INTELLIGENT AGENT

Unit 2

Presented By: Saroj Bhandari

Syllabus(4 hours)

2.1. Introduction of agents, Structure of Intelligent agent, Properties of Intelligent Agents

2.2. Configuration of Agents, PEAS description of Agents, PAGE

2.3. Types of Agents: Simple Reflexive, Model Based, Goal Based, Utility Based, Learning Agent

2.4. Environment Types: Deterministic, Stochastic, Static, Dynamic, Observable, Semi-observable, Single Agent, Multi Agent

Agents

- **An AI agent is a *software program that can interact with its surroundings, gather information, and use that information to complete tasks on its own to achieve goals set by humans.***
- For instance, an **AI agent** on an online shopping platform can ***recommend products, answer customer questions, and process orders***. If agent needs more information, it can ask users for additional details.
- AI agents employ advanced **natural language processing** and **machine learning** techniques to understand user input, interact step-by-step, and use external tools when needed for accurate responses.
- Common AI Agent Applications are ***software development and IT automation, coding tools, chat assistants, and online shopping platforms*.**

How do **AI Agents Work?**

- AI agents follow a structured process to **perceive, analyze, decide, and act** within their environment. Here's an overview of how AI agents operate:

1. Collecting Information (Perceiving the Environment)

- ❑ AI agents gather information from their surroundings through various means:
- ❑ **Sensors:** For example, a self-driving car uses cameras and radar to detect objects.
- ❑ **User Input:** Chatbots read text or listen to voice commands.
- ❑ **Databases & Documents:** Virtual assistants search records or knowledge bases for relevant data.

How do AI Agents Work?

2. Processing Information & Making Decisions

- After gathering data, AI agents analyze it and decide what to do next. Some agents rely on **pre-set rules**, while others utilize **machine learning** to predict the best course of action. Advanced agents may also use **retrieval-augmented generation (RAG)** to access external databases for more accurate responses.

3. Taking Action (Performing Tasks)

- Once an agent makes a decision, it performs the required task, such as:
- Answering a customer query in a chatbot.
- Controlling a device, like a smart assistant turning off lights.
- Running automated tasks, such as processing orders on an online store.

How do AI Agents Work?

4. Learning & Improving Over Time

- Some AI agents can **learn** from past experiences to improve their responses. This self-learning process, often referred to as **reinforcement learning**, allows agents to refine their behavior over time. For example, a **recommendation system** on a streaming platform learns users' preferences and suggests content accordingly.

Properties of Agents

- **Successful** : An agent is successful to the extent that it accomplishes the specified task in the given environment.
- **Capable** : An agent is capable if it possesses the effectors needed to accomplish the task.
- **Perceptive** : An agent is perceptive if it can distinguish salient characteristics of the world that would allow it to use its effectors to achieve the task.
- **Reactive** : An agent is reactive if it is able to respond sufficiently quickly to events in the world to allow it to be successful.
- **Reflexive** : An agent is reflexive if it behaves in a stimulus-response fashion
- **Interpretive** : An agent is interpretive if can correctly interpret its sensor readings.
- **Rational** : An agent is rational if it chooses to perform commands that it predicts will achieve its goals.
- **Sound** : An agent is sound if it is predictive, interpretive and rational.

