ARTIFICIAL INTELLIGENCE

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UNIT 1: Fundamentals Of AI

INTRODUCTION

What is AI?

1. According to the father of AI, John McCarthy, AI is "The science and engineering of making intelligent machines, especially intelligent computer programs".
2. AI is accomplished by studying how the 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.

Intelligence

1. It is the computational part of the ability to achieve goals in the world.
2. Or the ability to learn and solve problems.
3. Or the ability to acquire and apply knowledge.
4. Intelligence is composed of
    a. Reasoning
    b. Learning
    c. Problem Solving
    d. Perception
    e. Linguistic Intelligence

Philosophy Behind AI

1. The development of AI started with the intention of creating similar intelligence in machines that we find and regard high in humans.

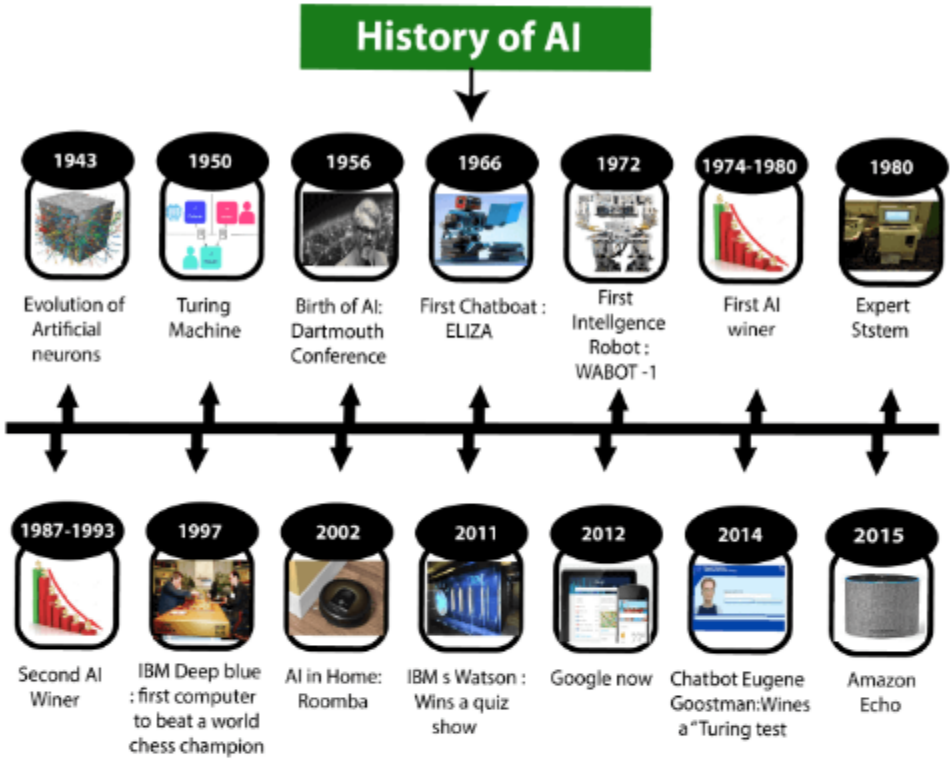
Goals Of AI

1. To create expert systems: The system that exhibits intelligent behaviour, to learn, demonstrate, explain and advise its users.
2. To implement human intelligence in machines: Creating systems that understand, think, learn and behave like humans.

History 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.



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:** Alan Turing who was an English mathematician and pioneered Machine learning in 1950. Alan Turing published "Computing Machinery and Intelligence" in which he proposed a test. The test can check the machine's ability to exhibit intelligent behaviour equivalent to human intelligence, called a Turing test.

The birth of Artificial Intelligence (1952-1956)

- **Year 1955:** Allen Newell and Herbert A. Simon created the "first artificial intelligence program"Which was named as "Logic Theorist". This program has proved 38 of 52 Mathematics theorems, and found 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 was 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.

The golden years-Early enthusiasm (1956-1974)

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

The first AI winter (1974-1980)

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

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 1980, the first national conference of the American Association of Artificial Intelligence was held at Stanford University.

