ARTIFICIAL INTELLIGENCE

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What is Intelligence?

" Intelligence can be defined as one's capacity for understanding, self-awareness, learning, emotional knowledge, planning, creativity, and problem solving "

- Artificial intelligence is *intelligence in machines*
- It is commonly implemented in computer systems using program software
- Accordingly there are two possibilities:
  - A system with intelligence is expected to behave as intelligently as a human
  - A system with intelligence is expected to behave in the best possible manner

ARTIFICIAL INTELLIGENCE

Artificial intelligence (AI) is a wide-ranging branch of computer science concerned with building smart machines capable of performing tasks that typically require human intelligence.

Artificial intelligence is the simulation of human intelligence processes by machines, especially computer systems. Specific applications of AI include expert systems, natural language processing, speech recognition and machine vision.

" Artificial intelligence (AI) is a field of computer science that emphasizes on the creation of intelligent machines which can work and react like humans "

Can machines think? – Alan Turing, 1950

- **Create Machine just like a Human Being**
- **Artificial intelligence allows machines to model, and even improve upon, the capabilities of the human mind.**
- **Specific applications of AI include expert systems, natural language processing, speech recognition and machine vision.**

The automation of activities that we associate with human thinking, activities such as decision-making, problem solving, learning ..." (Bellman, 1978)

The exciting new effort to make computers think ... *machines with minds*, in the full and literal sense" (Haugeland, 1985)

The study of mental faculties through the use of computational models" (Charniak and McDermott, 1985)

The art of creating machines that perform functions that require intelligence when performed by people" (Kurzweil, 1990)

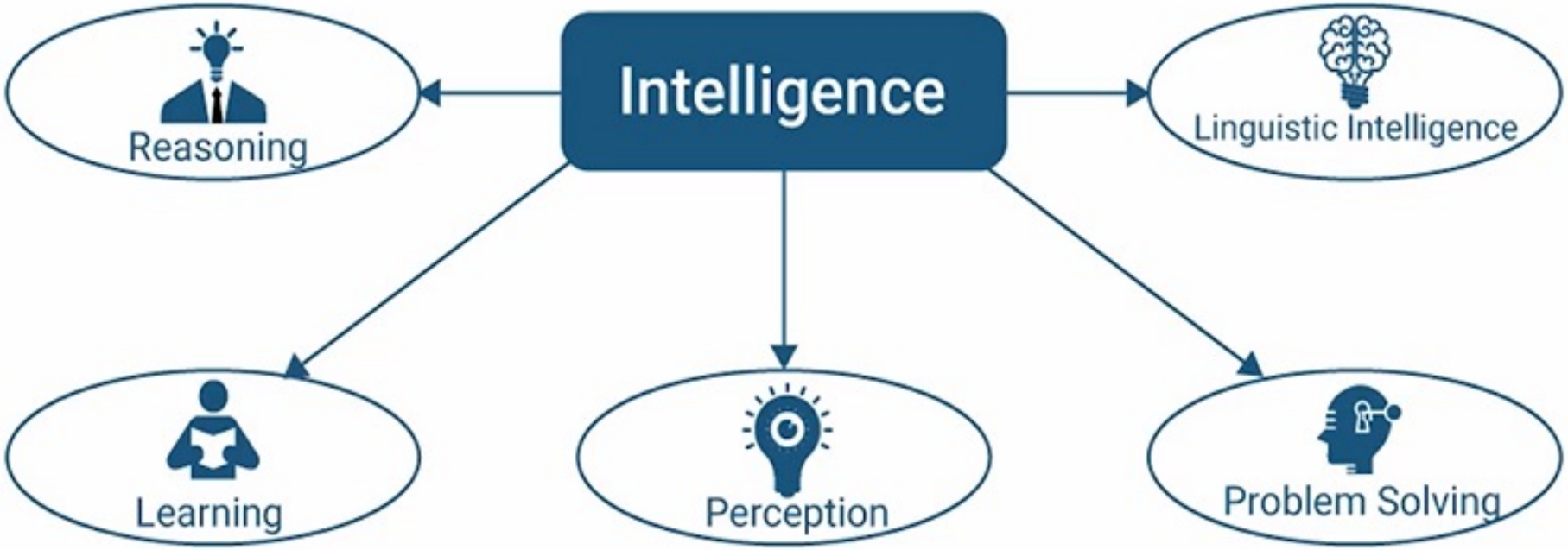
The study of how to make computers do things at which, at the moment, people are better" (Rich and Knight, 1991)

The study of the computations that make it possible to perceive, reason, and act" (Winston, 1992)

The branch of computer science that is concerned with the automation of intelligent behavior" (Luger and Stubblefield, 1993)

What makes Humans Intelligent?

The core problems of artificial intelligence includes programming computers for certain traits such as:



Acting humanly: The Turing Test approach

- **Natural language processing** to enable it to communicate successfully in English;
- **Knowledge representation** to store information provided before or during the interrogation;
- **Automated reasoning** to use the stored information to answer questions and to draw new conclusions;
- **Machine learning** to adapt to new circumstances and to detect and extrapolate patterns.
- **Computer vision** to perceive objects, and
- **Robotics** to move them about.

Thinking humanly: The cognitive modelling approach

Thinking rationally: The laws of thought approach

Acting rationally: The rational agent approach

Human approach:

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

Ideal approach:

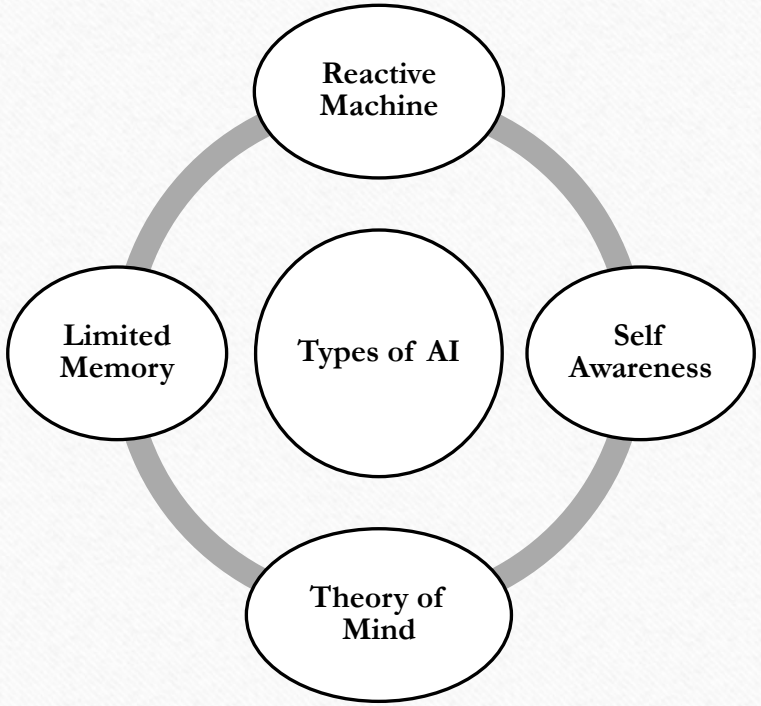
- Systems that think rationally
- Systems that act rationally

Weak V/S Strong AI

- Weak AI, also known as narrow AI, is an AI system that is designed and trained to complete a specific task. Industrial robots and virtual personal assistants, such as Apple's Siri, use weak AI.

- Strong AI, also known as artificial general intelligence (AGI), describes programming that can replicate the cognitive abilities of the human brain. When presented with an unfamiliar task, a strong AI system can use fuzzy logic to apply knowledge from one domain to another and find a solution autonomously. In theory, a strong AI program should be able to pass both a Turing Test and the Chinese room test.

What are the 4 types of artificial intelligence?



Type 1: Reactive machines

These AI systems have no memory and are task specific. An example is Deep Blue, the IBM chess program that beat Garry Kasparov in the 1990s. Deep Blue can identify pieces on the chessboard and make predictions, but because it has no memory, it cannot use past experiences to inform future ones.

Type 2: Limited memory

These AI systems have memory, so they can use past experiences to inform future decisions. Some of the decision-making functions in self-driving cars are designed this way.

