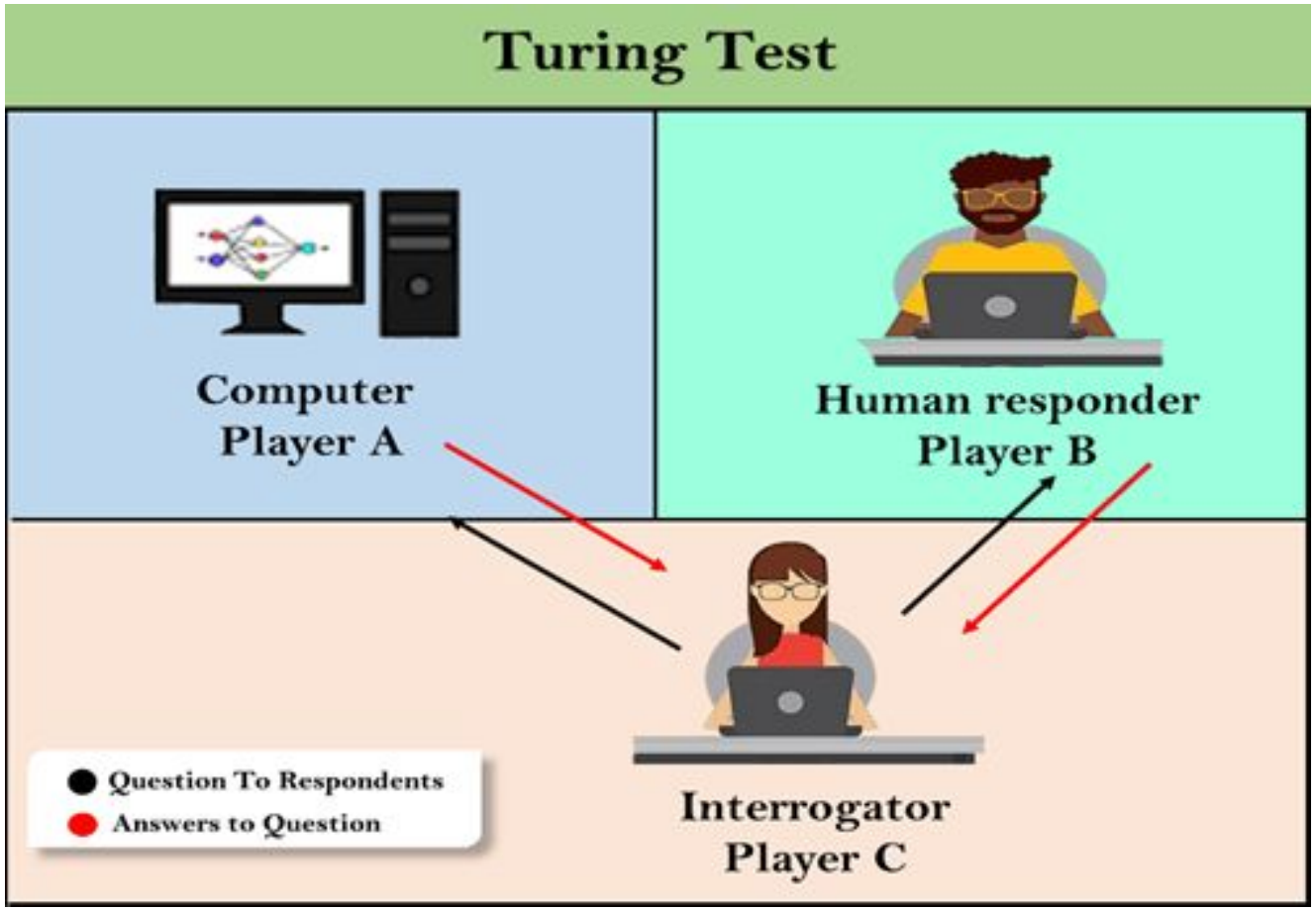
Approaches to AI

Turing Test

- Turing Test was introduced by Turing in his 1950 paper, "Computing Machinery and Intelligence," which considered the question, "Can Machine think?"
- 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.
  - So, The success of an intelligent behavior of a system can be measured with Turing Test.

Turing Test

- Two persons and a machine to be evaluated participate in the test.
- Out of the two persons, one plays the role of the tester.
- Each of them sits in different rooms.
- The tester is unaware of who is machine and who is a human.
- He/She interrogates the questions by typing and sending them to both intelligences, to which he receives typed responses.
- This test aims at fooling the tester.
- If the tester fails to determine machine's response from the human response, then the machine is said to be intelligent.


Turing Test
Computer
Player A
Human responder
Player B
Question To Respondents
Answers to Question
Interrogator
Player C

Turing Test

- 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?
  - **Player A (Computer):** No
  - **Interrogator:** Multiply two large numbers such as (256896489*456725896)
  - **Player A:** Long pause and give the wrong answer.

Turing Test

- 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.