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 funding for AI research due to high cost but not efficient result. The expert system such as XCON was very cost effective.

The emergence of intelligent agents (1993-2011)

- **Year 1997:** In the year 1997, IBM Deep Blue beat 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.

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 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 appointments on call, and the lady on the 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.

State of the art

- Deep Blue defeated the reigning world chess champion Garry Kasparov in 1997
- Proved a mathematical conjecture (Robbins conjecture) unsolved for decades
- No hands across America (driving autonomously 98% of the time from Pittsburgh to San Diego)
- During the 1991 Gulf War, US forces deployed an AI logistics planning and scheduling program that involved up to 50,000 vehicles, cargo, and people
- NASA's on-board autonomous planning program controlled the scheduling of operations for a spacecraft
- `Proverb` solves crossword puzzles better than most humans
- DARPA grand challenge 2003-2005, Robocup

Applications of AI

1. **Gaming:** Strategic games such as chess, poker, tic-tac-toe, etc, machines can think of a large number of possible positions based on heuristic knowledge..
2. **Natural Language Processing:** Interact with a computer that understands natural languages spoken by humans.
3. **Expert Systems:** Softwares that integrates machine, software and special information to prove reasoning and advice.
4. **Vision Systems:** Understand, interpret and comprehend visual input on the computer. Eg: Spying Aeroplane to take map pictures, doctors to diagnose patients, police to recognise criminals.
5. Speech Recognition
6. Handwriting Recognition
7. Intelligent Robots
8. Marketing
9. Finance (Fraud Detection, Assessment of risks, Financial Advisory)
10. Health Care (Managing medical records, drug creation, healthcare bots)

Benefits of Artificial Intelligence

1. Less Errors and better precision
2. Helping with daily activities
3. Assisted digital help
4. Work 24/7, 365 days/year and do not need holidays and breaks
5. More precise and accurate
6. They are not paid
7. They can be used in dangerous places such as nuclear power stations as opposed to humans who can be in danger.
8. Fast decision making

Disadvantages OF Existing AI Machines

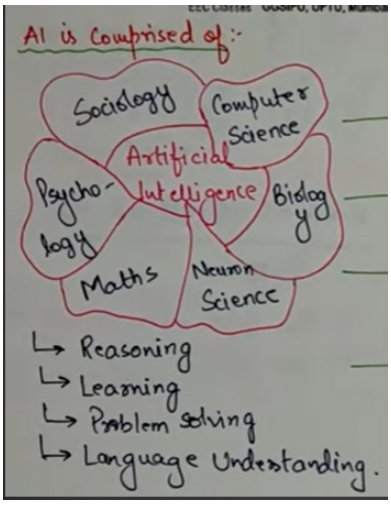
1. High costs of creation
2. Unemployment
3. No human replication due to lack of emotions
4. Zero creativity
5. No improvement with experience
6. More dependency on machines

Risks of AI

1. **AI can do something devastating:** There are various applications of AI which are even used to design autonomous weapons and missiles. In the wrong hands, this could be highly devastating. Wrong use of AI could lead to an AI war too. This is not a present threat, however, because narrow AI is harmless. But this could be an increasing concern as the levels of AI increase.
2. **AI is programmed to do something but it develops a destructive method to achieve the goal:** What we have in mind, can be extremely difficult to feed into the machines. Just like GIGO (garbage in garbage out), we need to be highly careful in aligning the AI's goals to ours. For example, if you ask a self-driving car to take you to the airport as fast as possible, it might exceed the speed limit, make you nauseous due to the high speed, and can even land you in legal disputes due to the breach of the speed limit. Another example in the higher levels of AI can be – if you design an AI and ask it to take measures to balance the ecosystem, it might just go and kill some of the people to reduce the population to normal so that the ecosystem is balanced.
3. **AI can someday overpower humans:** The reason why humans sit at the top of the ladder of all creatures is that we are the smartest of the species there ever exist. If we develop an AI which is smarter than us, it may pose a threat to humans. Various movies are based on this concept. Also, famous scientists like Stephen Hawking, Elon Musk, etc are highly concerned about the same issue.