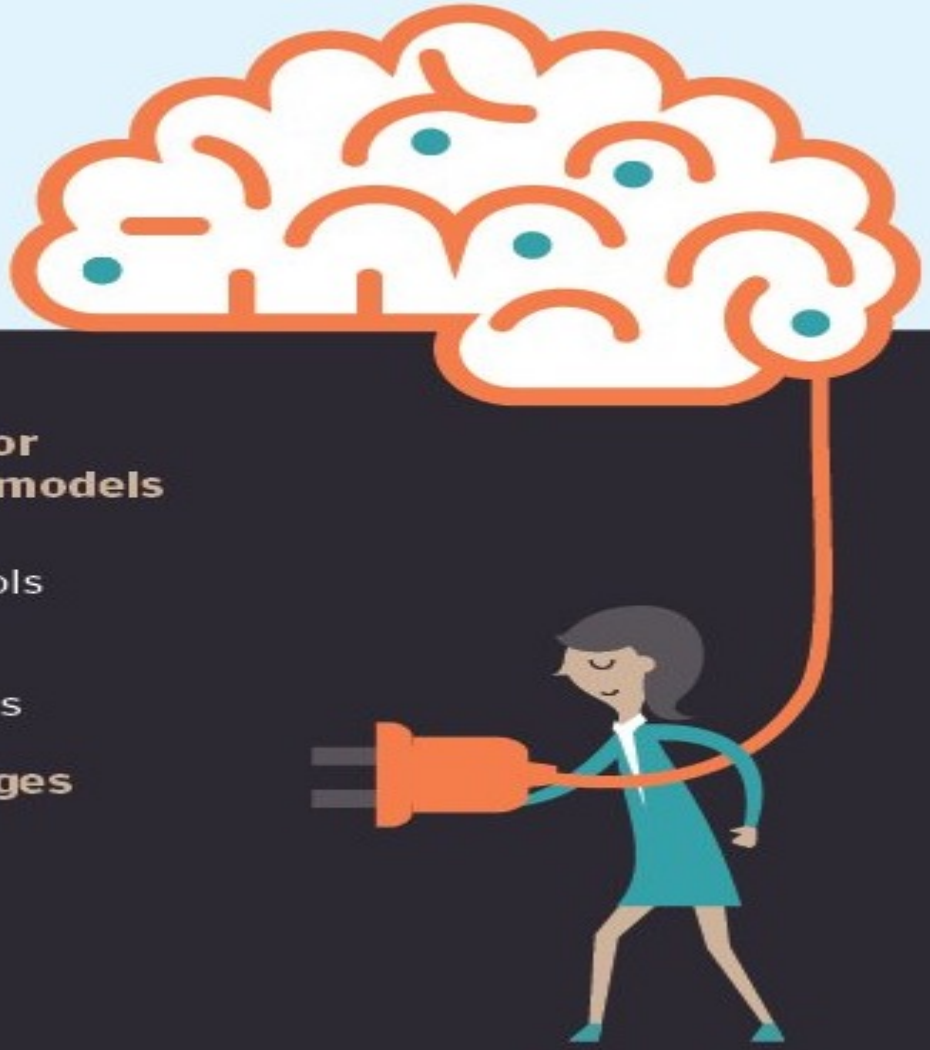
Type 3: Theory of Mind

Theory of mind is a psychology term. When applied to AI, it means that the system would have the social intelligence to understand emotions. This type of AI will be able to infer human intentions and predict behavior, a necessary skill for AI systems to become integral members of human teams.

Type 4: Self-Awareness

In this category, AI systems have a sense of self, which gives them consciousness. Machines with self-awareness understand their own current state. This type of AI does not yet exist.

Components of AI



Applications

- Image recognition
- Speech recognition
- Chatbots
- Natural language generation
- Sentiment analysis

Types of models

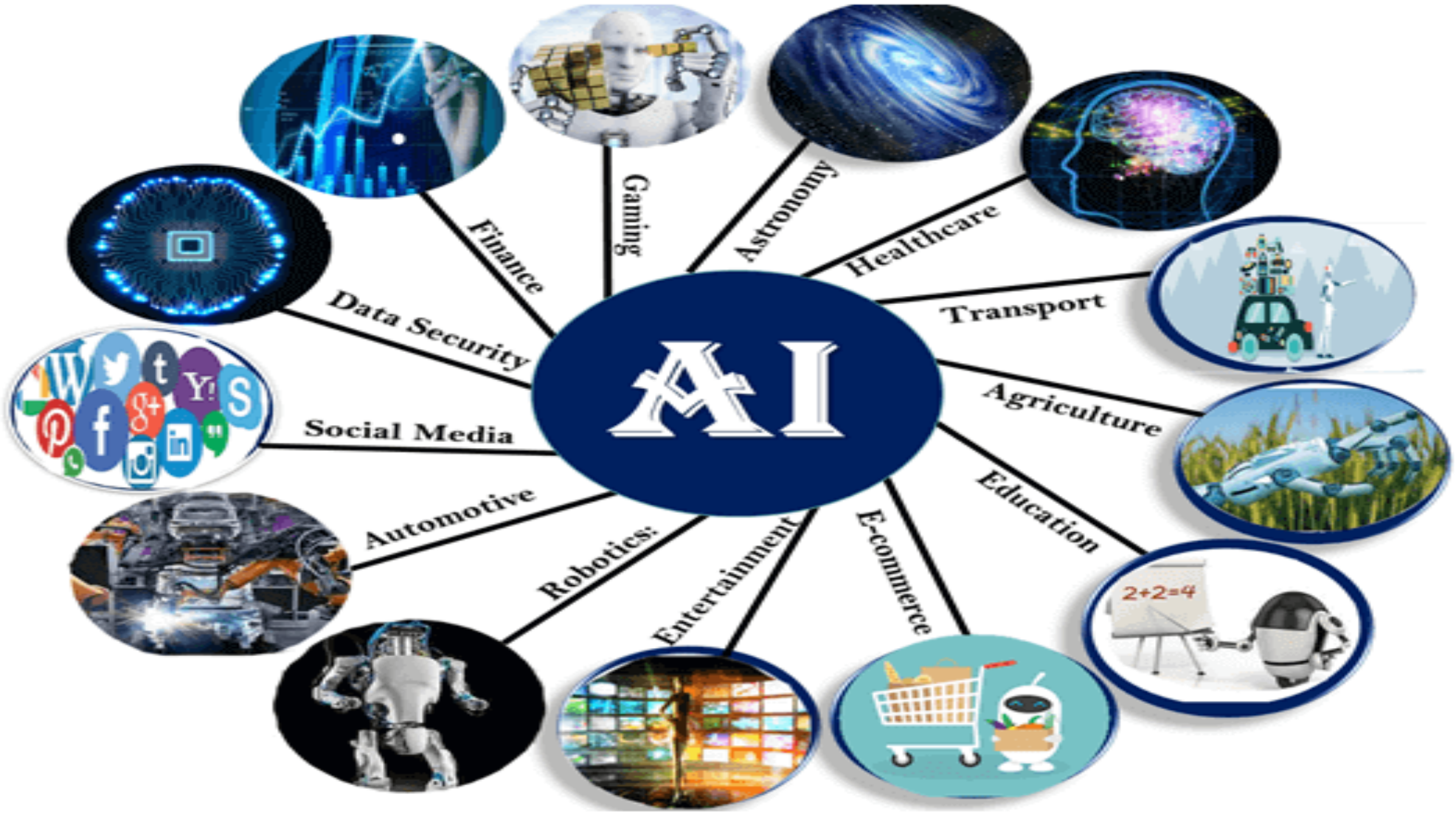
- Deep learning
- Machine learning
- Neural networks

Software/hardware for training and running models

- GPUs
- Parallel processing tools (like Spark)
- Cloud data storage and compute platforms

Programming languages for building models

- Python
- TensorFlow
- Java
- C


AI
Finance
Gaming
Astronomy
Healthcare
Transport
Agriculture
Education
E-commerce
Entertainment
Robotics:
Automotive
Social Media
Data Security
2+2=4