Agents and Environment

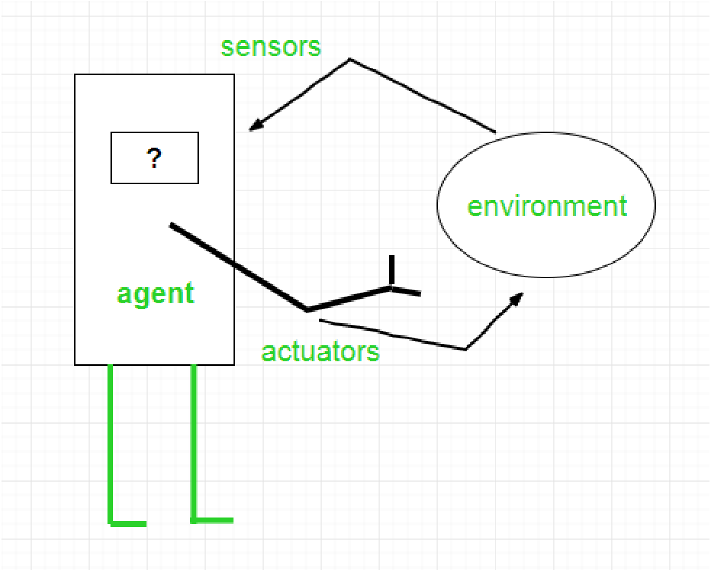
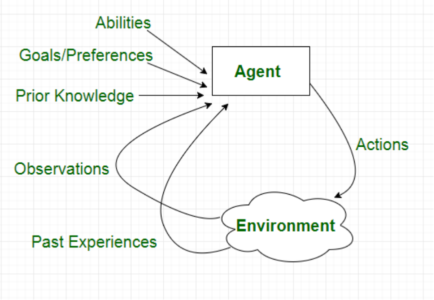


Fig: Interaction of Agents with the Environment

Structure of an AI Agent

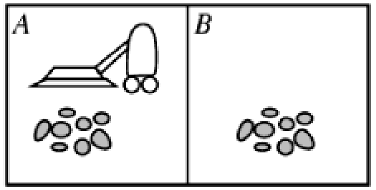


1. Architecture
   - Architecture refers to the underlying hardware or system on which the agent operates. It is the "machinery" that enables the agent to perceive and act within its environment. Examples of architecture include devices equipped with sensors and actuators, such as a robotic car, camera, or a PC. These physical components enable the agent to gather sensory input and execute actions in the world.
2. Agent Program
   - Agent Program is the software component that defines the agent's behavior. It implements the agent function, which is a mapping from the agent's percept sequence (the history of all perceptions it has gathered so far) to its actions. The agent function determines how the agent will respond to different inputs it receives from its environment.

     Agent = Architecture + Agent Program
   - The overall structure of an AI agent can be understood as a combination of both the architecture and the agent program. The architecture provides the physical infrastructure, while the agent program dictates the decision-making and actions of the agent based on its perceptual inputs.

Example:

Vacuum-cleaner world



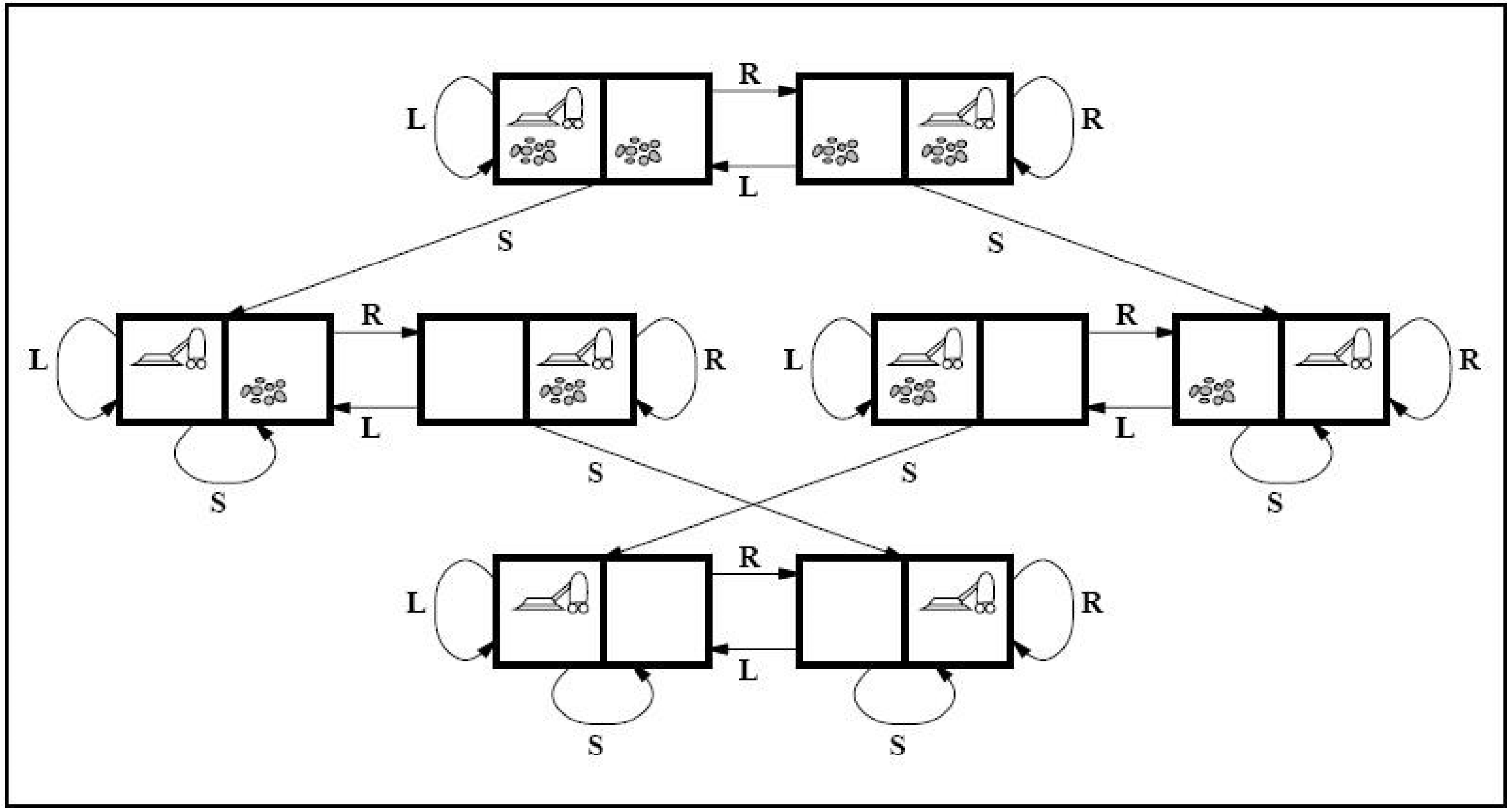
- Two locations: A and B
- Percepts: location and contents, e.g., [A,Dirty]
- Actions: *Left*, *Right*, *Suck*, *NoOp*

Percept sequence	Actions
[A,Clean]	Right
[A, Dirty]	Suck
[B,Clean]	Left
[B,Dirty]	Suck
[A,Clean],[A,Clean]	Right
[A,Clean],[A,Dirty]	Suck
…	…
[A,Clean],[A.Clean],[A,Clean]	Right
[A,Clean],[A,Clean],[A,Clean]	Suck

One simple function is :

if the current square is dirty then suck, otherwise move to the other square

Let’s Visualize Intelligent Agent



Rational Agent

- **Rational Agent**: For each possible percept sequence, a rational agent should select an action that is expected **to maximize its performance measure**, given the evidence provided by the percept sequence and whatever built-in knowledge the agent has.
- An agent should strive to **"do the right thing",** based on what it can perceive and the actions it can perform. The right action is the one that will cause the agent to be most successful.
- Rationality is distinct from omniscience (all knowing with infinite knowledge). Agents can perform actions in order to **modify future percepts** so as to obtain useful information (information gathering, exploration).

Rational Agent Demonstration Delivery Bot

- A rational agent does the **right thing to reach its goal.**
- For example, a **delivery bot wants to deliver a package**.
  - It starts at one point and must go to the destination.
  - If a **road is blocked**, it chooses another path.
  - It always picks the **shortest and safest way**.
- This makes it a smart and rational agent.

Autonomous Agent

- An **autonomous agent** is a system that can make decisions and act on its own without human help.
- ***It senses its environment, processes information, and then acts to achieve its goal.***
- **Examples :**self-driving cars, delivery robots, and smart thermostats.
- **It learns or adapts over time to perform better.**
- **Unlike remote-controlled systems, it acts independently.**
- It is a k**ey part of artificial intelligence and robotics.**

