AI can automate grading so that the tutor can have more time to teach. AI chatbot can communicate with students as a teaching assistant.
- 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.

1.4 HISTORY AND FUTURE OF ARTIFICIAL INTELLIGENCE

Artificial Intelligence is not a new word and not a new technology for researchers. This technology is much older than you would imagine. Even there are the myths of Mechanical men in Ancient Greek and Egyptian Myths. Following are some milestones in the history of AI which defines the journey from the AI generation to till date development.



1.4.1 Maturation of Artificial Intelligence (1943-1952)

- **Year 1943:** The first work which is now recognized as AI was done by Warren McCulloch and Walter pits in 1943. They proposed a model of **artificial neurons**.
- **Year 1949:** Donald Hebb demonstrated an updating rule for modifying the connection strength between neurons. His rule is now called **Hebbian learning**.
- **Year 1950:** The Alan Turing who was an English mathematician and pioneered Machine learning in 1950. Alan Turing publishes **"Computing Machinery and Intelligence"** in which he proposed a test. The test can check the machine's ability to exhibit intelligent behavior equivalent to human intelligence, called a **Turing test**.

1.4.2 The birth of Artificial Intelligence (1952-1956)

- **Year 1955:** An Allen Newell and Herbert A. Simon created the "first artificial intelligence program"Which was named as **"Logic Theorist"**. This program had proved 38 of 52 Mathematics theorems, and find new and more elegant proofs for some theorems.

- **Year 1956:** The word "Artificial Intelligence" first adopted by American Computer scientist John McCarthy at the Dartmouth Conference. For the first time, AI coined as an academic field. At that time high-level computer languages such as FORTRAN, LISP, or COBOL were invented. And the enthusiasm for AI was very high at that time.

1.4.3 The golden years-Early enthusiasm (1956-1974)

- **Year 1966:** The researchers emphasized developing algorithms which can solve mathematical problems. Joseph Weizenbaum created the first chatbot in 1966, which was named as ELIZA.
- **Year 1972:** The first intelligent humanoid robot was built in Japan which was named as WABOT-1.

1.4.4 The first AI winter (1974-1980)

- The duration between years 1974 to 1980 was the first AI winter duration. AI winter refers to the time period where computer scientist dealt with a severe shortage of funding from government for AI researches.
- During AI winters, an interest of publicity on artificial intelligence was decreased.

1.4.5 A boom of AI (1980-1987)

- **Year 1980:** After AI winter duration, AI came back with "Expert System". Expert systems were programmed that emulate the decision-making ability of a human expert.
- In the Year 1980, the first national conference of the American Association of Artificial Intelligence **was held at Stanford University**.

1.4.6 The second AI winter (1987-1993)

- The duration between the years 1987 to 1993 was the second AI Winter duration.
- Again Investors and government stopped in funding for AI research as due to high cost but not efficient result. The expert system such as XCON was very cost effective.

1.4.7 The emergence of intelligent agents (1993-2011)

- **Year 1997:** In the year 1997, IBM Deep Blue beats world chess champion, Gary Kasparov, and became the first computer to beat a world chess champion.
- **Year 2002:** for the first time, AI entered the home in the form of Roomba, a vacuum cleaner.

- **Year 2006:** AI came in the Business world till the year 2006. Companies like Facebook, Twitter, and Netflix also started using AI.

1.4.8 Deep learning, big data and artificial general intelligence (2011-present)

- **Year 2011:** In the year 2011, IBM's Watson won jeopardy, a quiz show, where it had to solve the complex questions as well as riddles. Watson had proved that it could understand natural language and can solve tricky questions quickly.
- **Year 2012:** Google has launched an Android app feature "Google now", which was able to provide information to the user as a prediction.
- **Year 2014:** In the year 2014, Chatbot "Eugene Goostman" won a competition in the infamous "Turing test."
- **Year 2018:** The "Project Debater" from IBM debated on complex topics with two master debaters and also performed extremely well.
- Google has demonstrated an AI program "Duplex" which was a virtual assistant and which had taken hairdresser appointment on call, and lady on other side didn't notice that she was talking with the machine.

Now AI has developed to a remarkable level. The concept of Deep learning, big data, and data science are now trending like a boom. Nowadays companies like Google, Facebook, IBM, and Amazon are working with AI and creating amazing devices. The future of Artificial Intelligence is inspiring and will come with high intelligence.

1.4.9 Future of artificial intelligence

Autonomous Transportation:

In future, enhanced automated transportation the technology will evolve and we will see in our roads replicas from Back to the Future, where transportations like public buses, cabs, and even private vehicles will go driverless and on autopilot. With more precision, smart vehicles will take over the roads and pave way for safer, faster and economical transport systems.

Robots into Risky Jobs:

Today, some of the most dangerous jobs are done by humans. Right from cleaning sewage to fighting fire and diffusing bombs, it’s we who get down, get our hands dirty and risk our lives. The number of human lives we lose is also very high in these processes. In the near future, we can expect machines or robots to take care of them. As artificial intelligence evolves and smarter robots roll out, we can see them replacing humans at some of the riskiest jobs in the world. That’s the only time we expect automation to take away jobs.

Personal Assistants:

Virtual assistants are already there and some of us would've used them. However, as the technology grows, we can expect them to act as personal assistants and emote like humans. With artificial intelligence, deep learning, and neural networks, it's highly possible that we can make robots emote and make them assistants. They could be used in tons of different purposes such as in hospitality industry, day care centers, elder care, in clerical jobs and more.