Competition for Turing Test

- "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 till date, come 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 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.

Chatbots to attempt the Turing test

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 contestant, in which it has convinced 29% of judges that it was a human.
- Goostman resembled as 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**."

The Chinese Room Argument

- In the year **1980, John Searle** presented "**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 Machine such as ELIZA and Parry could easily pass the Turing test by manipulating keywords and symbol, but they had no real understanding of language.
- So it cannot be described as "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 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.

AI System

- An AI system is composed of an agent and its environment.
- The agents act in their environment.
- The environment may contain other agents.

Intelligent Agent

- A program
  - Persistent
    - It persists all the time as long as they are alive like all of us. Not like normal programs that when run does something for us.
  - Autonomous
    - When it is executing, it takes its own decisions.
  - Proactive
    - They decide what is the next course of action to be done and they have goals to achieve essentially.
  - Goal Directed
    - since it decides goals to achieve higher level goals set by user, in that sense it is also goal directed.

knowing

- There are several ways one can know something
  - Empiricism: involves acquiring knowledge through observation and experience
    - Seeing is believing? Mind fake videos
  - The Scientific Method: is a process of systematically collecting and evaluating evidence to test ideas and answer questions
    - As physicists do lot of experiments
  - Intuition: Rather than examining facts or using rational thought, intuition involves believing what feels true
  - Authority: Accepting ideas because some authority figure says that they are true
    - My teacher/mother said so!
  - Rationalism: involves using logic and reasoning to acquire new knowledge.

Inferences

- Reasoning = Making Inferences
- If an agent knows something what else can the agent know?

Types of inferences

- Deduction: from a given set of facts infer another fact that is *necessarily* true
  - From Cause to Effect
  - Example: if we know that anyone has certain disease we can infer that he/she will show those symptoms that necessarily follows because there is a causal connection between disease and the symptoms that occur because of that.
- Abduction: from a given set of facts infer another fact that is possibly true
  - From Effect to Cause
  - Generally what we do is we go in the other direction: we look at the symptoms and we infer the disease. That may not necessarily (always) be true but possibly true (that's why doctors ask for some test)
  - Doctors generally use abduction
  - It has been shown that abduction is not always a valid form of reasoning.
- Induction: from a given set of facts infer a new fact
  - Also known as generalization: recognizing that a number of entities in the domain share some common property, and assert that as a general statement
  - The peepul leaf is green, the neem leaf is green, The Mango leaf is green….
  - All leaves are green.

Induction

- What is the next number in the series
  - 1, 2, 3, 4, ….

RA 1 (Remote Agent 1)

- Example of one of the most well known Agent softwares
- Implemented by NASA many years ago
- You give it some goals and send it into space and then they demonstrated it takes some decisions autonomously
  - Even if it ran into some faults, it could detect those faults and get around them in some way etc.

What are Intelligent Agent and Environment?

- 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.
  - A **software agent** has encoded bit strings as its programs and actions.

- **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.

Agent Terminology

- **Performance Measure of Agent**
  - It is the criteria, which determines how successful an agent is.
- **Behavior of Agent**
  - It is the action that agent performs after any given sequence of percepts.
- **Percept**
  - It is agent's perceptual inputs at a given instance.
- **Percept Sequence**
  - It is the history of all that an agent has perceived till date.
- **Agent Function**
  - It is a map from the precept sequence to an action.

Structure of Intelligent Agents

- To understand the structure of Intelligent Agents, we should be familiar with *Architecture* and *Agent* programs.
- **Architecture** is the machinery that the agent executes on. It is a device with sensors and actuators, for example, a robotic car, a camera, a PC.
- **Agent program** is an implementation of an agent function. An agent program executes on the physical architecture to produce function f.
- *Agent = Architecture + Agent Program*

Rationality

- Rationality is concerned with expected actions and results depending upon what the agent has perceived.
- Rationality is nothing but status of being reasonable, sensible, and having good sense of judgment.
- Performing actions with the aim of obtaining useful information is an important part of rationality.

Rational agent approach in artificial intelligence

- Artificial intelligence is defined as the study of rational agents.
- A rational agent could be anything that makes decisions, as a person, firm, machine, or software.
- It carries out an action with the best outcome after considering past and current percepts (agent's perceptual inputs at a given instance).
- AI is about creating rational agents to use for game theory and decision theory for various real-world scenarios.

Game Theory

- It is a branch of applied mathematics that provides tools for analyzing situations in which parties, called players, make decisions that are interdependent.
- This interdependence causes each player to consider the other player's possible decisions, or strategies, in formulating strategy.