Approaches Of AI

1. **Acting Humanly (The Turing Test Approach):** This approach was designed by Alan Turing. The ideology behind this approach is that a computer passes the test if a human interrogator, after asking some written questions, cannot identify whether the written responses come from a human or from a computer.
2. **Thinking Humanly (The cognitive Approach):** The idea behind this approach is to determine whether the computer thinks like a human.
3. **Thinking rationally (The "laws of thought" approach):** The idea behind this approach is to determine whether the computer thinks rationally i.e. with logical reasoning.
4. **Acting rationally (The rational agent approach):** The idea behind this approach is to determine whether the computer acts rationally i.e. with logical reasoning.



Forms of AI:

1) Weak AI:

- Weak AI is an AI that is created to solve a particular problem or perform a specific task.
- It is not a general AI and is only used for specific purposes.
- For example, the AI that was used to beat the chess grandmaster is a weak AI as it serves only 1 purpose but it can do it efficiently.

2) Strong AI:

- Strong AI is more difficult to create than weak AI.
- It is a general purpose intelligence that can demonstrate human abilities.
- Human abilities such as learning from experience, reasoning, etc. can be demonstrated by this AI.

3) Super Intelligence

- As stated by a leading AI thinker Nick Bostrom, "Super Intelligence is an AI that is much smarter than the best human brains in practically every field".
- It ranges from a machine being just smarter than a human to a machine being trillion times smarter than a human.

- Super Intelligence is the ultimate power of AI.

Agents And Environment

1. An AI system is composed of an agent and its environment. An agent(human or robot) is anything that can perceive its environment through sensors and acts upon that environment through effectors or actuators.
2. Intelligent agents must be able to set goals and achieve them.

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

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

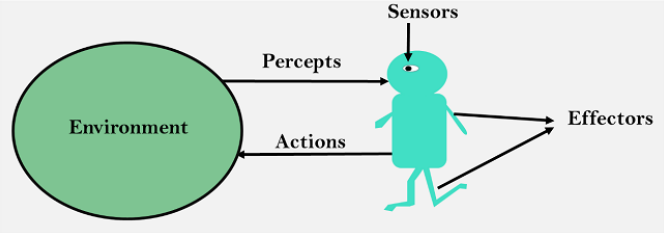
Hence the world around us is full of agents such as thermostat, cellphone, camera, and even we are also agents.

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 components of machines that convert 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 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.

Rational Agent:

A rational agent is an agent which has clear preference, models uncertainty, and acts in a way to maximise 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 the AI reinforcement learning algorithm, for each best possible action, the agent gets the positive reward and for each wrong action, an agent gets a negative reward.
Note: Rational agents in AI are very similar to intelligent agents.

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.

Note: Rationality differs from Omniscience because an Omniscient agent knows the actual outcome of its action and acts accordingly, which is not possible in reality.

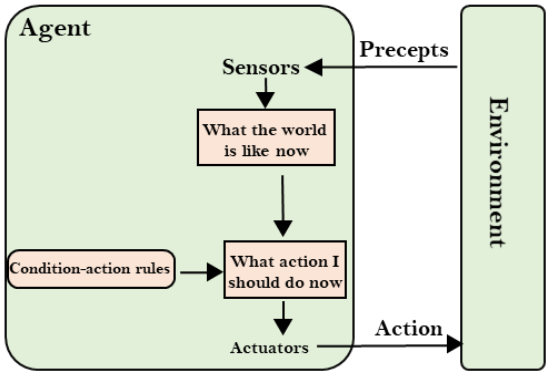
Types of Agents

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 time. These are given below:

1. Simple Reflex agent:

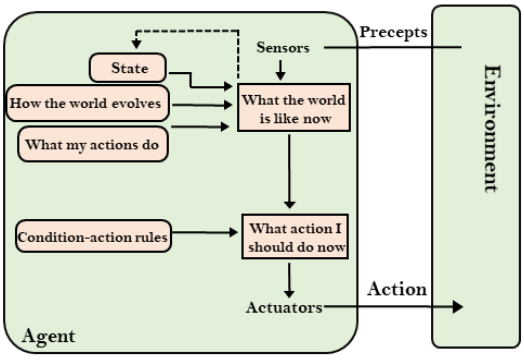
- The Simple reflex agents are the simplest agents. These agents take decisions on the basis of the current percepts and ignore the rest of the percept history.
- These agents only succeed in the fully observable environment.
- The Simple reflex agent does not consider any part of perceived history during 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.