1.5 AGENT

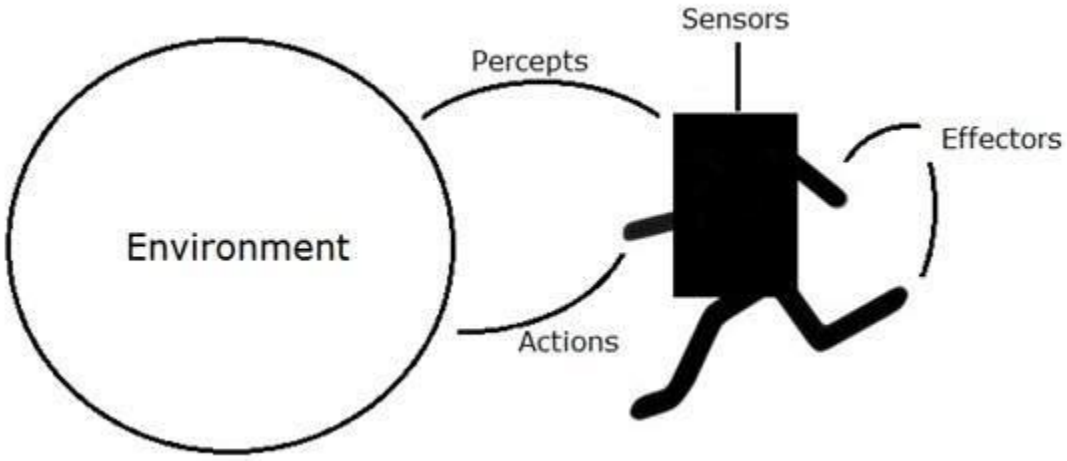
An agent is anything that can viewed as perceiving its environment through sensors and acting upon that environment through effectors. An Agent runs in the cycle of perceiving, thinking, and acting those inputs and display output on the screen.

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

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.



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. An agent can be:

Human-Agent: A human agent has eyes, ears, and other organs which work 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 for actuators.

Software Agent: Software agent can have keystrokes, file contents as sensory input and act on those inputs and display output on the screen.

1.6 INTELLIGENT AGENTS

An intelligent agent is an autonomous entity which acts 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:

- **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.

1.6.1 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 percepts.

1.6.2 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.

$$\mathbf{F : P^* \rightarrow A}$$

Agent program: Agent program is an implementation of agent function. An agent program executes on the physical architecture to produce function **F**.

1.6.3 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:

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

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

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.

Example of Agents with their PEAS representation

Agent	Performance measure	Environment	Actuators	Sensors
1. Medical Diagnose	• Healthy patient • Minimized cost	• Patient • Hospital • Staff	• Tests • Treatments	• Keyboard (Entry of symptoms)
2. Vacuum Cleaner	• Cleanness • Efficiency • Battery life • Security	• Room • Table • Wood floor • Carpet • Various obstacles	• Wheels • Brushes • Vacuum Extractor	• Camera • Dirt detection sensor • Cliff sensor • Bump Sensor • Infrared Wall Sensor
3. Part - picking Robot	• Percentage of parts in correct bins.	• Conveyor belt with parts, • Bins	• Jointed Arms • Hand	• Camera • Joint angle sensors.

1.6.4 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. An environment is mostly said to be non-feministic.

1.6.5 Features of Environment

As per Russell and Norvig, 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:

- 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**.

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.

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.

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.

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.
- Taxi driving is an example of a dynamic environment whereas Crossword puzzles are an example of a static environment.

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

7. Known vs Unknown

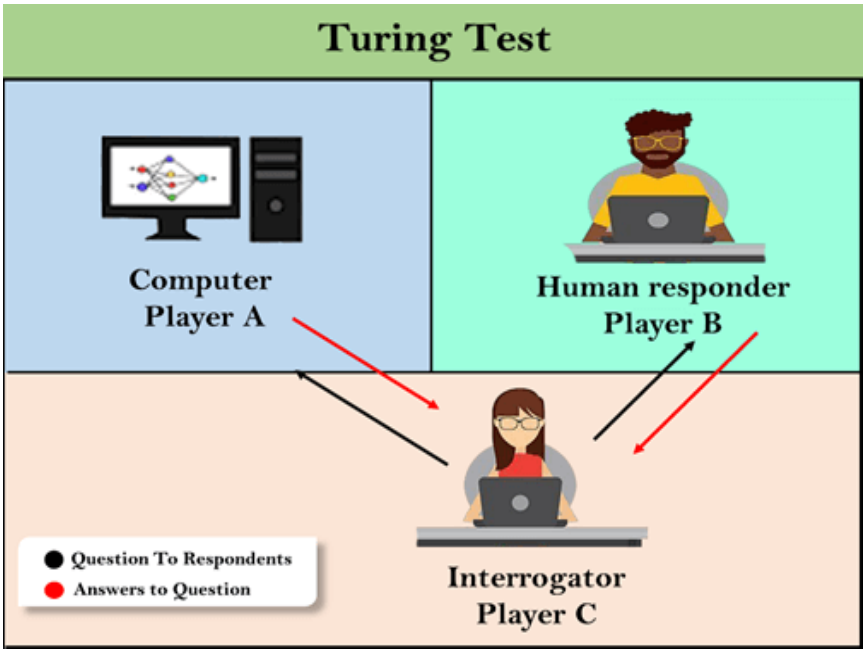
- Known and unknown are not actually a feature of an environment, but it is an agent's state of knowledge to perform an action.
- In a known environment, the results for all actions are known to the agent. While in unknown environment, agent needs to learn how it works in order to perform an action.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

8. 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.

1.7 TURING TEST IN AI

In 1950, Alan Turing introduced a test to check whether a machine can think like a human or not, this test is known as the Turing Test. In this test, Turing proposed that the computer can be said to be an intelligent if it can mimic human response under specific conditions. Turing Test was introduced by Turing in his 1950 paper, "Computing Machinery and Intelligence," which considered the question, "Can Machine think?"



The Turing test is based on a party game "Imitation game," with some modifications. This game involves three players in which one player is Computer, another player is human responder, and the third player is a human Interrogator, who is isolated from other two players and his job is to find that which player is machine among two of them.

Consider, Player A is a computer, Player B is human, and Player C is an interrogator. Interrogator is aware that one of them is machine, but he needs to identify this on the basis of questions and their responses. The conversation between all players is via keyboard and screen so the result would not depend on the machine's ability to convert words as speech.