Performance measure vs. Utility function

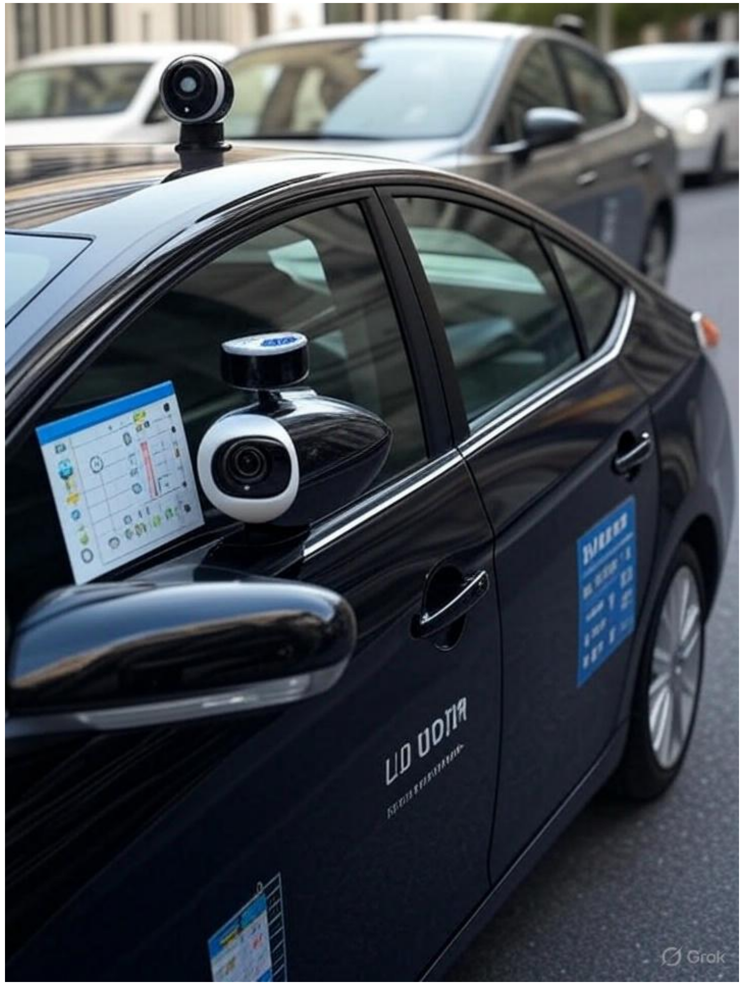
Point	Performance Measure	Utility Function
What is it?	Tells how good the agent is doing its job	Tells how much the agent likes a result
Who uses it?	Set by the system designer (outside the agent)	Used by the agent itself to decide
Example	Reaching the destination in less than 10 minutes	Preferring the shortest, safest, or fastest route
Simple Use	"Did the agent complete the task well?"	"Which option is better for me?"
Demo	A robot gets 10 points for cleaning a room	The robot prefers cleaning faster even if the reward is same
Goal	Judge success	Make the best choice

PEAS

- Must first specify the setting for intelligent agent design.
  - **Performance –** which qualities it should have?
  - **Environment –** where it should act?
  - **Actuators –** how will it perform actions?
  - **Sensors –** how will it perceive environment?

Examples of PEAS:

- **Automated taxi driver:**
  - **Performance measure**: Safe, fast, legal, comfortable trip, maximize profits
  - **Environment:** Roads, other traffic, pedestrians, customers
  - **Actuators:** Steering wheel, accelerator, brake, signal, horn
  - **Sensors:** Cameras, sonar, speedometer, GPS, odometer, engine sensors, keyboard



Examples of PEAS:

Agent: Interactive English tutor

- **Performance measure**: Maximize student's score on test
- **Environment:** Set of students
- **Actuators:** Screen display (exercises, suggestions, corrections)
- **Sensors:** Keyboard

Examples of PEAS:

- **Agent: Medical diagnosis system**
  - https://www.youtube.com/watch?v=C5euaa4p4Pk&ab_channel=NBCNews
  - **Performance measure**: Healthy patient, minimize costs, lawsuits
  - **Environment**: Patient, hospital, staff
  - **Actuators**: Screen display (questions, tests, diagnoses, treatments, referrals)
  - **Sensors**: Keyboard (entry of symptoms, findings, patient's answers)
- **Agent: Part-picking robot**
  - https://www.youtube.com/watch?v=N9p6eJ1mhqk&ab_channel=MecaluxGroup
  - **Performance measure**: Percentage of parts in correct bins
  - **Environment:** Conveyor belt with parts, bins
  - **Actuators:** Jointed arm and hand
  - **Sensors:** Camera, joint angle sensors