Decision Theory

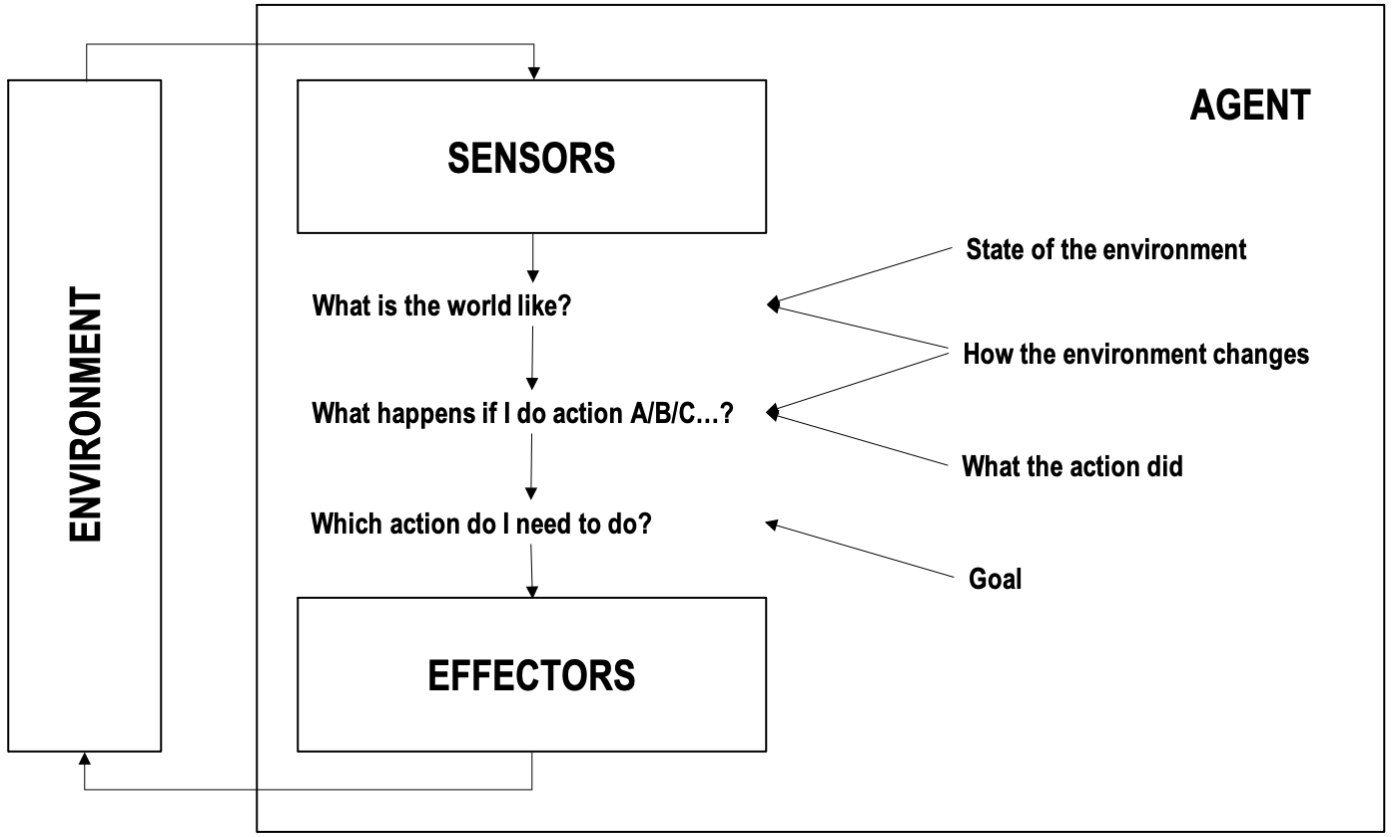
- Decision theory is **the study of a person or agents' choices**.
- The theory helps us understand the logic behind the choices professionals, consumers, or even voters make.
- The choices come with consequences.

Rational Agent

- 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.

How Does a Rational Agent Work?

- A rational agent is essentially a goal-based agent.
- It assesses its environment by considering what it is like.
- It then looks at each available action in its arsenal and determines how it will affect the environment and help it attain its goal.
- It tries out all the possible steps before choosing the best one, that will move it closest to its objective.



How Does a Rational Agent Work?

- A sensor could be a camera, an infrared device, a sonar, an ultrasound, a radar, or a lidar in the image above.
- It helps an AI robot determine an object's or its surroundings, size, identify a thing, and determine distances.
- An effector, meanwhile, is any device that affects a particular environment.
  - It could be a robot's legs, wheels, arms, fingers, wings, or fins.

Real-World Applications of a Rational Agent

- Rational agents are also used in
  - self-driving vehicles,
  - energy-saving air-conditioning units,
  - automated lights,
  - Autonomous vacuum cleaner, and
  - other devices that need environmental inputs to decide the best course of action to take

Vacuum Cleaner

- A rational agent can be used for an autonomous vacuum cleaner.
- When it runs, it always looks at its surroundings to determine where it will go next.
- If something is preventing it from moving to the left (e.g., a sofa leg), it will consider moving to the right and do so if it can.
- It moves around a room, avoiding obstructions (i.e., furniture) while moving back and forth, sucking dirt when present.
- It has the environment as the floor which it is trying to clean.
- It has sensors like Camera's or dirt sensors which try to sense the environment.
- It has the brushes and the suction pumps as actuators which take action.