The test result does not depend on each correct answer, but only how closely its responses like a human answer. The computer is permitted to do everything possible to force a wrong identification by the interrogator.

The questions and answers can be like:

Interrogator: Are you a computer?

PlayerA (Computer): No

Interrogator: Multiply two large numbers such as (256896489*456725896)

Player A: Long pause and give the wrong answer.

In this game, if an interrogator would not be able to identify which is a machine and which is human, then the computer passes the test successfully, and the machine is said to be intelligent and can think like a human.

"In 1991, the New York businessman Hugh Loebner announces the prize competition, offering a $100,000 prize for the first computer to pass the Turing test. However, no AI program to till date, come close to passing an undiluted Turing test".

ELIZA: ELIZA was a Natural language processing computer program created by Joseph Weizenbaum. It was created to demonstrate the ability of communication between machine and humans. It was one of the first chatterbots, which has attempted the Turing Test.

Parry: Parry was a chatterbot created by Kenneth Colby in 1972. Parry was designed to simulate a person with **Paranoid schizophrenia**(most common chronic mental disorder). Parry was described as "ELIZA with attitude." Parry was tested using a variation of the Turing Test in the early 1970s.

Eugene Goostman: Eugene Goostman was a chatbot developed in Saint Petersburg in 2001. This bot has competed in the various number of Turing Test. In June 2012, at an event, Goostman won the competition promoted as largest-ever Turing test content, in which it has convinced 29% of judges that it was a human. Goostman resembled as a 13-year old virtual boy.

Features required for a machine to pass the Turing test:

- **Natural language processing:** NLP is required to communicate with Interrogator in general human language like English.
- **Knowledge representation:** To store and retrieve information during the test.
- **Automated reasoning:** To use the previously stored information for answering the questions.
- **Machine learning:** To adapt new changes and can detect generalized patterns.
- **Vision (For total Turing test):** To recognize the interrogator actions and other objects during a test.
- **Motor Control (For total Turing test):** To act upon objects if requested.

1.8 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:

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

1.8.1 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 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.

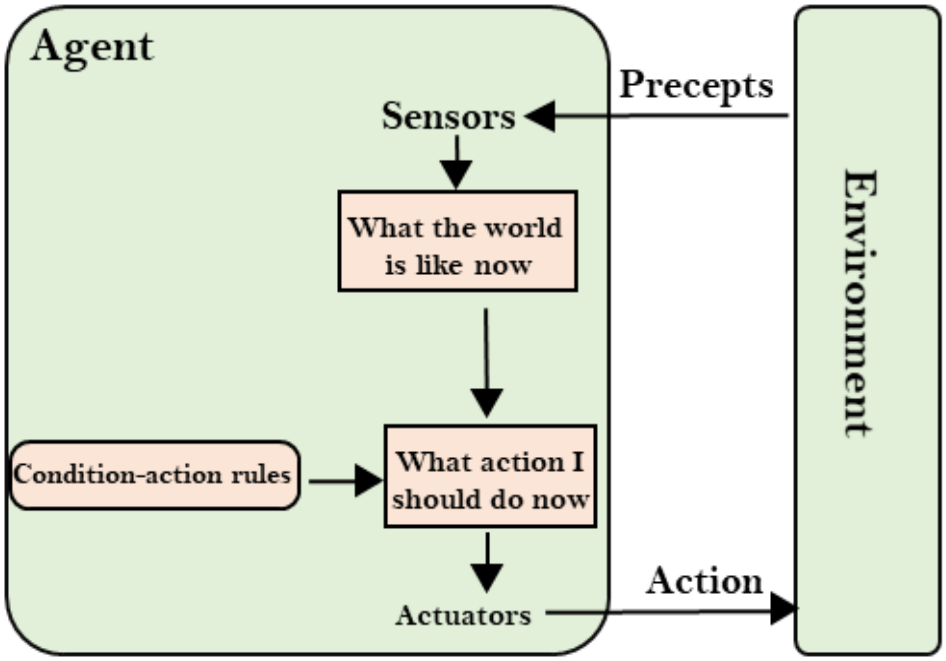


Fig: Simple Reflex Agent

- Problems for the simple reflex agent design approach:
  - They have very limited intelligence
  - They do not have knowledge of non-perceptual parts of the current state
  - Mostly too big to generate and to store.
  - Not adaptive to changes in the environment.

1.8.2. Model-based reflex agent

- The Model-based agent can work in a partially observable environment, and track the situation.
- 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.

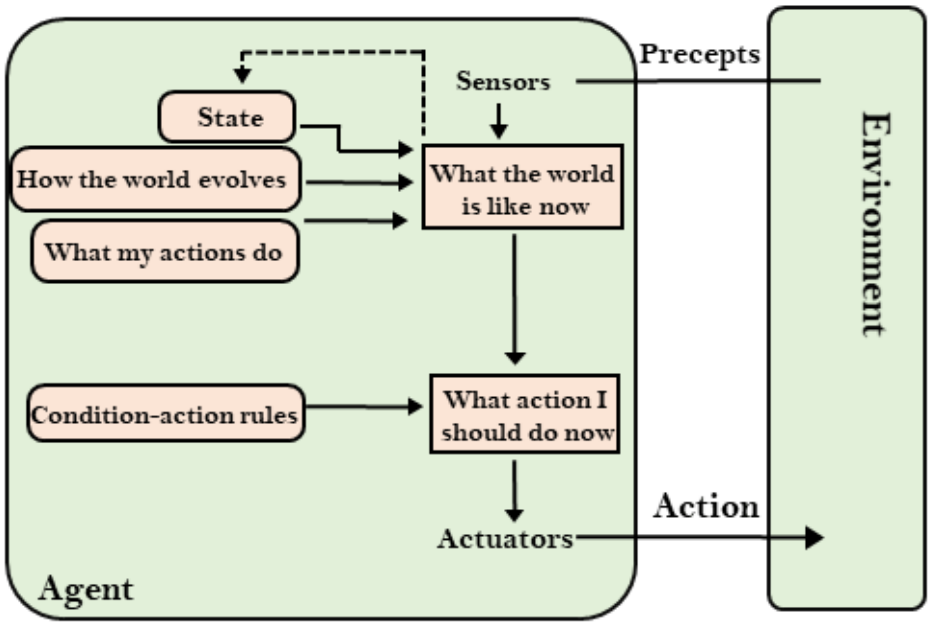


Fig: Model-based reflex agent

1.8.3. Goal-based agents

- The knowledge of the current state environment is not always sufficient to decide for an agent to what to do.
- The agent needs to know its goal which describes desirable situations.
- Goal-based agents expand the capabilities of the model-based agent by having the "goal" information.
- They choose an action, so that they can achieve the goal.
- 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.