Widely used in banking and finance industry

Important feature of medical science

Perfect for heavy industries

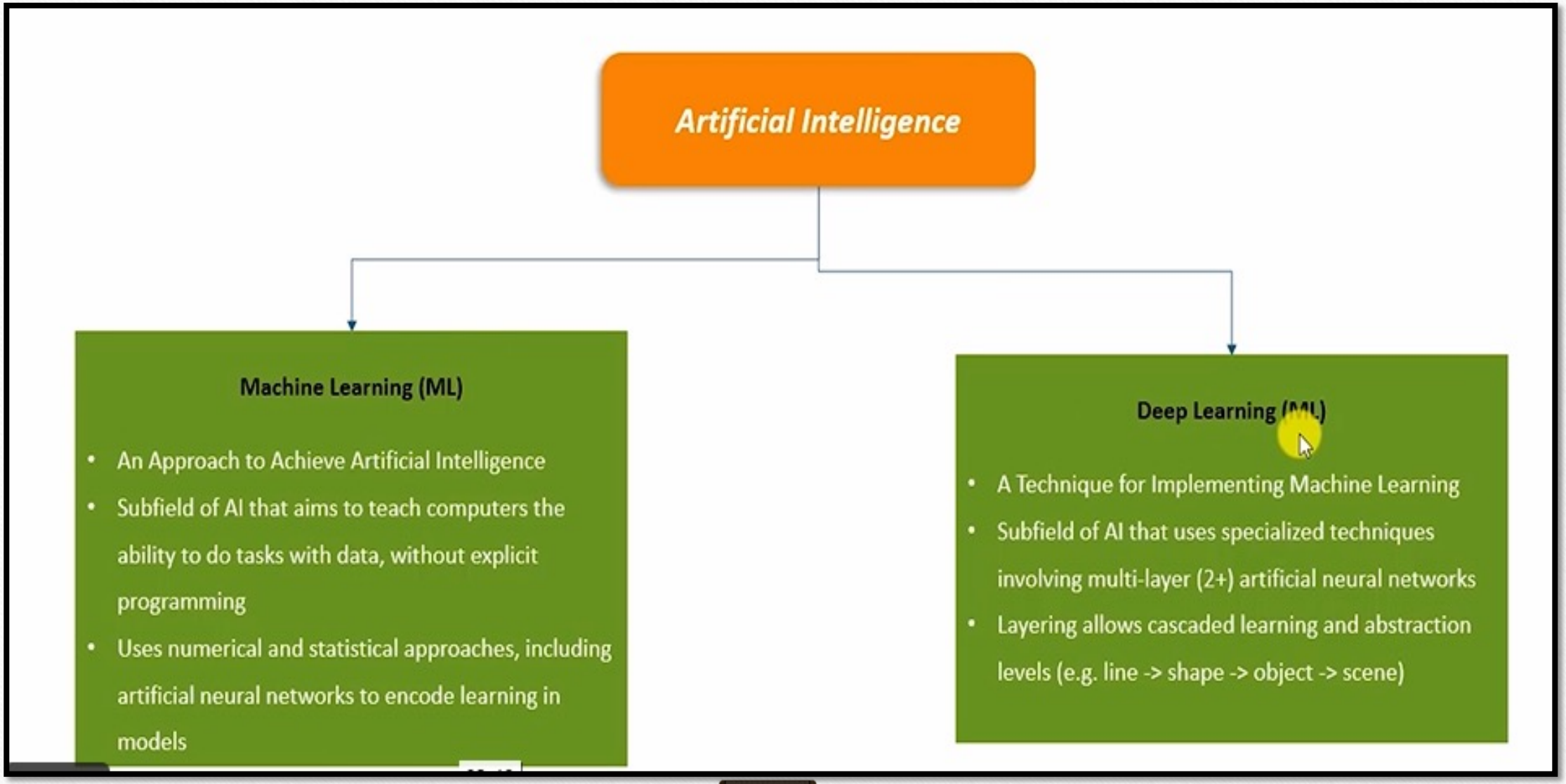
Efficient use in Air transport

Changed the face of gaming

Reinvent the world

A great help for humans

32:04


Artificial Intelligence
Machine Learning (ML)
An Approach to Achieve Artificial Intelligence
Subfield of AI that aims to teach computers the ability to do tasks with data, without explicit programming
Uses numerical and statistical approaches, including artificial neural networks to encode learning in models
Deep Learning (ML)
A Technique for Implementing Machine Learning
Subfield of AI that uses specialized techniques involving multi-layer (2+) artificial neural networks
Layering allows cascaded learning and abstraction levels (e.g. line -> shape -> object -> scene)

Introduction to Machine Learning

Machine learning is a growing technology which enables computers to learn automatically from past data. Machine learning uses various algorithms for building mathematical models and making predictions using historical data or information.

Currently, it is being used for various tasks such as image recognition, speech recognition, email filtering, Facebook auto-tagging, recommender system, and many more.

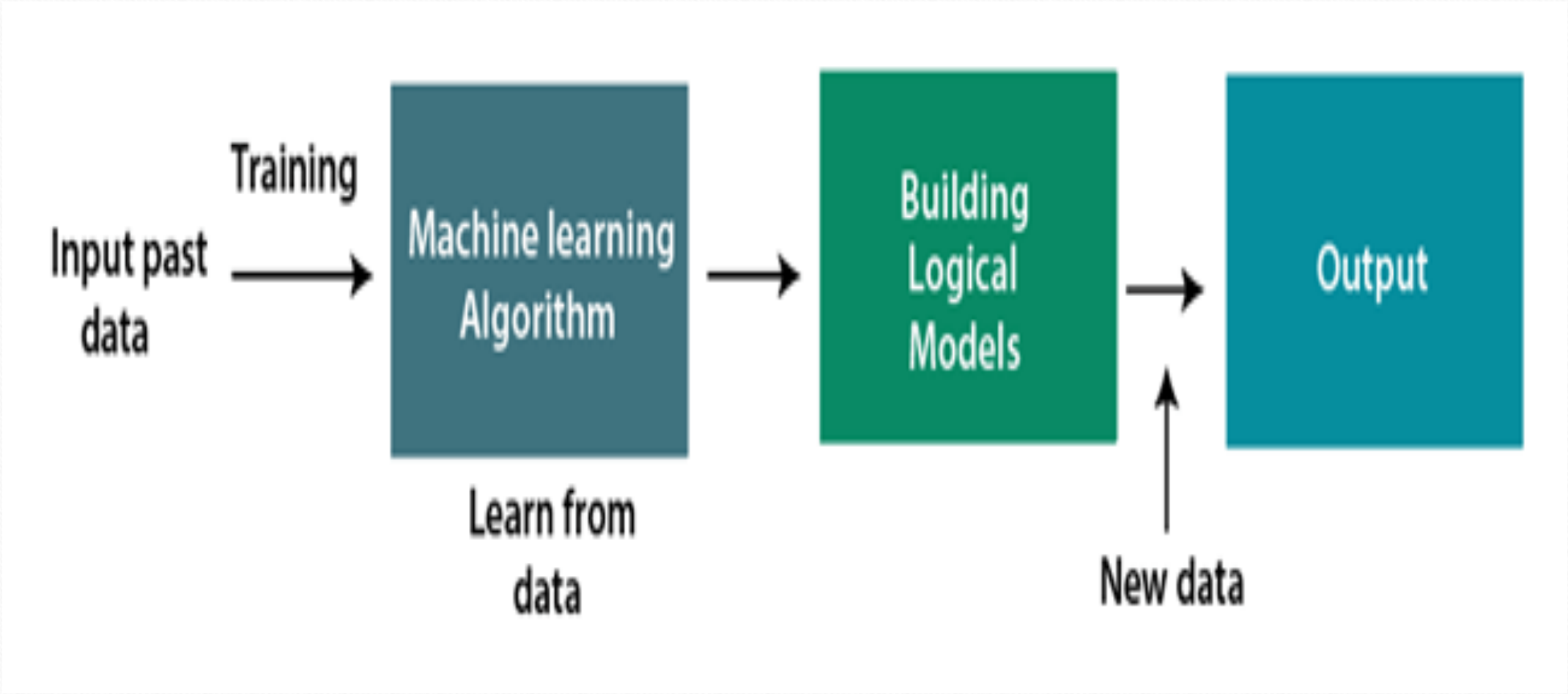
Human

I can learn everything automatically from experiences. Can u learn?

Machine

Yes, I can also learn from past data with the help of Machine learning

How does Machine Learning work



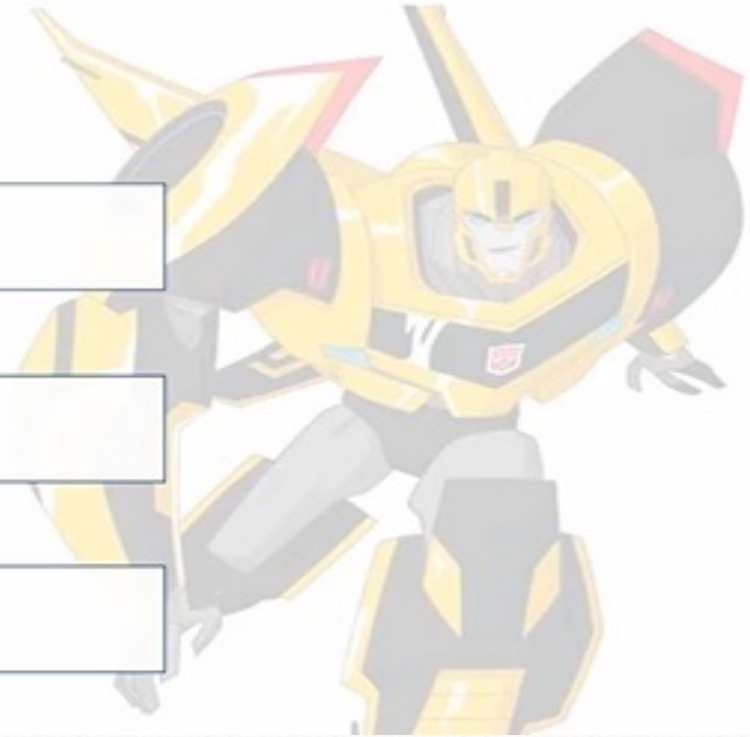
Features of Machine Learning:

- Machine learning uses data to detect various patterns in a given dataset.
- It can learn from past data and improve automatically.
- It is a data-driven technology.
- Machine learning is much similar to data mining as it also deals with the huge amount of the data.

Machine Learning Types

Machine learning is sub-categorized into three types

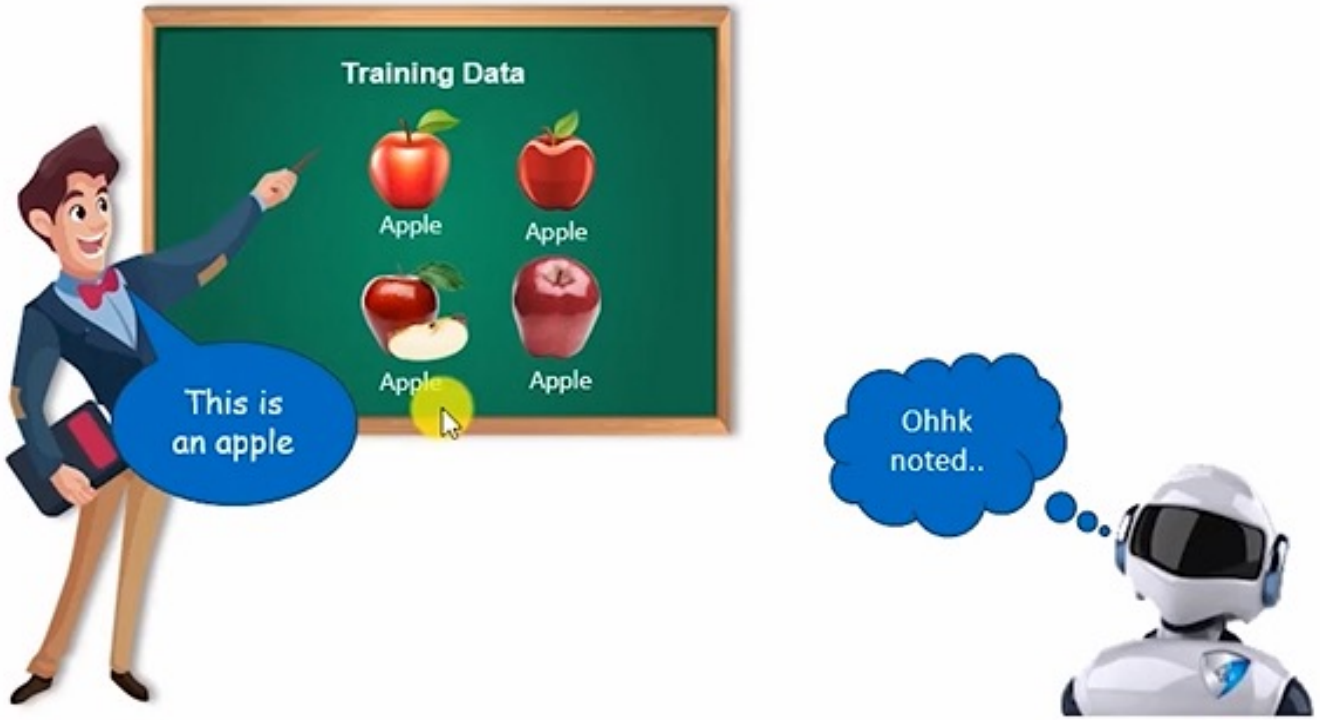
- Supervised Learning
- Unsupervised Learning
- Reinforcement Learning



Machine Learning Types!