- 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.



2. Model-based reflex agent

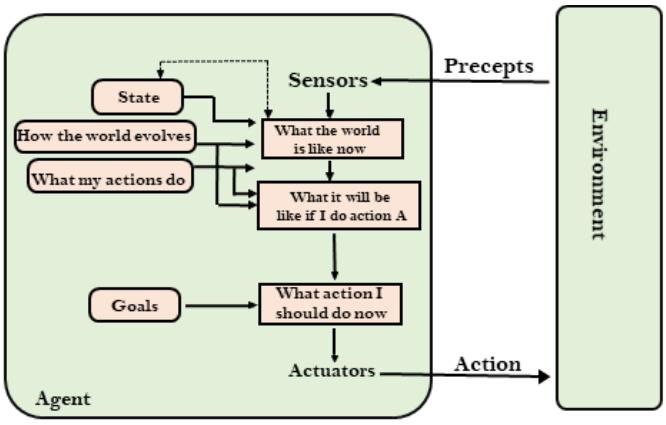
- The Model-based agent can work in a partially observable environment, and track the situation.
- A model-based agent has two important factors:
    a. Model: It is knowledge about "how things happen in the world," so it is called a Model-based agent.
    b. Internal State: It is a representation of 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:
    a. How the world evolves
    b. How the agent's action affects the world.



3. Goal-based agents

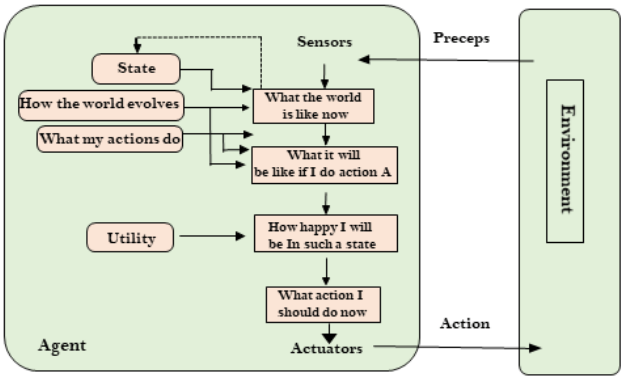
- The knowledge of the current state environment is not always sufficient to decide for an agent what to do.
- The agent needs to know its goal which describes desirable situations.
- Goal-based agents expand the capabilities of the model-based agent by having the "goal" information.

- They choose an action, so that they can achieve the goal.
- Agents may have to consider a long sequence of possible actions before deciding whether the goal is achieved or not. Such considerations of different scenarios are called searching and planning, which makes an agent proactive.



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.
- These acts are based not only on 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.

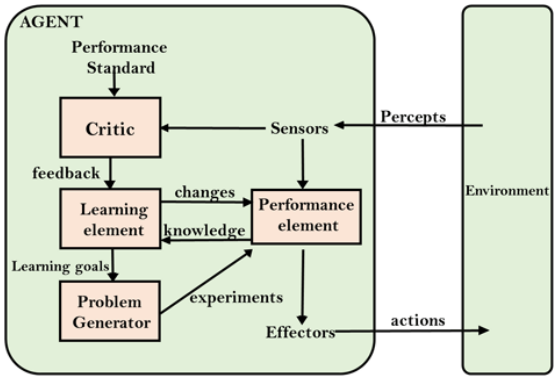


5. Learning Agents

- A learning agent in AI is the type of agent which can learn from its past experiences, or it has learning capabilities.
- It starts with basic knowledge and then is 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 the critic which describes 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, analyse performance, and look for new ways to improve the performance.