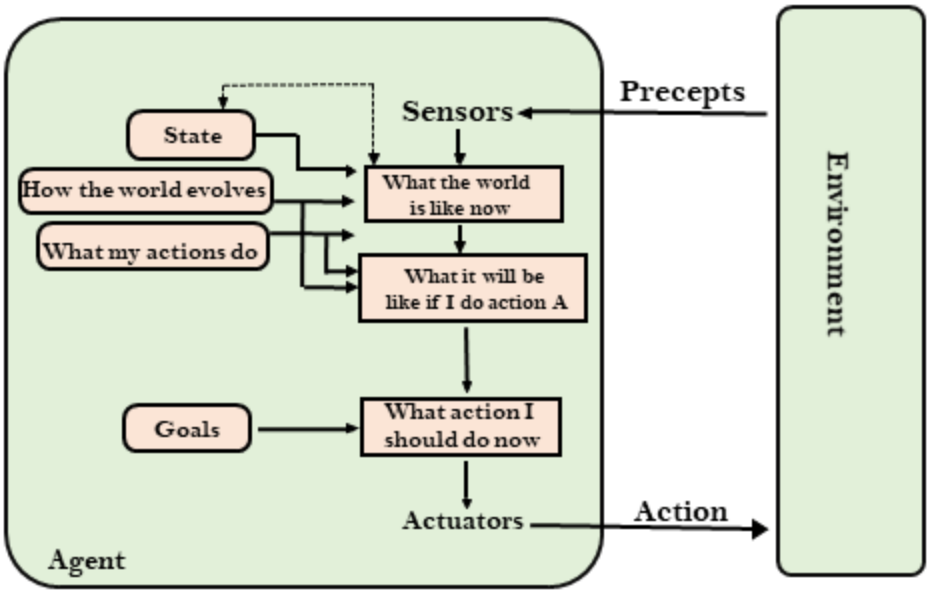


Fig: Goal-based agents

1.8.4. Utility-based agents

- 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.

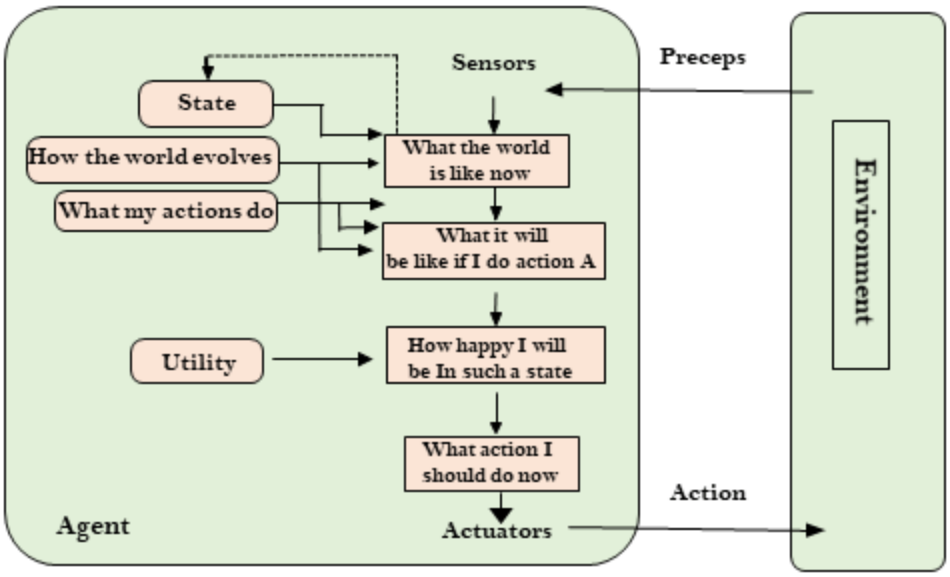


Fig: Utility-based agent

1.8.5 Learning Agents

- A learning agent in AI is the 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:

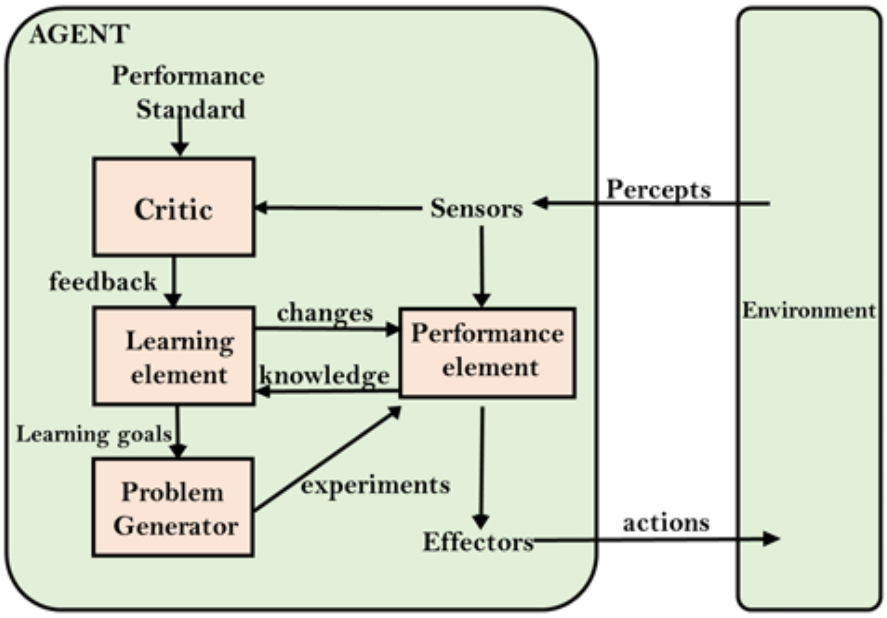
    a. **Learning element:** It is responsible for making improvements by learning from environment

    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.