- Supervised Learning
- Unsupervised Learning
- Reinforcement Learning

In Supervised Learning you can consider that the learning is guided by a teacher. We have a dataset which acts as a teacher and its role is to train the model or the machine. Once the model gets trained it can start making a prediction or decision when new data is given to it



Supervised Learning

Supervised learning is a type of machine learning method in which we provide sample labeled data to the machine learning system in order to train it, and on that basis, it predicts the output.

The goal of supervised learning is to map input data with the output data. The supervised learning is based on supervision, and it is the same as when a student learns things in the supervision of the teacher. The example of supervised learning is spam filtering.

Supervised learning can be grouped further in two categories of algorithms:

- **Classification**
- **Regression**

Machine Learning Types!

- Supervised Learning
- Unsupervised Learning
- Reinforcement Learning

The model learns through observation and finds structures in the data. Once the model is given a dataset, it automatically finds patterns and relationships in the dataset by creating clusters in it. What it cannot do is add labels to the cluster, like it cannot say this a group of apples or mangoes, but it will separate all the apples from mangoes

Unsupervised Learning

Unsupervised learning is a learning method in which a machine learns without any supervision.

The training is provided to the machine with the set of data that has not been labeled, classified, or categorized, and the algorithm needs to act on that data without any supervision. The goal of unsupervised learning is to restructure the input data into new features or a group of objects with similar patterns.

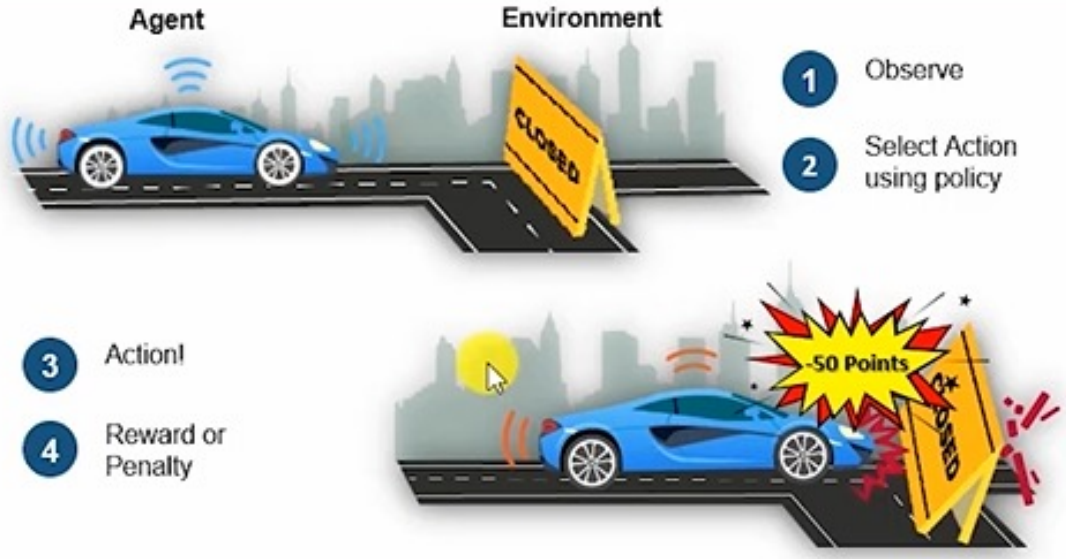
It can be further classifieds into two categories of algorithms:

- **Clustering**
- **Association**

Machine Learning Types!

- Supervised Learning
- Unsupervised Learning
- Reinforcement Learning

It is the ability of an agent to interact with the environment and find out what is the best outcome. It follows the concept of hit and trial method. The agent is rewarded or penalized with a point for a correct or a wrong answer, and on the basis of the positive reward points gained the model trains itself



Machine Learning Types!

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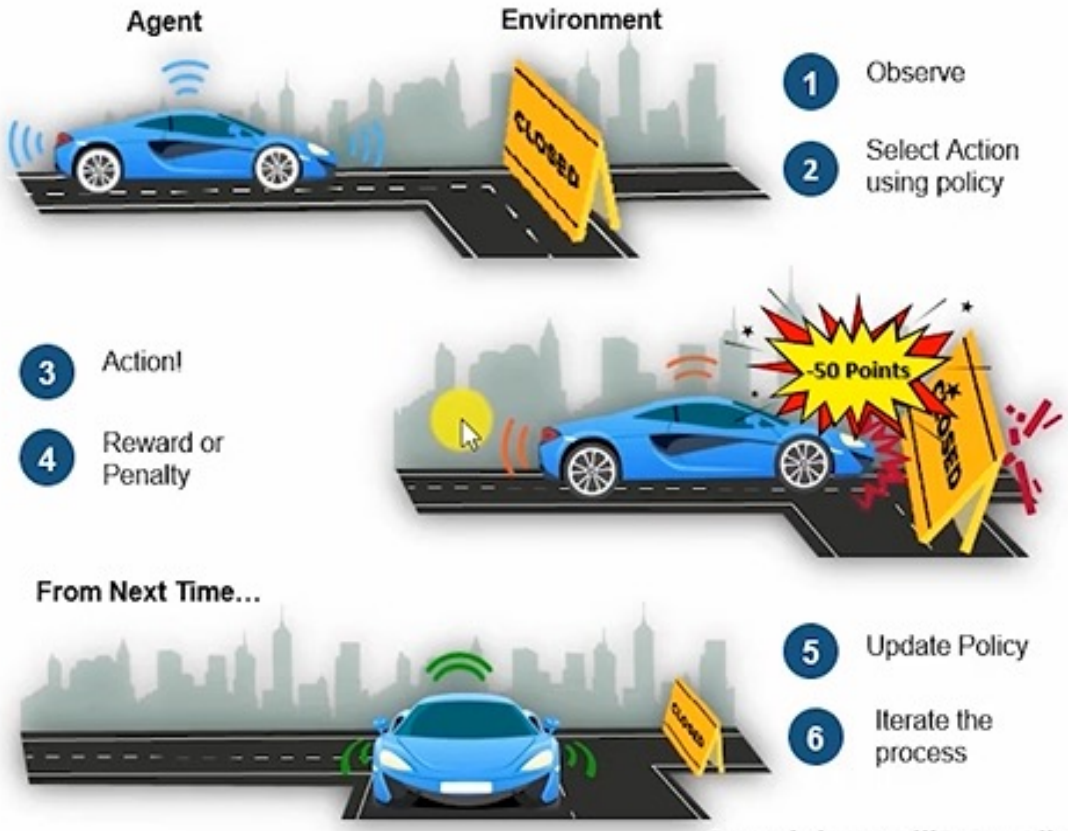


Machine Learning Types!

- Supervised Learning
- Unsupervised Learning
- Reinforcement Learning

Use Case: Self Driving Cars

Companies such as Tesla (You've heard of them), Google, Wayve, and more are working on such machines

These cars are powered by Reinforcement Learning. It allows machines (known as agents) to learn by experimentation