What Makes a Rational Agent Effective?

- A rational agent works if you can measure its performance.
- The higher its performance measure is, the more rational an agent is.
- Its performance measure is gauged using these criteria:
  - How well it achieves its goals
  - How well it assesses its environment
  - How many actions it can perform

A self-driving car

- A self-driving car, for example, is rational if it can bring you safely and comfortably where you need to go in the shortest amount of time.
- It needs to follow road signs and directions and avoid other vehicles, people, and other obstructions, including traffic.
- Autonomous vehicles have sensors that include cameras, sonars, Global Positioning System (GPS) devices, speedometers, odometers, accelerometers, and keyboards.
- They also have actuators, including steering wheels, accelerators, brakes, signals, and horns.

So, what is a rational agent?

- Similar to our **brain**, which tells parts of your body (e.g., your arms and legs) what to do when your sensors (e.g., eyes, ears, and nose) sense something in your surroundings you need to avoid so you will not get hurt.

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

PEAS for self-driving cars

- **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.

Types of Agents

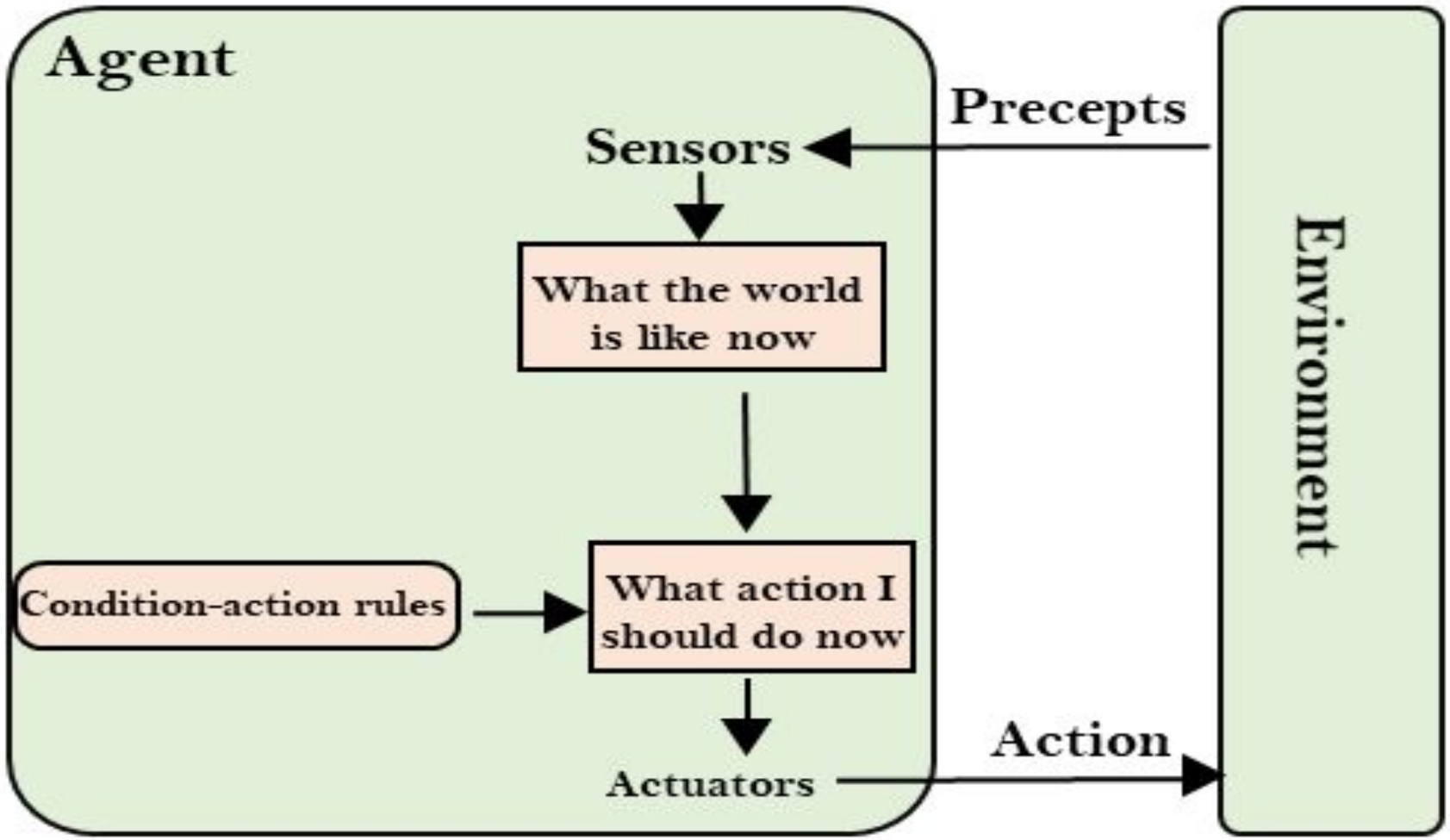
- Agents can be grouped into five classes based on their degree of perceived intelligence and capability
  - Simple Reflex Agents
  - Model Based Reflex Agents
  - Goal Based Agents
  - Utility Based Agents
  - Learning Agents

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.