1.9 PROBLEM SOLVING APPROACH TO TYPICAL AI PROBLEMS

In real world, there are different types of problems. Problem Solving in games such as "Sudoku" can be an example. It can be done by building an artificially intelligent system to solve that particular problem. To do this, one needs to define the problem statements first and then generating the solution by keeping the conditions in mind. Some of the most popularly used problem solving with the help of artificial intelligence are:

- Chess.
- Travelling Salesman Problem.
- Tower of Hanoi Problem.
- Water-Jug Problem.
- N-Queen Problem.

Problem Searching

In general, searching refers to as finding information one needs. Searching is the most commonly used technique of problem solving in artificial intelligence. The searching algorithm helps us to search for solution of particular problem.

Problem

Problems are the issues which come across any system. A solution is needed to solve that particular problem.

Steps to Solve Problem using Artificial Intelligence

The process of solving a problem consists of five steps. These are:

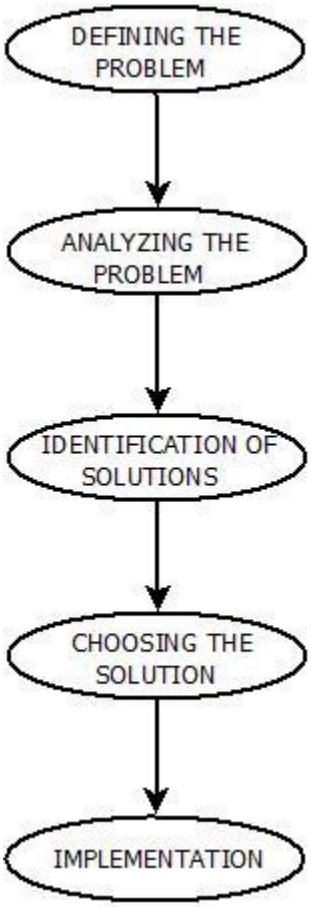


Fig: Steps in solving a problem

Defining the Problem:

The definition of the problem must be included precisely. It should contain the possible initial as well as final situations which should result in acceptable solution.

Analyzing the Problem:

Analyzing the problem and its requirement must be done as few features can have immense impact on the resulting solution.

Identification of Solutions:

This phase generates reasonable amount of solutions to the given problem in a particular range.

Choosing a Solution:

From all the identified solutions, the best solution is chosen basis on the results produced by respective solutions.

Implementation:

After choosing the best solution, its implementation is done.

1.9.1 Representation of AI Problems

Problem Formulation

Problem formulation involves deciding what actions and states to consider, when the description about the goal is provided. It is composed of:

- Initial State - start state
- Possible actions that can be taken
- Transition model – describes what each action does
- Goal test – checks whether current state is goal state
- Path cost – cost function used to determine the cost of each path.

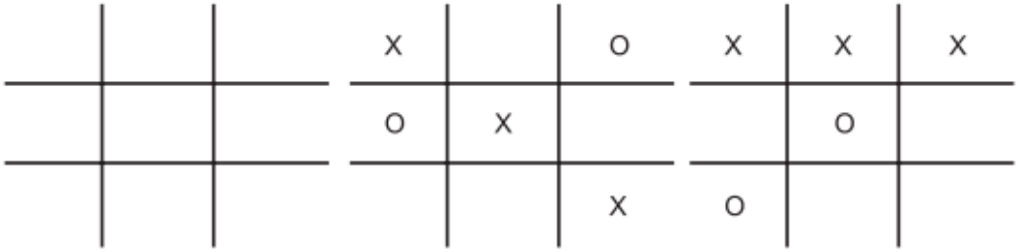
The initial state, actions and the transition model constitutes state space of the problem - the set of all states reachable by any sequence of actions. A path in the state space is a sequence of states connected by a sequence of actions. The solution to the given problem is defined as the sequence of actions from the initial state to the goal states. The quality of the solution is measured by the cost function of the path, and an optimal solution is the one with most feasible path cost among all the solutions.

1.9.2 TIC-TAC-TOE Game

Board position: = {1,2,3,4,5,6,7,8,9}

An element contains the value 0, if the corresponding square is blank; 1, if it is filled with "O" and 2, if it is filled with "X".

Hence starting state is {0,0,0,0,0,0,0,0,0}. The goal state or winning combination will be board position having "O" or "X" separately in the combination of ({1,2,3}, {4,5,6}, {7,8,9},{1,4,7},{2,5,8}, {3,6,9}, {1,5,9}, { 3,5,7}) element values. Hence two goal states can be {2,0,1,1,2,0,0,0,2} and {2,2,2,0,1,0,1,0,0}. These values correspond to the goal States.



Start and goal states of TIC-TAC-TOE

Any board position satisfying this condition would be declared as win for corresponding player. The valid transitions of this problem are simply putting '1' or '2' in any of the element position containing 0. In practice, all the valid moves are defined and stored. While selecting a move it is taken from this store. In this game, valid transition table will be a vector (having 3^9 entries), having 9 elements in each.

1.9.3 Water jug problem

In the water jug problem in Artificial Intelligence, we are provided with two jugs: one having the capacity to hold 3 gallons of water and the other has the capacity to hold 4 gallons of water. There is no other measuring equipment available and the jugs also do not have any kind of marking on them. So, the agent's task here is to fill the 4-gallon jug with 2 gallons of water by using only these two jugs and no other material. Initially, both our jugs are empty. So, to solve this problem, following set of rules were proposed:

Production rules for solving the water jug problem.