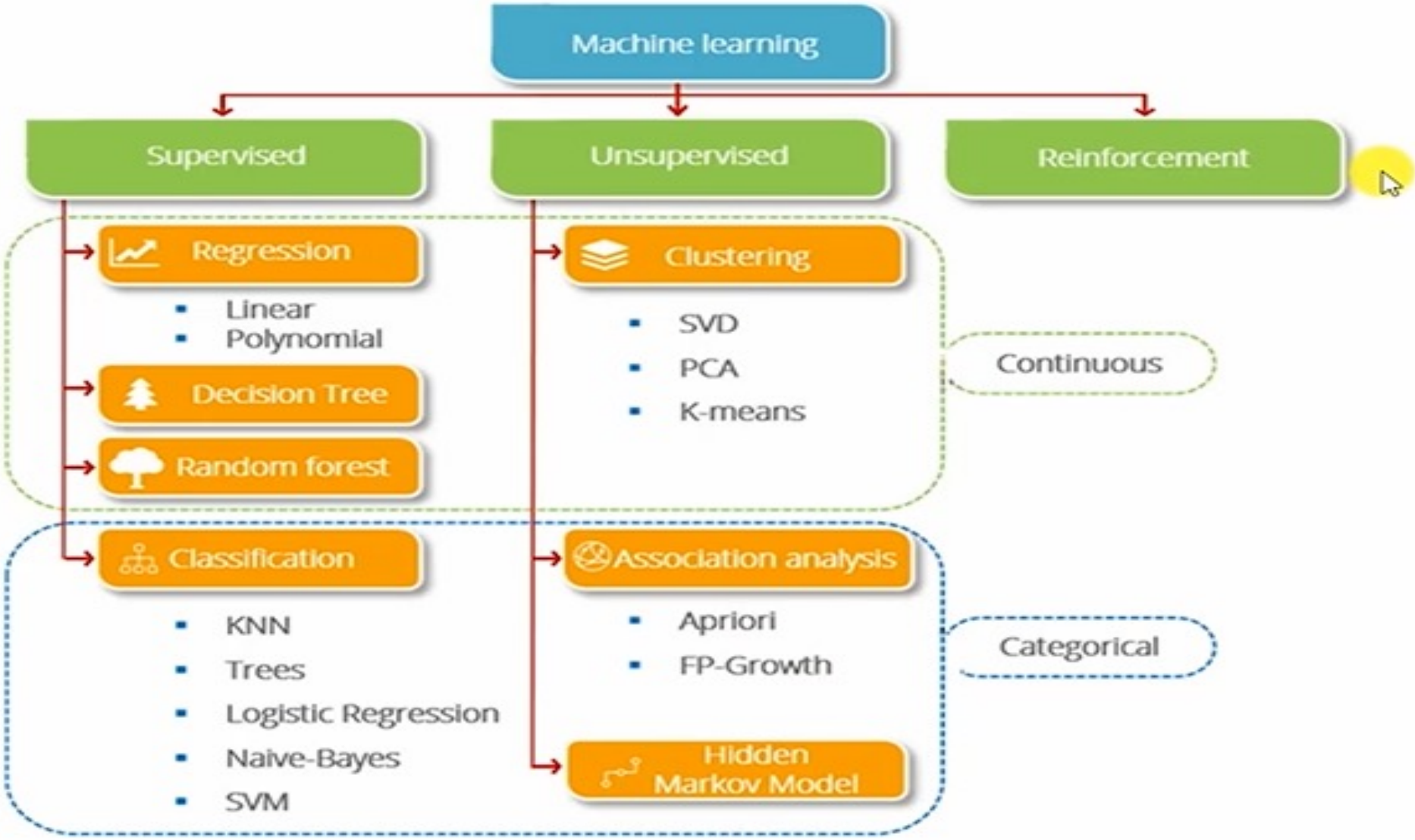
Reinforcement Learning

Reinforcement learning is a feedback-based learning method, in which a learning agent gets a reward for each right action and gets a penalty for each wrong action.

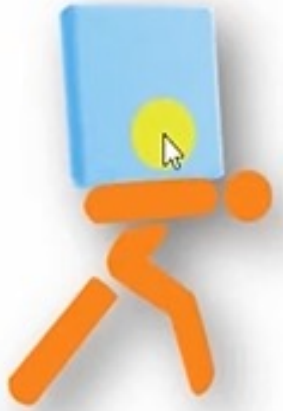
The agent learns automatically with these feedbacks and improves its performance. In reinforcement learning, the agent interacts with the environment and explores it.

The goal of an agent is to get the most reward points, and hence, it improves its performance.

The robotic dog, which automatically learns the movement of his arms, is an example of Reinforcement learning.


Machine learning
Supervised
Unsupervised
Reinforcement
Regression
Linear
Polynomial
Decision Tree
Random forest
Clustering
SVD
PCA
K-means
Continuous
Classification
KNN
Trees
Logistic Regression
Naive-Bayes
SVM
Association analysis
Apriori
FP-Growth
Hidden Markov Model
Categorical

Limitations of Machine Learning



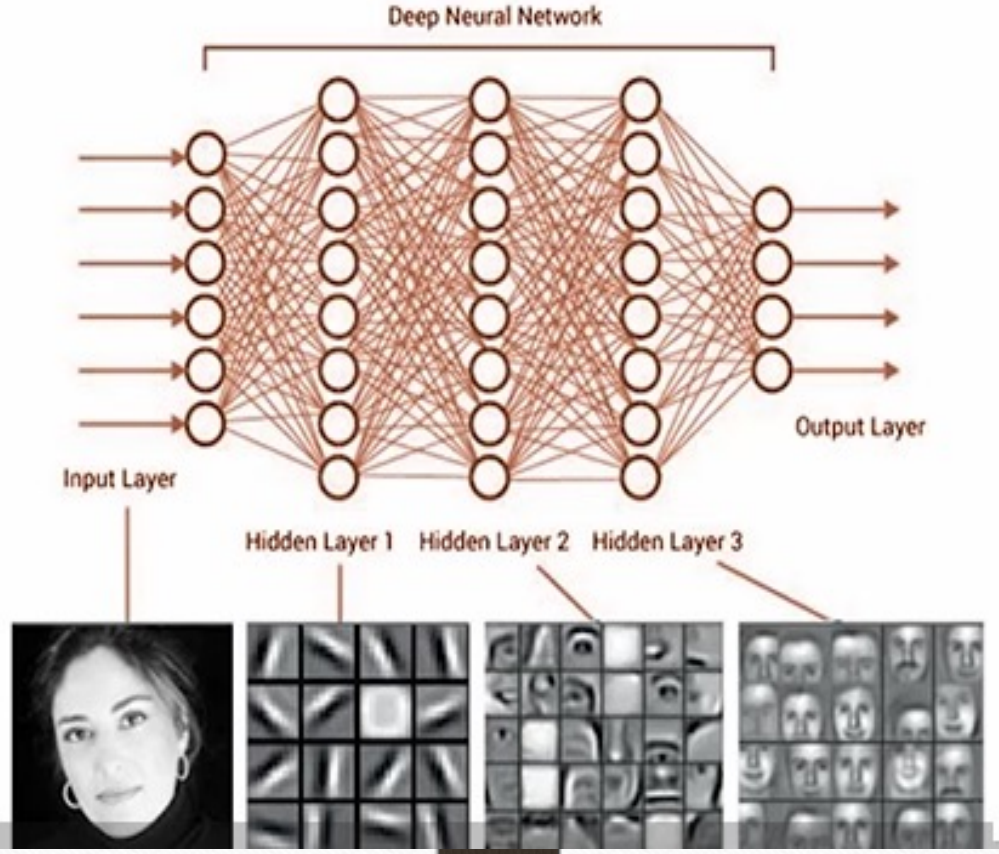
Machine Learning Algorithms Require Massive Stores of Training Data

Error diagnosis and correction can be difficult

Lack of creativity

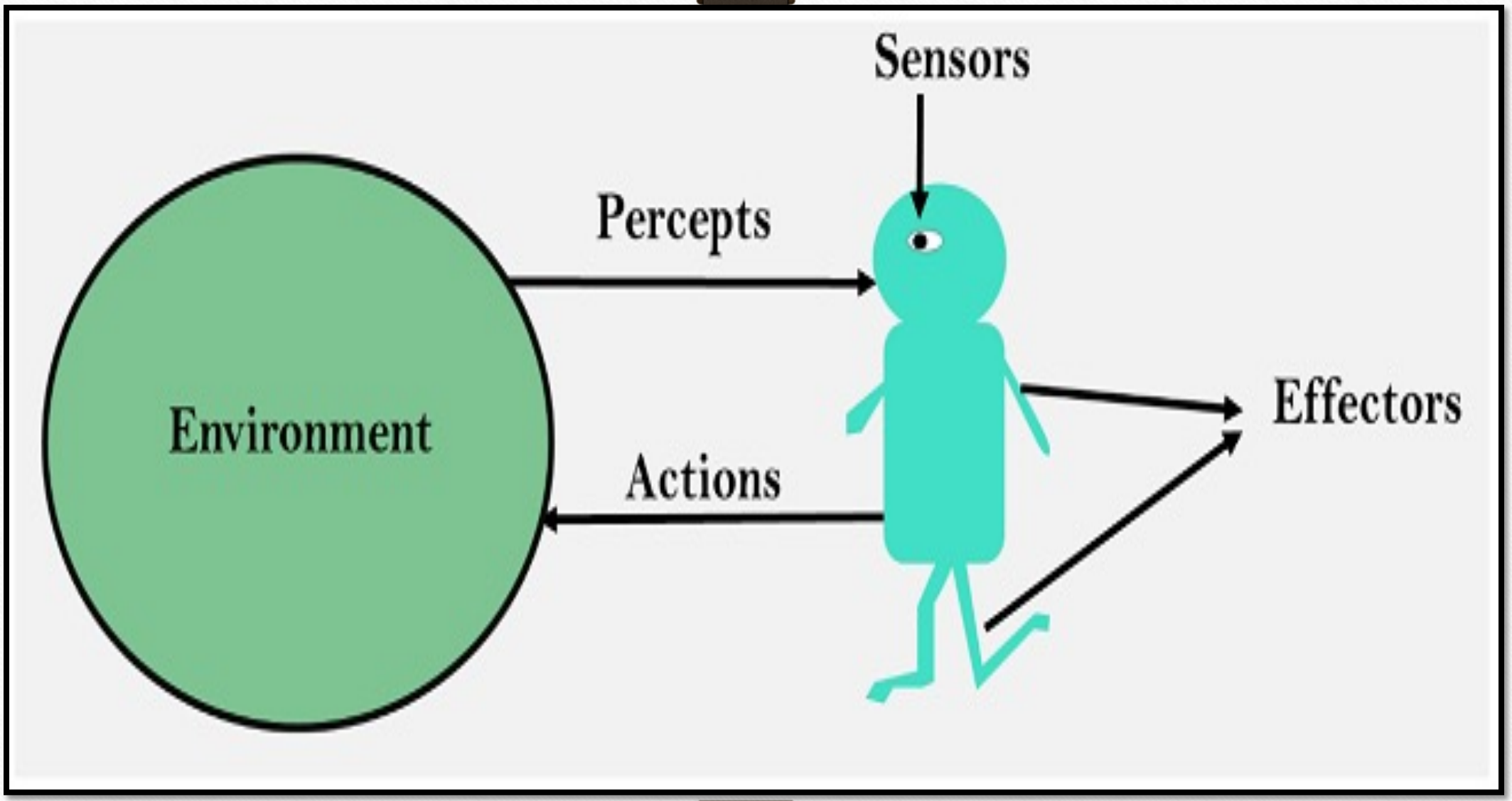
Time constraints in learning as it learns through historical data