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.


Agent
Precepts
Sensors
What the world is like now
Environment
Condition-action rules
What action I should do now
Action
Actuators

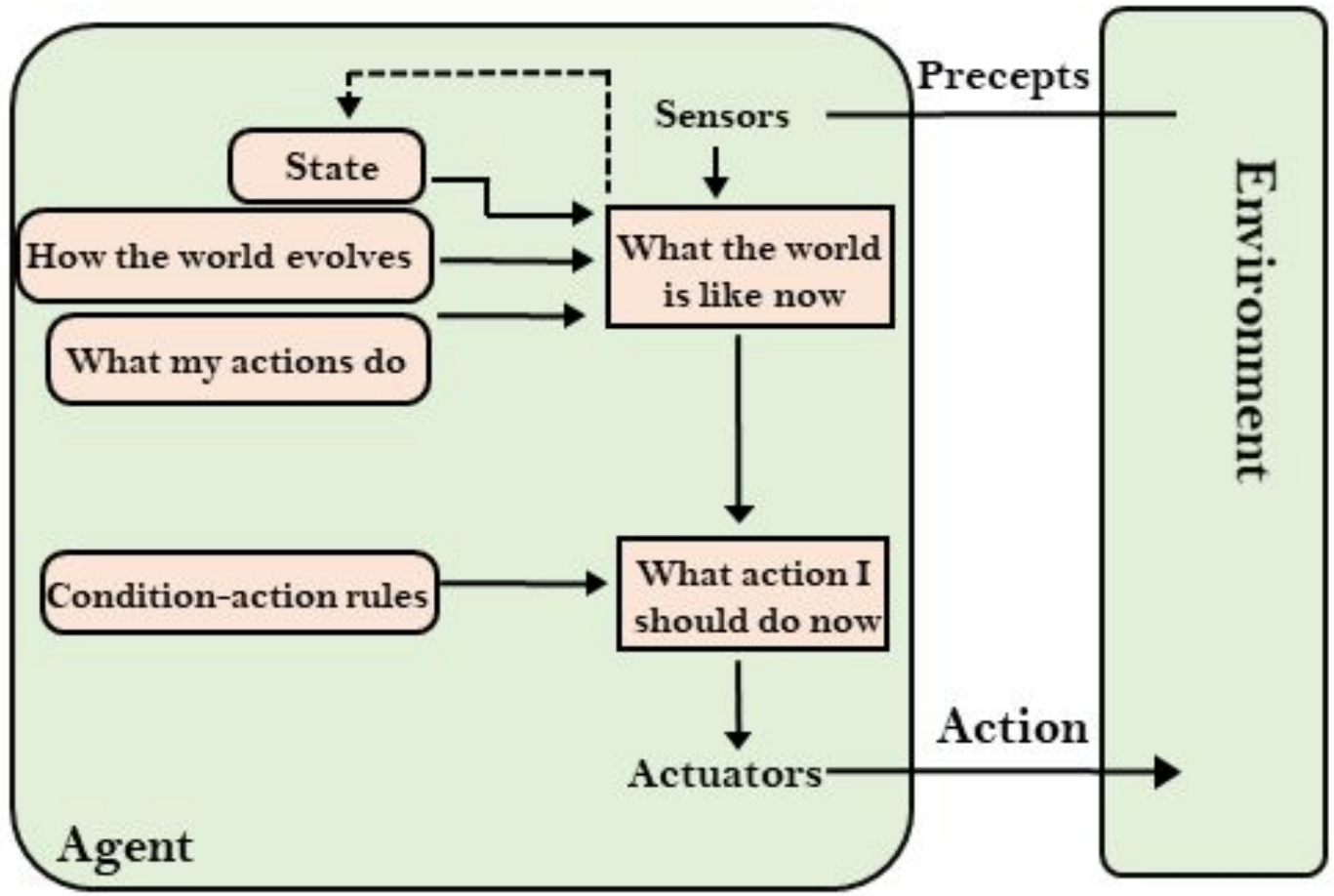
Model-based reflex agent

- The agent which performs actions based on current input as well as the previous input
- A Simple Reflex agent does not succeed in a partially observable environments. Thus, to overcome its limitations, this agent is designed.
- The reason for the success of a this agent is – the agent maintains some sort of internal state.
- The internal state depends upon the percept history and thus reflects atleast some of the unobserved aspects of the current state.
- In order to maintain the internal state of the world, an agent must,
  1. Know how agent's own actions affect the world. (Eg. : If the agent turns the steering clockwise, the car is bound to move towards the right).
  2. Know how the world evolves independent of an agent. (Eg. : A car trying to overtake will generally close behind the car than it was seconds ago)
- This knowledge about "how the world works" is called as the "Model" of the world.