Here, let x denote the 4-gallon jug and y denote the 3-gallon jug.

S.No.	Initial State	Condition	Final state	Description of action taken
1.	(x,y)	If x<4	(4,y)	Fill the 4 gallon jug completely
2.	(x,y)	if y<3	(x,3)	Fill the 3 gallon jug completely
3.	(x,y)	If x>0	(x-d,y)	Pour some part from the 4 gallon jug
4.	(x,y)	If y>0	(x,y-d)	Pour some part from the 3 gallon jug
5.	(x,y)	If x>0	(0,y)	Empty the 4 gallon jug
6.	(x,y)	If y>0	(x,0)	Empty the 3 gallon jug

7.	(x,y)	If (x+y)<7	(4, y-[4-x])	Pour some water from the 3 gallon jug to fill the four gallon jug
8.	(x,y)	If (x+y)<7	(x-[3-y],y)	Pour some water from the 4 gallon jug to fill the 3 gallon jug.
9.	(x,y)	If (x+y)<4	(x+y,0)	Pour all water from 3 gallon jug to the 4 gallon jug
10.	(x,y)	if (x+y)<3	(0, x+y)	Pour all water from the 4 gallon jug to the 3 gallon jug

The listed production rules contain all the actions that could be performed by the agent in transferring the contents of jugs. But, to solve the water jug problem in a minimum number of moves, following set of rules in the given sequence should be performed: Solution of water jug problem according to the production rules:

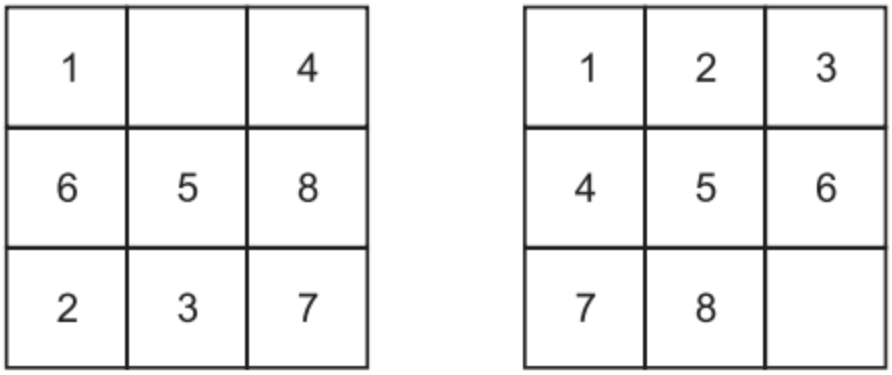
S.No.	4 gallon jug contents	3 gallon jug contents	Rule followed
1.	0 gallon	0 gallon	Initial state
2.	0 gallon	3 gallons	Rule no.2
3.	3 gallons	0 gallon	Rule no. 9
4.	3 gallons	3 gallons	Rule no. 2
5.	4 gallons	2 gallons	Rule no. 7
6.	0 gallon	2 gallons	Rule no. 5
7.	2 gallons	0 gallon	Rule no. 9

On reaching the 7th attempt, we reach a state which is our goal state. Therefore, at this state, our problem is solved.

1.9.4 8-Puzzle Problem

The 8-puzzle problem belongs to the category of "sliding-block puzzle" types of problems. It is described as follows:

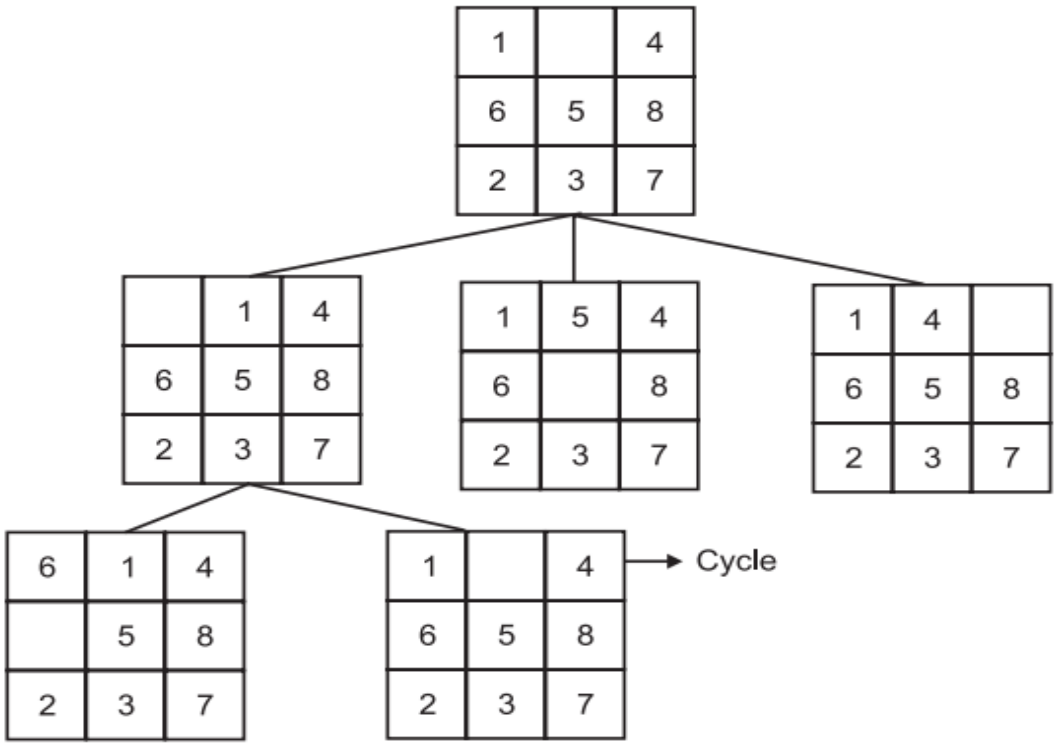
"It has set of a 3x3 board having 9 block spaces out of which, 8 blocks are having tiles bearing number from 1 to 8. One space is left blank. The tile adjacent to blank space can move into it. We have to arrange the tiles in a sequence." The start state is any situation of tiles, and goal state is tiles arranged in a specific sequence. Solution of this problem is reporting of "movement of tiles" in order to reach the goal state. The transition function or legal move is any one tile movement by one space in any direction (i.e. towards left or right or up or down) if that space is blank.