Examples of PEAS:

- **PEAS for a Satellite image analysis system**
- https://www.youtube.com/watch?v=Xo2g3AWIWPw&ab_channel=WIRED
  - **Performance measure**: Correct image categorization
  - **Environment:** downlink from orbiting satellite
  - **Actuators**: display categorization of scene
  - **Sensors:** color pixel arrays
- **PEAS for a refinery controller**
- https://www.youtube.com/watch?v=vDokbdIS6kE&ab_channel=ProductionTechnology
  - **Performance measure**: maximize purity, yield, safety
  - **Environment:** refinery, operators
  - **Actuators**: valves, pumps, heaters, displays
  - **Sensors**: temperature, pressure, chemical sensors

Examples of PEAS:

- **Mathematician's theorem-proving assistant**
  - **P**: good math knowledge, can prove theorems accurately and in minimal steps/time
  - **E**: Internet, library
  - **A**: display
  - **S**: keyboard

Examples of PEAS:

Autonomous Mars rover

https://www.youtube.com/watch?v=E3xWCqPBUFU&ab_channel=NASAJetPropulsionLaboratory

P: Terrain explored and reported, samples gathered and analyzed

E: Launch vehicle, lander, Mars

A: Wheels/legs, sample collection device, analysis devices, radio transmitter

S: Camera, touch sensors, accelerometers, orientation sensors, wheel/joint encoders, radio receiver

Internet book-shopping agent

https://www.youtube.com/watch?v=zMwyiNpbUXQ&ab_channel=CBSNews

- P: Obtain requested/interesting books, minimize expenditure
- E: Internet
- A: Follow link, enter/submit data in fields, display to user
- S: Web pages, user requests

Robot soccer player

https://www.youtube.com/watch?v=KfNRXTS55nY&ab_channel=Slate

- P: Winning game, goals for/against
- E: Field, ball, own team, other team, own body
- A: Devices (e.g., legs) for locomotion and kicking
- S: Camera, touch sensors, accelerometers, orientation sensors, wheel/joint encoders

Environment types:

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

1. 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.

2. 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 chess piece 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.

3. 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.

4. 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.

5. 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.

6. 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.

7.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.

8. 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.

Types of Agents in AI

- ❑ Types of Agents in AI, agents are the entities that perceive their environment and take actions to achieve specific goals.
- ❑ These agents exhibit diverse behaviors and capabilities, ranging from simple reactive responses to sophisticated decision-making.