Model-based reflex agent

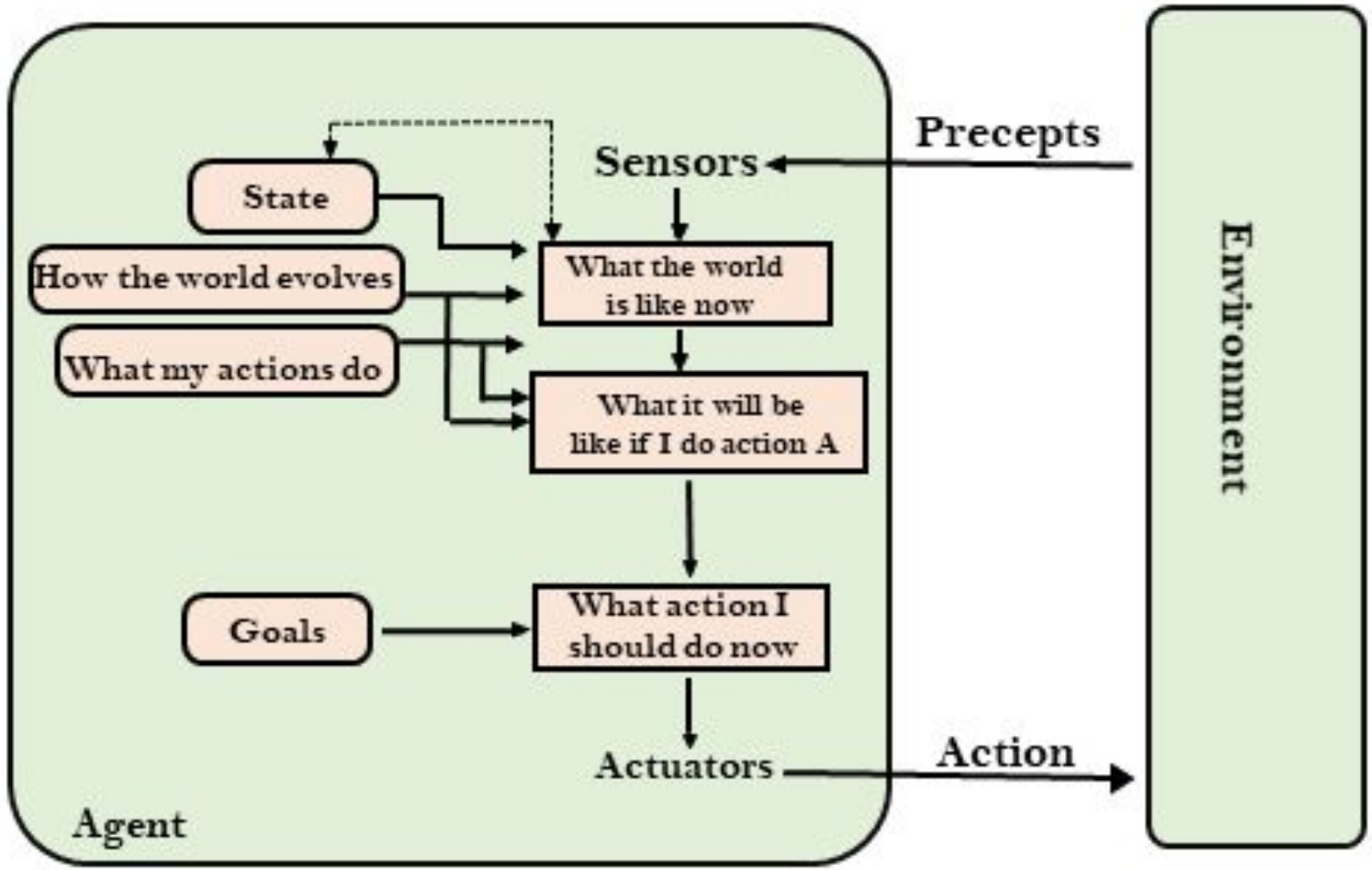
- These agents have the model, "which is knowledge of the world" and based on the model they perform actions.
- The Model-based agent can work in a partially observable environment, and track the situation.
- A model-based agent has two important factors:
  - **Model:** It is knowledge about "how things 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.

- Updating the agent state requires information about:
  - How the world evolves
  - How the agent's action affects the world.