Deep learning is a of machine learning methods based on learning data representations, as opposed to task-specific algorithms. It teaches computers to do what comes naturally to humans (learn by examples)



Applications of Deep Learning

Self Driving Cars


Sensors
Percepts
Environment
Actions
Effectors

Types of Environments in AI

- Fully Observable vs Partially Observable
- Deterministic vs Stochastic
- Competitive vs Collaborative
- Single-agent vs Multi-agent
- Static vs Dynamic
- Discrete vs Continuous
- Episodic vs Sequential
- Known vs Unknown

Fully Observable vs Partially Observable

- **When an agent sensor is capable to sense or access the complete state of an agent at each point in time, it is said to be a fully observable environment else it is partially observable.**
- **Maintaining a fully observable environment is easy as there is no need to keep track of the history of the surrounding.**
- **An environment is called unobservable when the agent has no sensors in all environments.**

Examples:

- **Chess** – the board is fully observable, and so are the opponent's moves.
- **Driving** – the environment is partially observable because what's around the corner is not known.

Deterministic vs Stochastic

- **When a uniqueness in the agent's current state completely determines the next state of the agent, the environment is said to be deterministic.**
- **The stochastic environment is random in nature which is not unique and cannot be completely determined by the agent.**

Examples:

- **Chess –** there would be only a few possible moves for a coin at the current state and these moves can be determined.
- **Self-Driving Cars-** the actions of a self-driving car are not unique, it varies time to time.

Competitive vs Collaborative

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

Single-agent vs Multi-agent

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

Dynamic vs Static

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

Discrete vs Continuous

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

Episodic vs Sequential

- In **an Episodic task environment**, each of the agent's actions is divided into atomic incidents or episodes. There is no dependency between current and previous incidents. In each incident, an agent receives input from the environment and then performs the corresponding action.
- **Example:** Consider an example of **Pick and Place robot**, which is used to detect defective parts from the conveyor belts. Here, every time robot(agent) will make the decision on the current part i.e. there is no dependency between current and previous decisions.
- In a **Sequential environment**, the previous decisions can affect all future decisions. The next action of the agent depends on what action he has taken previously and what action he is supposed to take in the future.
- **Example:**
  - **Checkers-** Where the previous move can affect all the following moves.

Known vs Unknown

- In a known environment, the output for all probable actions is given. Obviously, in case of unknown environment, for an agent to make a decision, it has to gain knowledge about how the environment works.

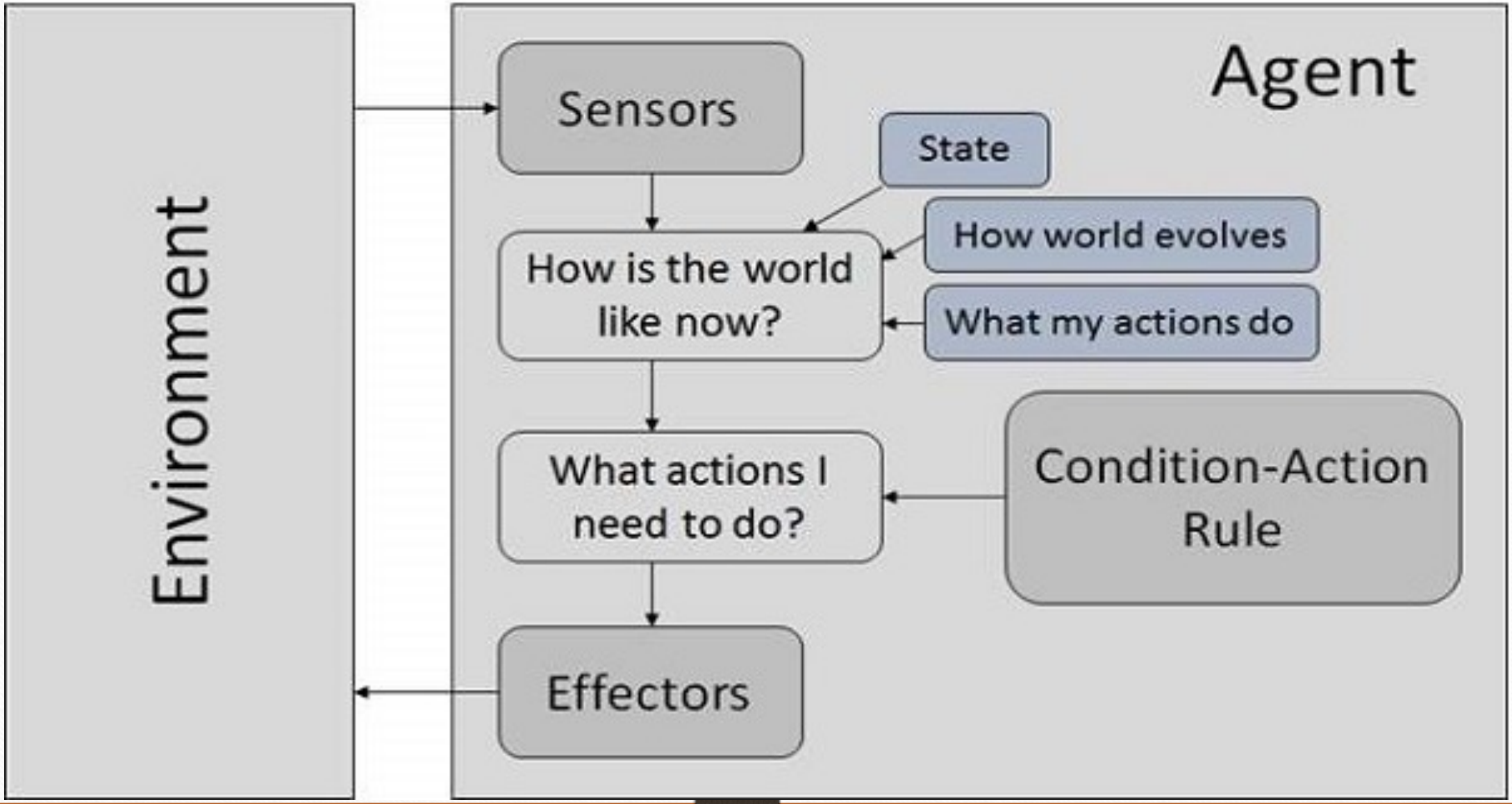
PEAS Representation

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

ENVIRONMENT AND PROPERTIES OF TASK ENVIRONMENT

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. Some programs operate in the entirely artificial environment confined to keyboard input, database, computer file systems and character output on a screen. In contrast, some software agents (software robots or softbots) exist in rich, unlimited softbots domains. The simulator has a very detailed, complex environment.


Environment
Agent
Sensors
State
How world evolves
How is the world like now?
What my actions do
What actions I need to do?
Condition-Action Rule
Effectors

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.

INTELLIGENT AGENTS:

An AI system can be defined as the study of the rational agent and its environment. The agents sense the environment through sensors and act on their environment through actuators. An AI agent can have mental properties such as knowledge, belief, intention, etc.

➢ What is an Agent?

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

- **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.

Sensor: Sensor is a device which detects the change in the environment and sends the information to other electronic devices. An agent observes its environment through sensors.

Actuators: Actuators are the component of machines that converts energy into motion. The actuators are only responsible for moving and controlling a system. An actuator can be an electric motor, gears, rails, etc.

Effectors: Effectors are the devices which affect the environment. Effectors can be legs, wheels, arms, fingers, wings, fins, and display screen.