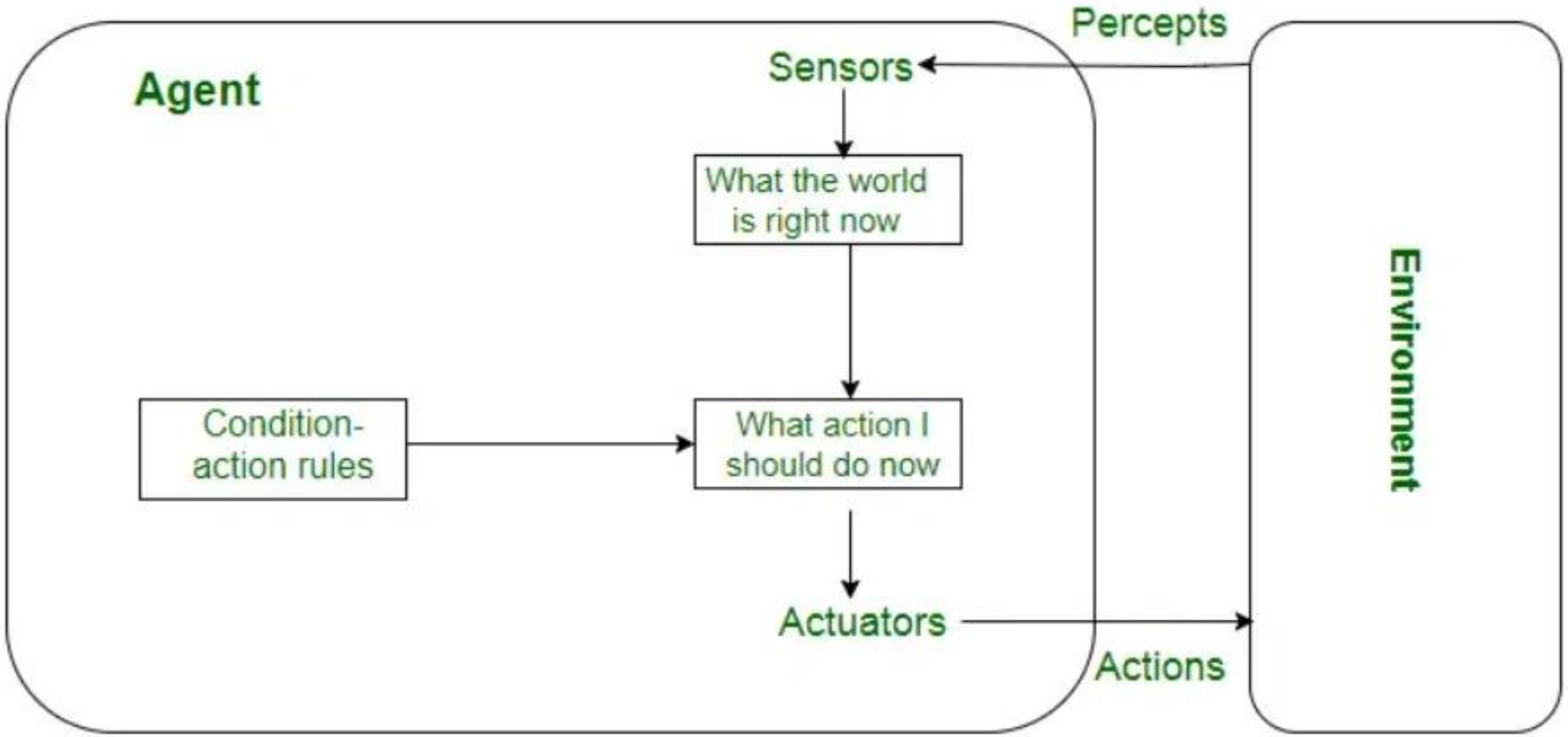
1. **Simple Reflex Agent**
2. **Model-Based Reflex Agents**
3. **Goal-Based Agents**
4. **Utility-Based Agents**

1. Simple Reflex Agent

- **Simple reflex agents** make decisions based solely on the current input, without considering the past or potential future outcomes. They react directly to the current situation without internal state or memory.
  - **Example:** A thermostat that turns on the heater when the temperature drops below a certain threshold but doesn't consider previous temperature readings or long-term weather forecasts.

- **Characteristics of Simple Reflex Agent:**
  - **Reactive:** Reacts directly to current sensory input without considering past experiences or future consequences.
  - **Limited Scope:** Capable of handling simple tasks or environments with straightforward cause-and-effect relationships.
  - **Fast Response:** Makes quick decisions based solely on the current state, leading to rapid action execution.
  - **Lack of Adaptability:** Unable to learn or adapt based on feedback, making it less suitable for dynamic or changing environments.