(a) Start state (b) Goal state

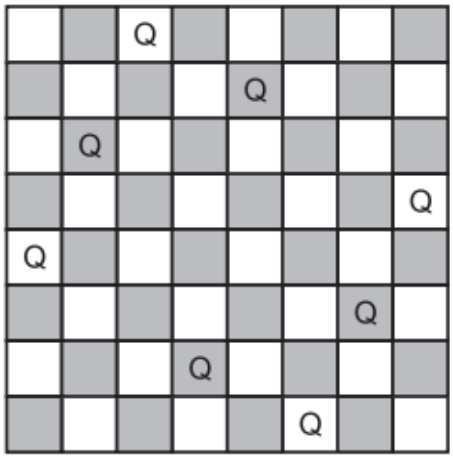
Start and Goal states of 8 puzzle problem

Here the data structure to represent the states can be 9-element vector indicating the tiles in each board position. Hence, a starting state corresponding to above configuration will be {1, blank, 4, 6, 5, 8, 2, 3, 7} (there can be various different start positions). The goal state is {1, 2, 3, 4, 5, 6, 7, 8, blank}. Here, the possible movement outcomes after applying a move can be many. They are represented as tree. This tree is called state space tree. The depth of the tree will depend upon the number of steps in the solution.



Partial search tree of 8-puzzle problem

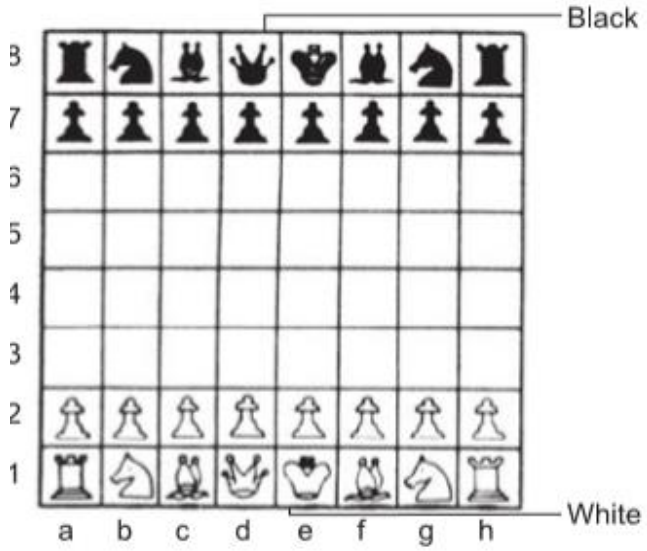
1.9.5 8-Queens Problem



A possible board configuration of 8 queens problem

This problem is presented as follows:“ We have 8 queens and a 8 x 8 chessboard having alternate black and white squares. The queens are placed on the chessboard. Any queen can attack any another queen placed on same row, or column, or diagonal. We have to find the proper placement of queens on the chessboard in such a way that no queen attacks other queen”.

1.9.6 Chess Problem



Start state of chess game

It is a normal chess game. In a chess game problem, the start state is the initial configuration of chessboard. The final or goal state is any board configuration, which is a winning position for any player (clearly, there may be multiple final positions and each board

configuration can be thought of as representing a state of the game). Whenever any player moves any piece, it leads to different state of game. It is estimated that the chess game has more than 10^{120} possible states. The game playing would mean finding (or searching) a sequence of valid moves which bring the board from start state to any of the possible final states.

1.9.7 Missionaries and Cannibals Problem

The problem is stated as follows:

"Three missionaries and three cannibals are present at one side of a river and need to cross the river. There is only one boat available. At any point of time, the number of cannibals should not outnumber the number of missionaries at that bank. It is also known that only two persons can occupy the boat available at a time." The objective of the solution is to find the sequence of their transfer from one bank of river to other using the boat sailing through the river satisfying these constraints. We can form various production rules as presented in water-jug problem. Let Missionary is denoted by 'M' and Cannibal, by 'C'. These rules are described below:

Rule 1 :	(0, M)	:	One missionary sailing the boat from bank-1 to bank-2
Rule 2 :	(M, 0)	:	One missionary sailing the boat from bank-2 to bank-1
Rule 3 :	(M, M)	:	Two missionaries sailing the boat from bank-1 to bank-2
Rule 4 :	(M, M)	:	Two missionaries sailing the boat from bank-2 to bank-1
Rule 5 :	(M, C)	:	One missionary and one Cannibal sailing the boat from bank-1 to bank-2
Rule 6 :	(C, M)	:	One missionary and one Cannibal sailing the boat from bank-2 to bank-1
Rule 7 :	(C, C)	:	Two Cannibals sailing the boat from bank-1 to bank-2
Rule 8 :	(C, C)	:	Two Cannibals sailing the boat from bank-2 to bank-1
Rule 9 :	(0, C)	:	One Cannibal sailing the boat from bank-1 to bank-2
Rule 10 :	(C, 0)	:	One Cannibal sailing the boat from bank-2 to bank-1

All or some of these production rules will have to be used in a particular sequence to find the solution of the problem. The rules applied and their sequence is presented in the following Table.