Intelligent Agents

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

Following are the main four rules for an AI agent:

- **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.**

The Structure of Intelligent Agents

Agent's structure can be viewed as:

Agent = Architecture + Agent Program

Architecture = The machinery that an agent executes on

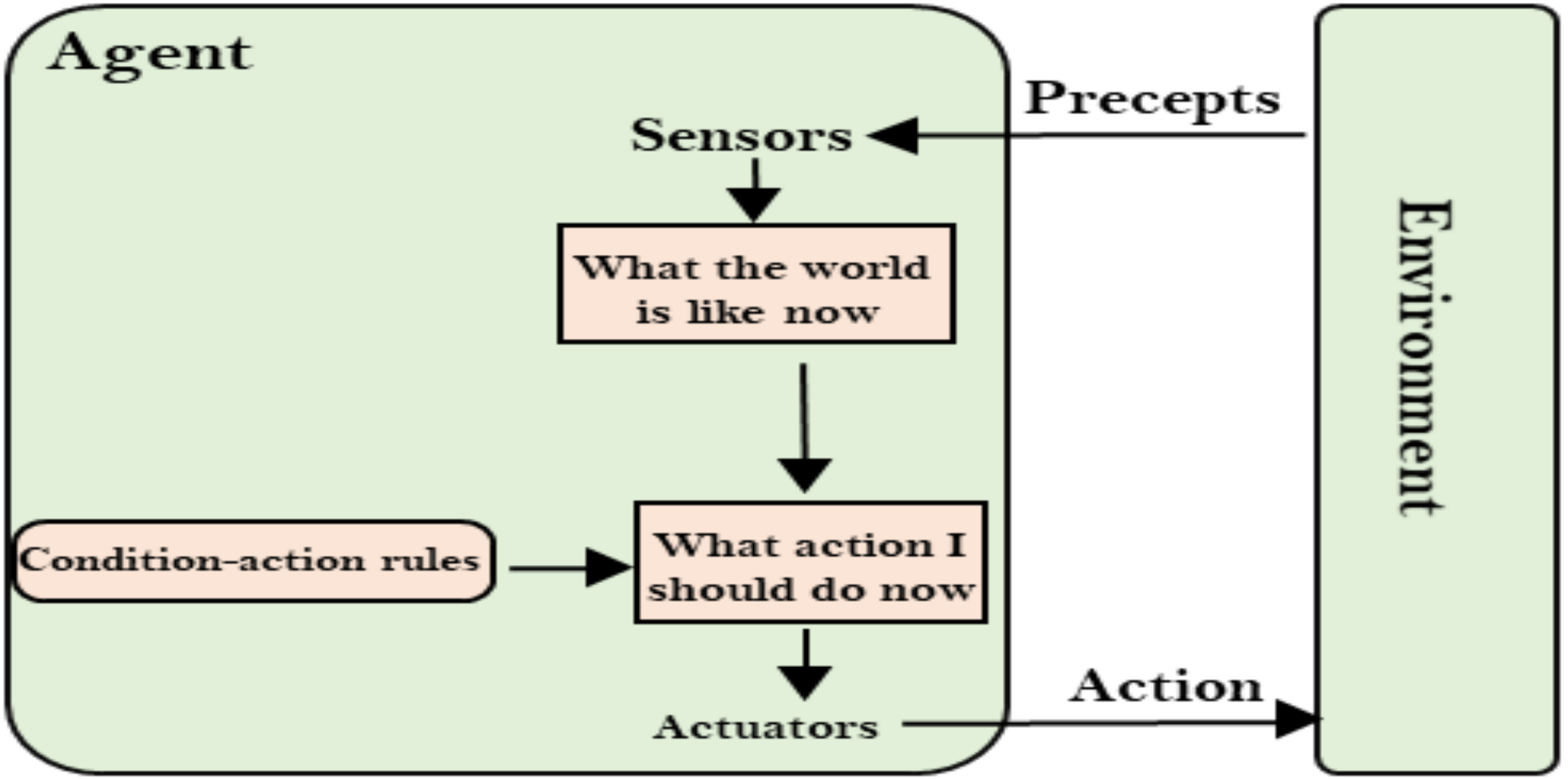
Agent Program = An implementation of an agent function

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**

Simple Reflex Agents

- 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.

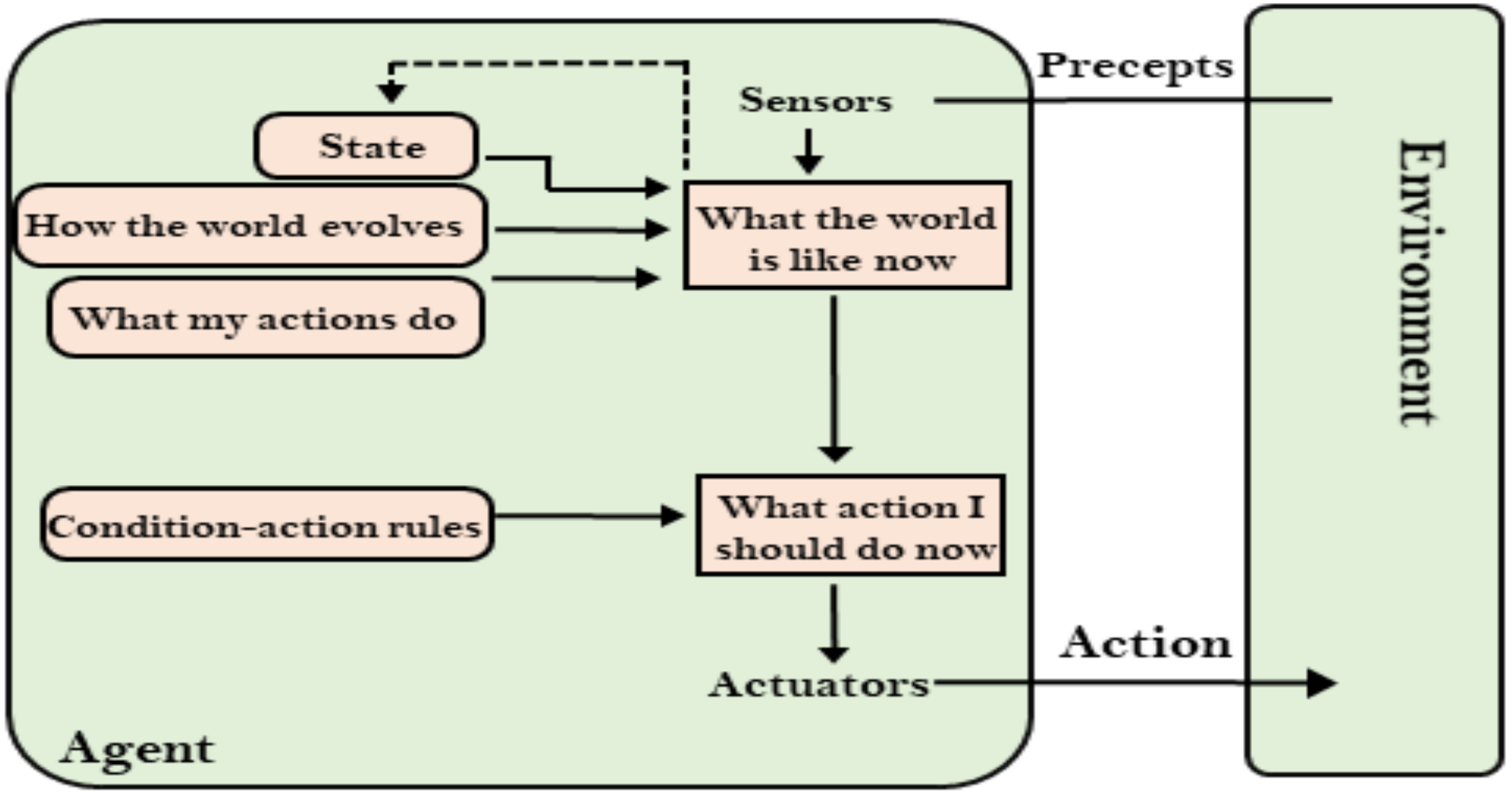

Agent
Precepts
Sensors
What the world is like now
Environment
Condition-action rules
What action I should do now
Action
Actuators

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.

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.


Precepts
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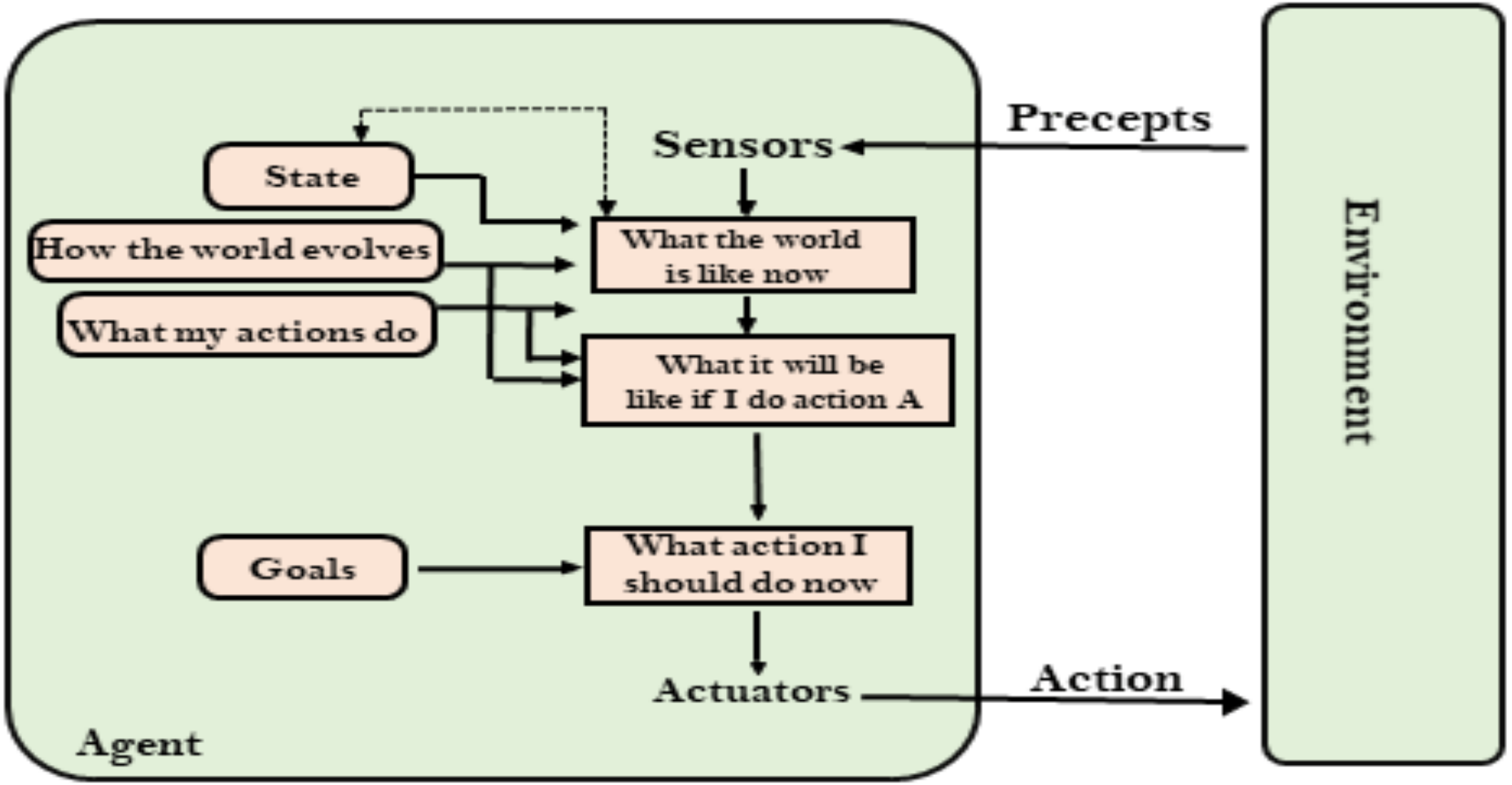
What action I should do now
Action
Actuators
Agent