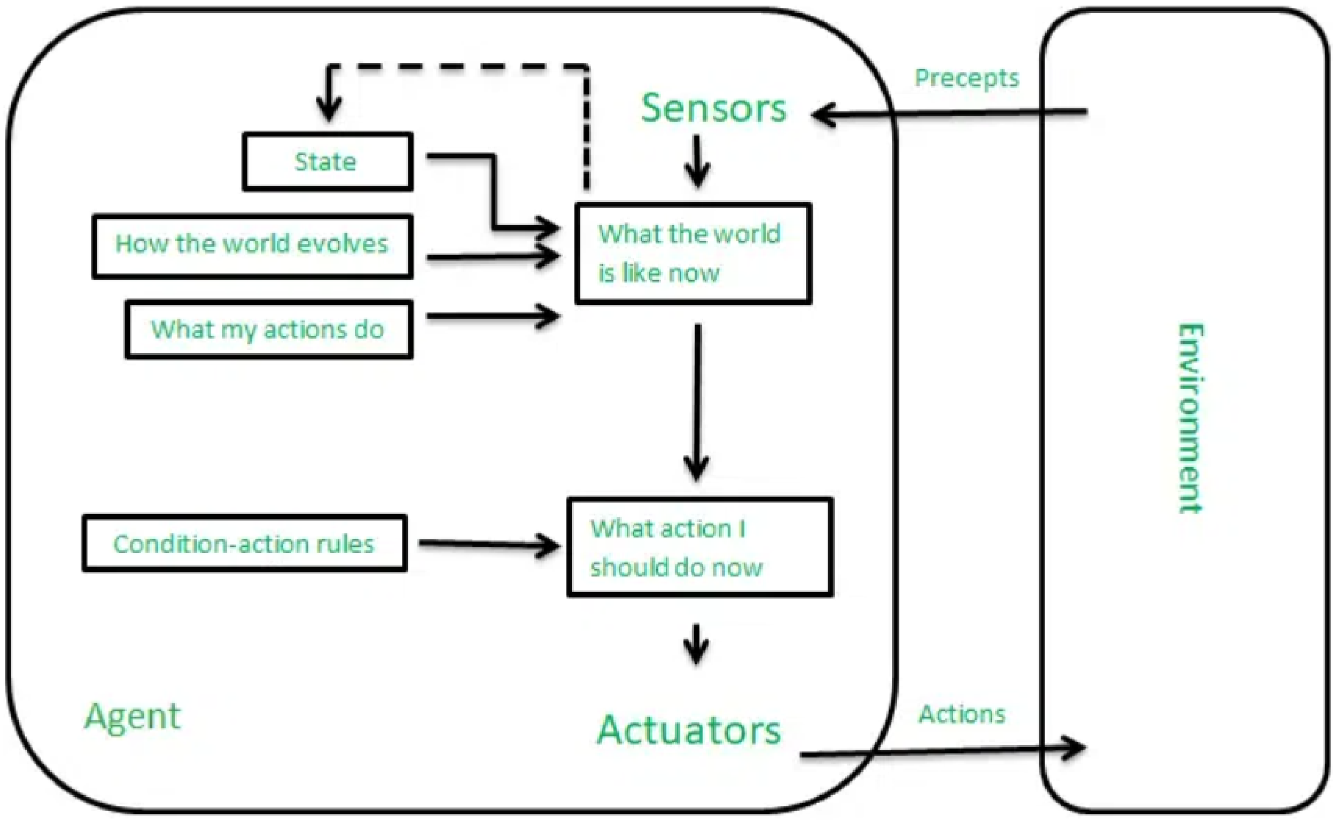
Simple Reflex AGENT



2. Model-Based Reflex Agents

- Model-based reflex agents enhance simple reflex agents by incorporating internal representations of the environment. These models allow agents to predict the outcomes of their actions and make more informed decisions. By maintaining internal states reflecting unobserved aspects of the environment and utilizing past perceptions, these agents develop a comprehensive understanding of the world. This approach equips them to effectively navigate complex environments, adapt to changing conditions, and handle partial observability.
- **Example:** A self-driving system not only responds to present road conditions but also takes into account its knowledge of traffic rules, road maps, and past experiences to navigate safely.
- **Characteristics Model-Based Reflex Agents**
  - **Adaptive:** Maintains an **internal model** of the environment to anticipate future states and make informed decisions.
  - **Contextual Understanding:** Considers both current input and historical data to determine appropriate actions, allowing for more nuanced decision-making.
  - **Computational Overhead**: Requires resources to build, update, and utilize the internal model, leading to increased computational complexity.
  - **Improved Performance:** Can handle more complex tasks and environments compared to simple reflex agents, thanks to its ability to incorporate past experiences.