Table : Rules applied and their sequence in Missionaries and Cannibals problem

After application of rule	persons in the river bank-1	persons in the river bank-2	boat position
Start state	M, M, M, C, C, C	0	bank-1
5	M, M, C, C	M, C	bank-2
2	M, M, C, C, M	C	bank-1
7	M, M, M	C, C, C	bank-2
10	M, M, M, C	C, C	bank-1
3	M, C	C, C, M, M	bank-2
6	M, C, C, M	C, M	bank-1
3	C, C	C, M, M, M	bank-2
10	C, C, C	M, M, M	bank-1
7	C	M, M, M, C, C	bank-2
10	C, C	M, M, M, C	bank-1
7	0	M, M, M, C, C, C	bank-2

Two Marks Questions and Answers

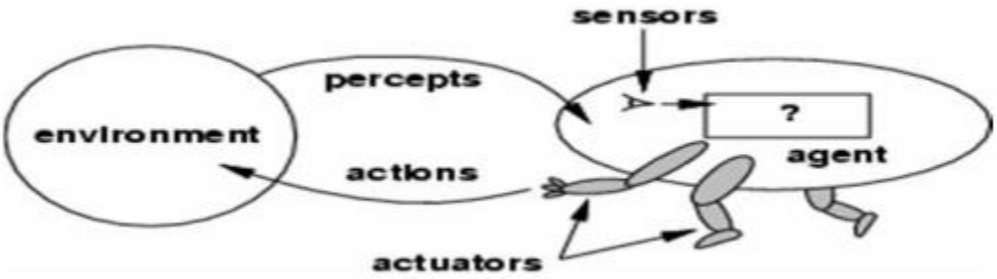
1. What is AI?

Artificial Intelligence is the branch of computer science concerned with making computers behave like humans.

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

2. Define an agent.

An agent is anything that can be viewed as perceiving its environment through sensors and acting upon that environment through actuators.



3. What is an agent function? Differentiate an agent function and an agent program.

An agent's behavior is described by the agent function that maps any given percept sequence to an action.

AGENT FUNCTION	AGENT PROGRAM
An abstract mathematical description	A concrete implementation, running on the agent Architecture.

4. What can AI do today?

- Autonomous Planning and Scheduling
- Game Planning
- Autonomous Control Diagnosis Logistics Planning
- Robotics

5. What is a task environment? How it is specified?

Task environments are essentially the "problems" to which rational agents are the "solutions". A Task environment is specified using PEAS (Performance, Environment, Actuators, and Sensors) description.

6. List the properties of task environments.

- Fully observable vs. partially observable.
- Deterministic vs. stochastic.
- Episodic vs sequential
- Static vs dynamic.
- Discrete vs. continuous.
- Single agent vs. multiagent.

7. What are the four different kinds of agent programs?

- Simple reflex agents;
- Model-based reflex agents;
- Goal-based agents; and
- Utility-based agents.

8. Explain a simple reflex agent with a diagram.

The simplest kind of agent is the simple reflex agent. These agents select actions on the basis AGENT of the current percept, ignoring the rest of the percept history.

9. Explain goal based reflex agent.

Knowing 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 get to. In other words, as well as a current state description, the agent needs some sort of goal information that describes situations that are desirable-for example, being at the passenger's destination.

10. What are utility based agents?

Goals alone are not really enough to generate high-quality behavior in most environments. For example, there are many action sequences that will get the taxi to its destination (thereby achieving the goal) but some are quicker, safer, more reliable, or cheaper than others. A utility function maps a state (or a sequence of states) onto a real number, which describes the associated degree of happiness.

11. What are learning agents?

A learning agent can be divided into four conceptual components. The most important distinction is between the learning element, which is re-ELEMENT possible for making improvements, and performance element, which is responsible for selecting external actions. The performance element is what we have previously considered to be the entire agent: it takes in percepts and decides on actions. The learning element uses CRITIC feedback from the critic on how the agent is doing and determines how the performance element should be modified to do better in the future.

12. Define the problem solving agent.

A Problem solving agent is a goal-based agent. It decides what to do by finding sequence of actions that lead to desirable states. The agent can adopt a goal and aim at satisfying it. Goal formulation is the first step in problem solving.

13. List the steps involved in simple problem solving agent.

- Goal formulation
- Problem formulation
- Search
- Search Algorithm
- Execution phase

14. Define search and search algorithm.

The process of looking for sequences actions from the current state to reach the goal state is called search. The search algorithm takes a problem as input and returns a solution in the form of action sequence. Once a solution is found, the execution phase consists of carrying out the recommended action.

15. What are the components of well-defined problems?

- The initial state that the agent starts in .
- A Successor Function returns the possible actions available to the agent. Given a state successor-FN(x) returns a set of {action, successor} ordered pairs where each action is one of the legal actions in state x, and each successor is a state that can be reached from x by applying the action.
- The goal test determines whether the given state is a goal state.
- A path cost function assigns numeric cost to each action. For the Romania problem the cost of path might be its length in kilometers.

16. Differentiate toy problems and real world problems.

TOY PROBLEMS	REAL WORLD PROBLEMS
A **toy problem** is intended to illustrate various problem solving methods. It can be easily used by different researchers to compare the performance of algorithms.	A **real world problem** is one whose solutions people actually care about.

17. Give examples of real world problems.

(ii) Touring problems

(iii) Travelling Salesperson Problem(TSP)

(iv) VLSI layout

(v) Robot navigation

(vi) Automatic assembly sequencing

(vii) Internet searching

18. What does Turing test mean?

The Turing test proposed by Alan Turing was designed to provide a satisfactory operational definition of intelligence. Turing defined intelligent behavior as the ability to achieve human level performance in all cognitive tasks, sufficient to fool an interrogator.

19. Define an Omniscient agent.

An omniscient agent knows the actual outcome of its action and can act accordingly; but omniscience is impossible in reality.

20. How agent should act?

Agent should act as a rational agent. Rational agent is one that does the right thing, (i.e.) right actions will cause the agent to be most successful in the environment.

PART B (13 MARK QUESTIONS)

1. Explain in detail about Problem Solving Approach to Typical AI Problems.
2. What are the types of Agents? Describe it in detail.
3. Discuss in detail about the History of AI.
4. Explain briefly about the properties of Environments.
5. Write short notes on
    a) Agent
    b) Intelligent Agent.