Precepts
Sensors
State
How the world evolves
What my actions do
What the world is like now
Environment
Condition-action rules
What action I should do now
Action
Actuators
Agent

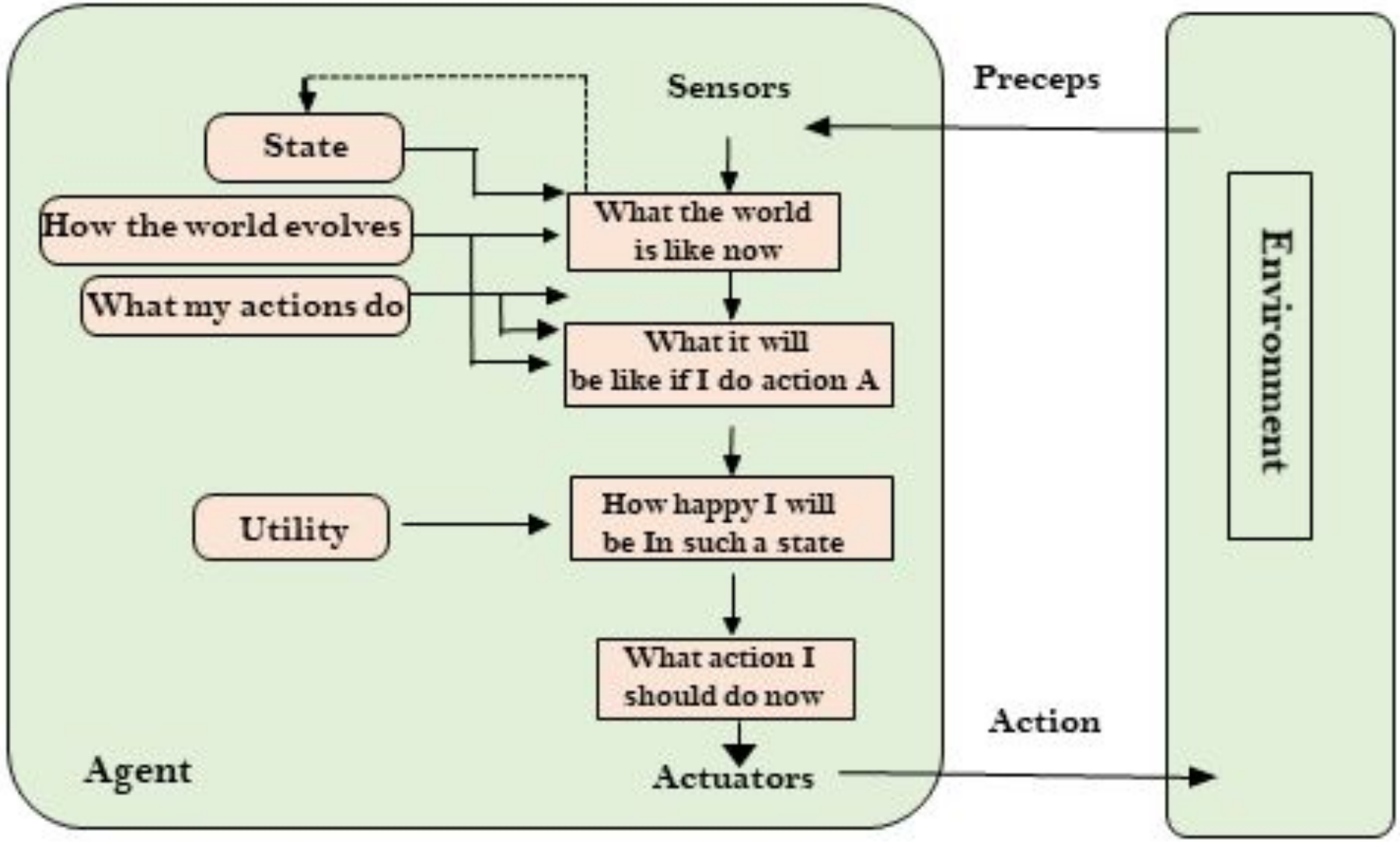
Goal-based agents

- 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.


Precepts
Sensors
State
How the world evolves
What my actions do
What the world is like now
What it will be like if I do action A
Goals
What action I should do now
Actuators
Action
Agent
Environment

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.