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:

1. **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.

1. **f:P* → A**

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 the 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 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.
Example of Agents with their PEAS representation

Agent	Performance measure	Environment	Actuators	Sensors
1. Medical Diagnose	• Healthy patient • Minimised 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.

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 the agent lives, operates and provides the agent with something to sense and act upon. An environment is mostly said to be non-feminist.
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 of the 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 an 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, an 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 a 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 a 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 environments.

5. Static vs Dynamic:

- If the environment can change itself while an agent is deliberating then such an environment is called a dynamic environment else it is called a static environment.
- Static environments are easy to deal with because an agent does not need to continue looking at the world while deciding for an action.

- However, for a 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 a continuous environment.
- A chess game comes under a 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 an unknown environment, an agent needs to learn how it works in order to perform an action.
- It is quite possible for 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.

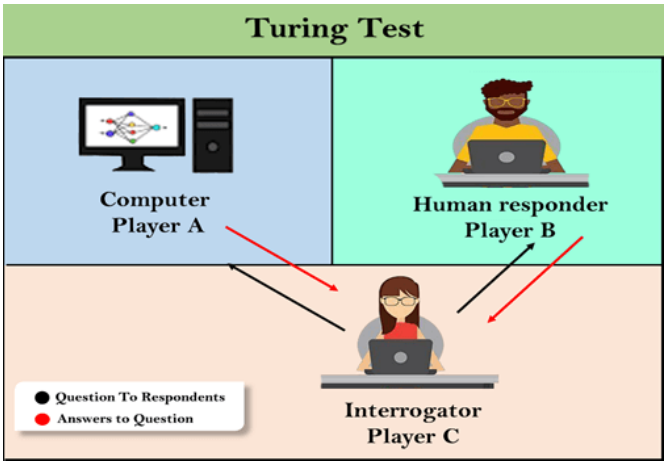
Conclusion

There are mainly six groups of environment and an environment can be in multiple groups. Below are 10 more real-life examples and categories into environment groups.

	Fully vs Partially Observable	Deterministic vs Stochastic	Episodic vs Sequential	Static vs Dynamic	Discrete vs Continuous	Single vs Multi Agents
Brushing Your Teeth	*Fully*	*Stochastic*	*Sequential*	*Static*	*Continuous*	*Single*
Playing Chess	*Partially*	*Stochastic*	*Sequential*	*Dynamic*	*Continuous*	*Multi-Agent*
Playing Cards	*Partially*	*Stochastic*	*Sequential*	*Dynamic*	*Continuous*	*Multi-Agent*
Playing	*Partially*	*Stochastic*	*Sequential*	*Dynamic*	*Continuou*	*Multi Agent*
Autonomous Vehicles	*Fully*	*Stochastic*	*Sequential*	*Dynamic*	*Continuous*	*Multi-Agent*
Order in Restaurant	Fully	Deterministic	Episodic	Static	Discrete	Single Agent

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 intelligent if it can mimic human response under specific conditions.
The Turing Test was introduced by Turing in his 1950 paper, "Computing Machinery and Intelligence," which considered the question, "Can machines 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 which player is the 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 a 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 are 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 announced the prize competition, offering a $100,000 prize for the first computer to pass the Turing test. However, no AI program to date, comes close to passing an undiluted Turing test".

Chatbots to attempt the 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 machines and humans. It was one of the first chatterbots, which 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 various Turing Tests. 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 a 13-year old virtual boy.

The Chinese Room Argument:

There were many philosophers who really disagreed with the complete concept of Artificial Intelligence. The most famous argument in this list was "Chinese Room."
In the year 1980, John Searle presented the "Chinese Room" thought experiment, in his paper "Mind, Brains, and Program," which was against the validity of Turing's Test. According to his argument, "Programming a computer may make it to understand a language, but it will not produce a real understanding of language or consciousness in a computer."
He argued that machines such as ELIZA and Parry could easily pass the Turing test by manipulating keywords and symbols, but they had no real understanding of language. So it cannot be described as the "thinking" capability of a machine such as a human.
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 generalised 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.