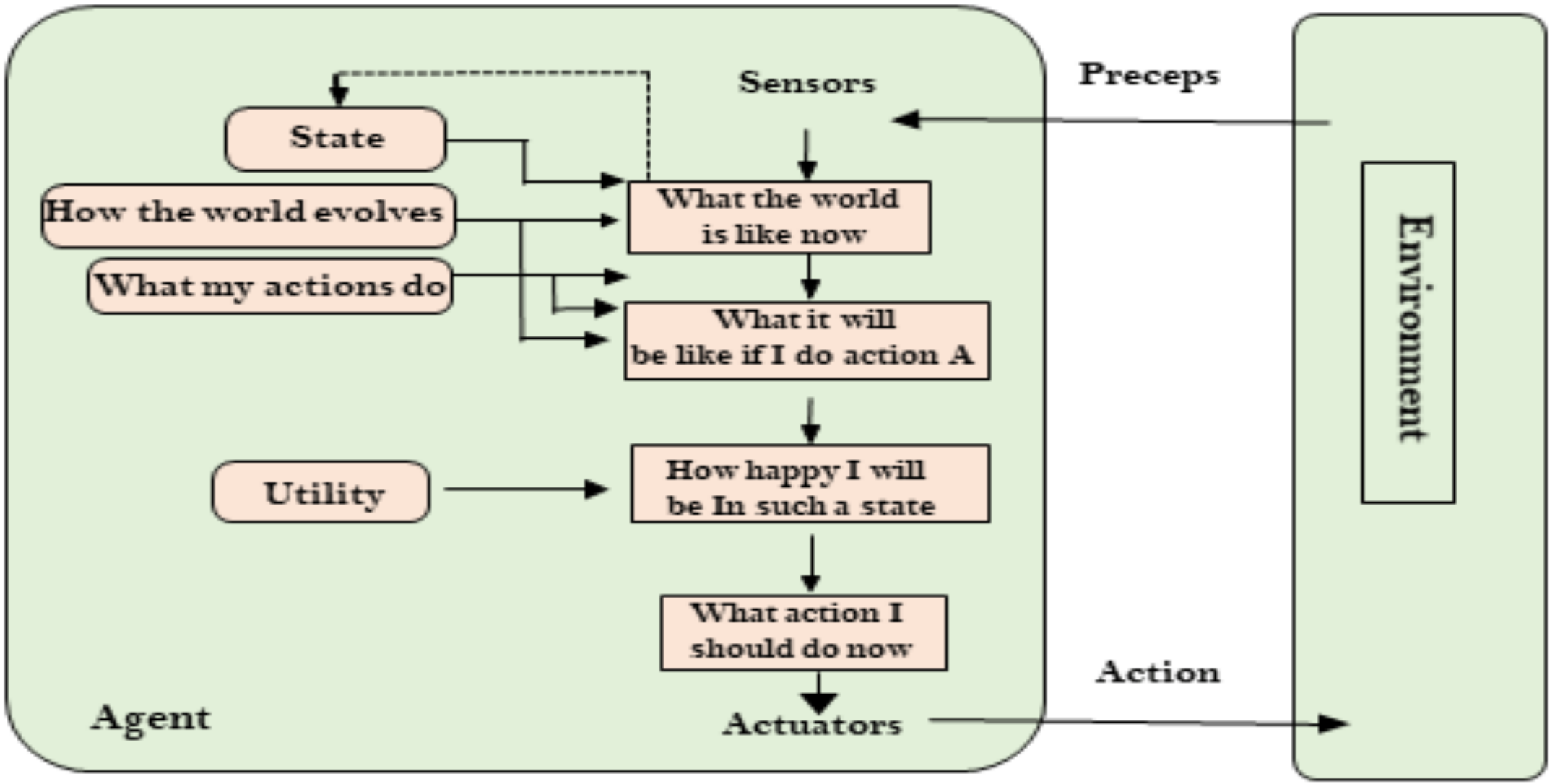
Goal-based agents

- The knowledge of the current state environment is not always sufficient to decide for an agent to what to do.
- The agent nėeds 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
Agent
Actuators
Action
Environment

Learning Agents

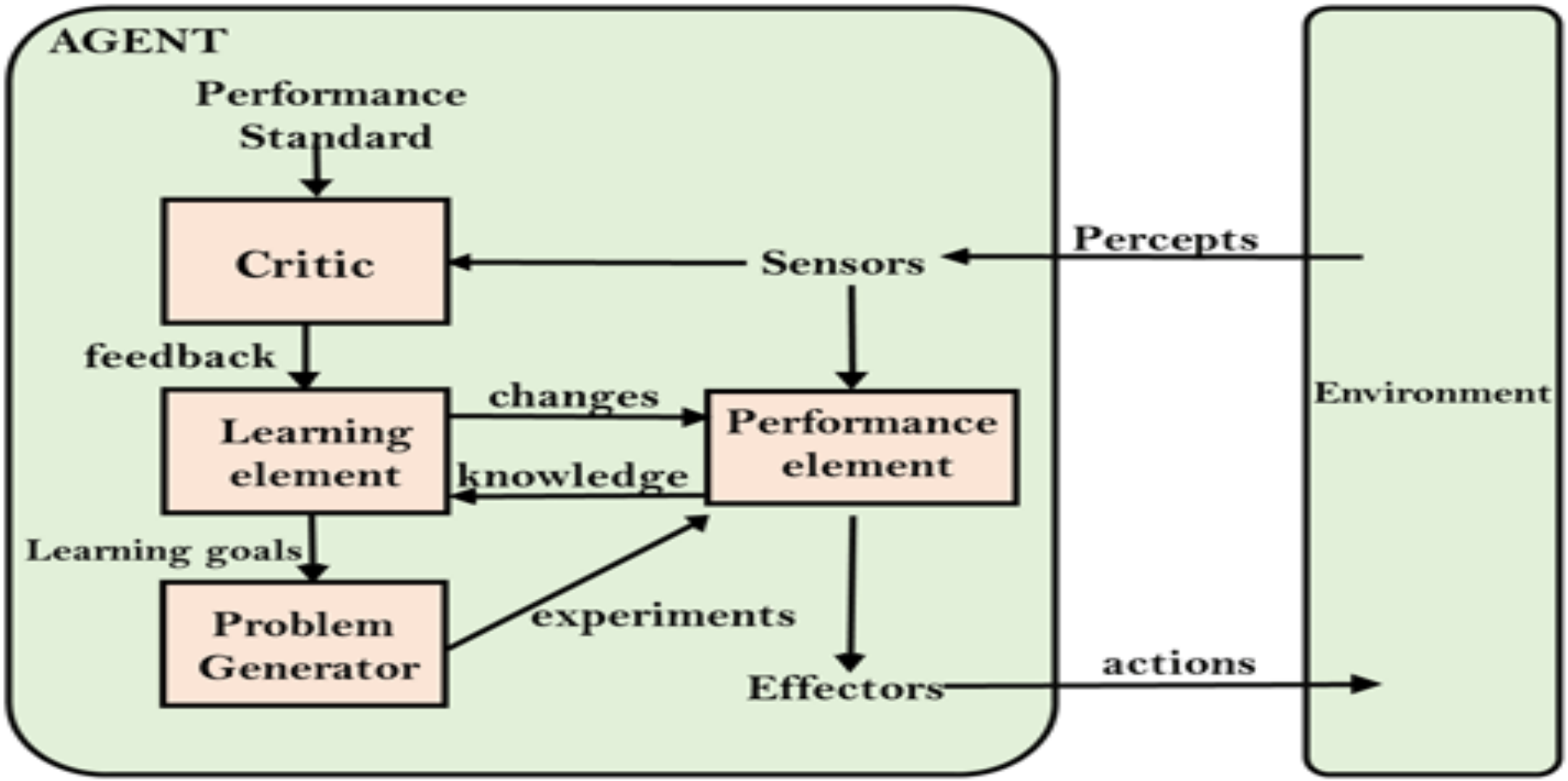
•A learning agent in AI is the type of agent which can learn from its past experiences, or it has learning capabilities.

•It starts to act with basic knowledge and then able to act and adapt automatically through learning.

•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 selecting external action
- **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
feedback
Learning element
changes
knowledge
Performance element
Learning goals
Problem Generator
experiments
Effectors
Sensors
Percepts
Environment
actions