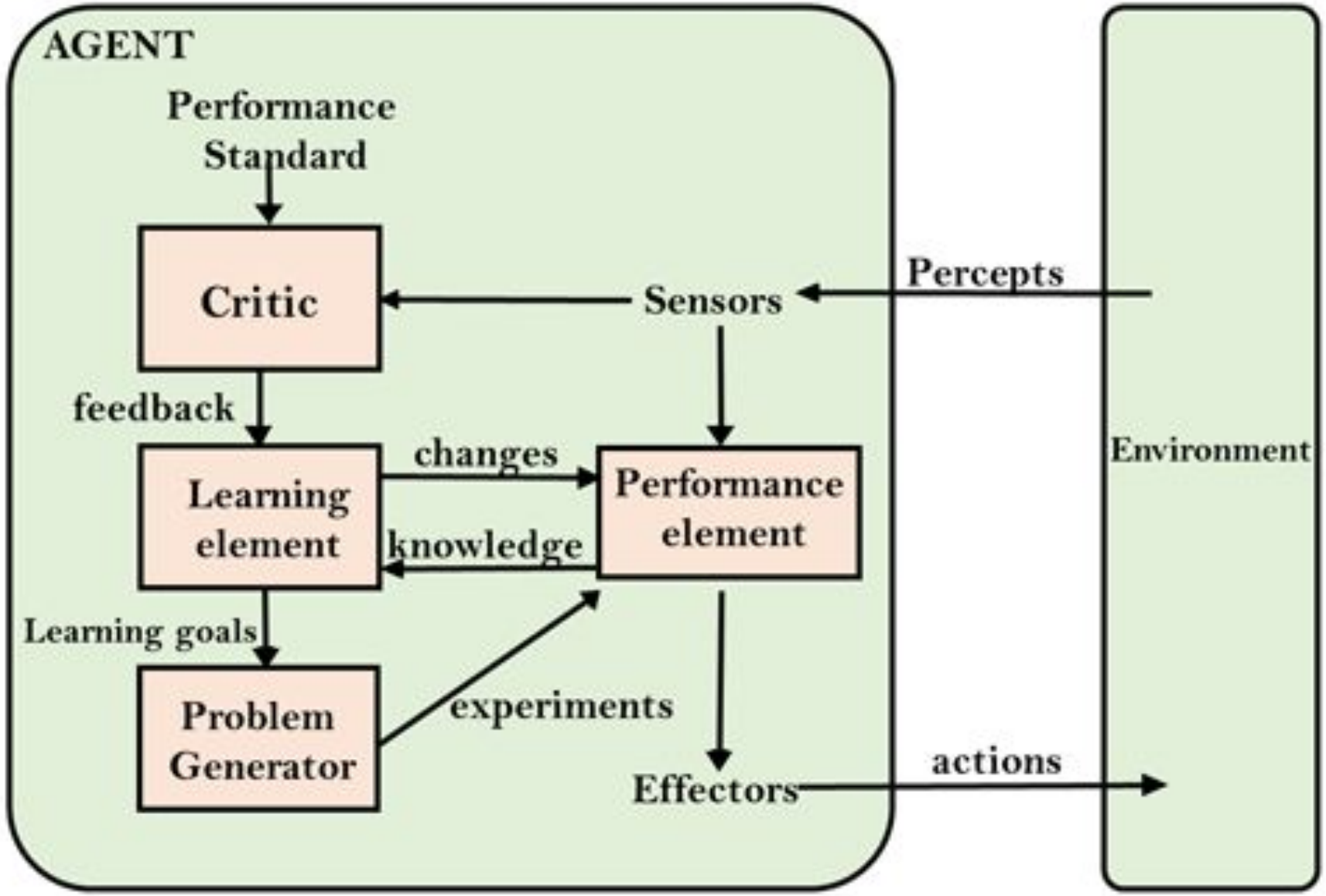

Sensors
Preceps
State
How the world evolves
What my actions do
What the world is like now
What it will be like if I do action A
Utility
How happy I will be In such a state
What action I should do now
Actuators
Action
Agent
Environment

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.
- Unlike intelligent agents that act on information provided by a programmer, learning agents are able to perform tasks, analyze performance, and look for new ways to improve on those tasks - all on their own.

Learning agent

- A learning agent has mainly four conceptual components, which are:
  - **Learning element:** It is responsible for making improvements by learning from environment
  - **Critic:** Learning element takes feedback from critic which describes that how well the agent is doing with respect to a fixed performance standard.
  - **Performance element:** It is responsible for performance evaluation
  - **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.


AGENT
Performance Standard
Critic
Sensors
Percepts
feedback
changes
Learning element
Performance element
knowledge
Environment
Learning goals
Problem Generator
experiments
Effectors
actions

Agent Environment in AI

- An environment is everything in the world which surrounds the agent, but it is not a part of an agent itself.
- An environment can be described as a situation in which an agent is present.
- The environment is where agent lives, operate and provide the agent with something to sense and act upon it.

Features of Environment

- 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

Fully observable vs Partially Observable

- an environment where the agent has complete and accurate information about the current state of the environment at any given time.
- Tic-Tac-Toe Game: In the game of Tic-Tac-Toe, the board is a 3x3 grid, and each cell can be empty or occupied by either an "X" or an "O." The agent has complete knowledge of the current state of the board, including the positions of all the X's and O's. The agent can observe the entire board and make decisions accordingly.
- the AI agent does not have complete knowledge of the current state of the environment.
- Poker Game: In a game of poker, each player holds a set of cards that are hidden from other players. The agent can only see its own cards and the community cards (cards placed on the table), but it cannot directly observe the cards held by other players. The agent has to infer the potential cards held by opponents based on their actions and behaviors.

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.

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.
- In an episodic environment, the agent's experience or interaction is divided into discrete episodes or individual episodes.
- The agent's actions and decisions in one episode do not directly impact subsequent episodes.
- In a sequential environment, the agent's experience or interaction is continuous and unfolds over time.
- The current state and subsequent actions of the agent can be influenced by past actions and observations.

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.

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.

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.

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.