Schematic Diagram of a Model-Based Reflex Agents



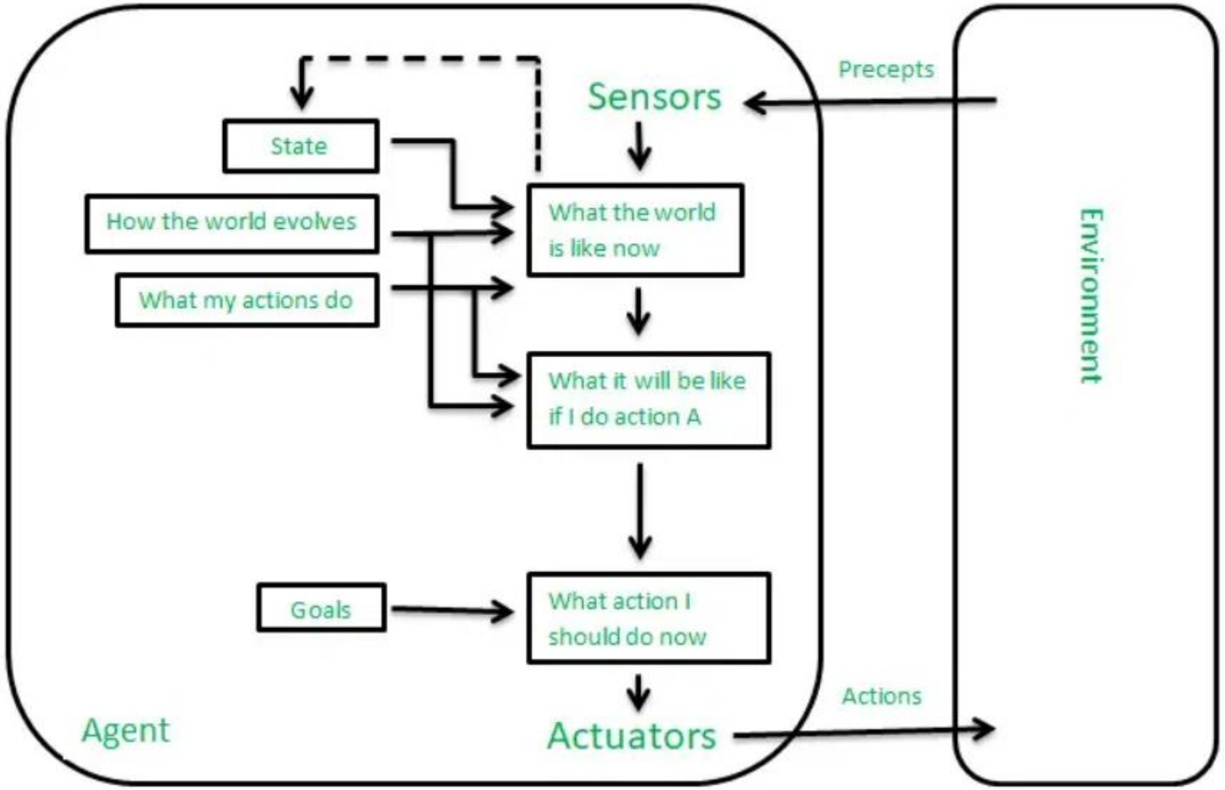
3. Goal-Based Agents

- **Goal-based agents** have predefined objectives or goals that they aim to achieve. By combining descriptions of goals and models of the environment, these agents plan to achieve different objectives, like reaching particular destinations. They use search and planning methods to create sequences of actions that enhance decision-making in order to achieve goals. Goal-based agents differ from reflex agents by including forward-thinking and future-oriented decision-making processes.

- **Example**: A delivery robot tasked with delivering packages to specific locations. It analyzes its current position, destination, available routes, and obstacles to plan an optimal path towards delivering the package.

- **Characteristics of Goal-Based Agents:**
  - **Purposeful:** Operates with predefined goals or objectives, providing a clear direction for decision-making and action selection.
  - **Strategic Planning:** Evaluates available actions based on their contribution to goal achievement, optimizing decision-making for goal attainment.
  - **Goal Prioritization:** Can prioritize goals based on their importance or urgency, enabling efficient allocation of resources and effort.
  - **Goal Flexibility:** Capable of adapting goals or adjusting strategies in response to changes in the environment or new information.

Schematic Diagram of a **Goal-Based Agents**



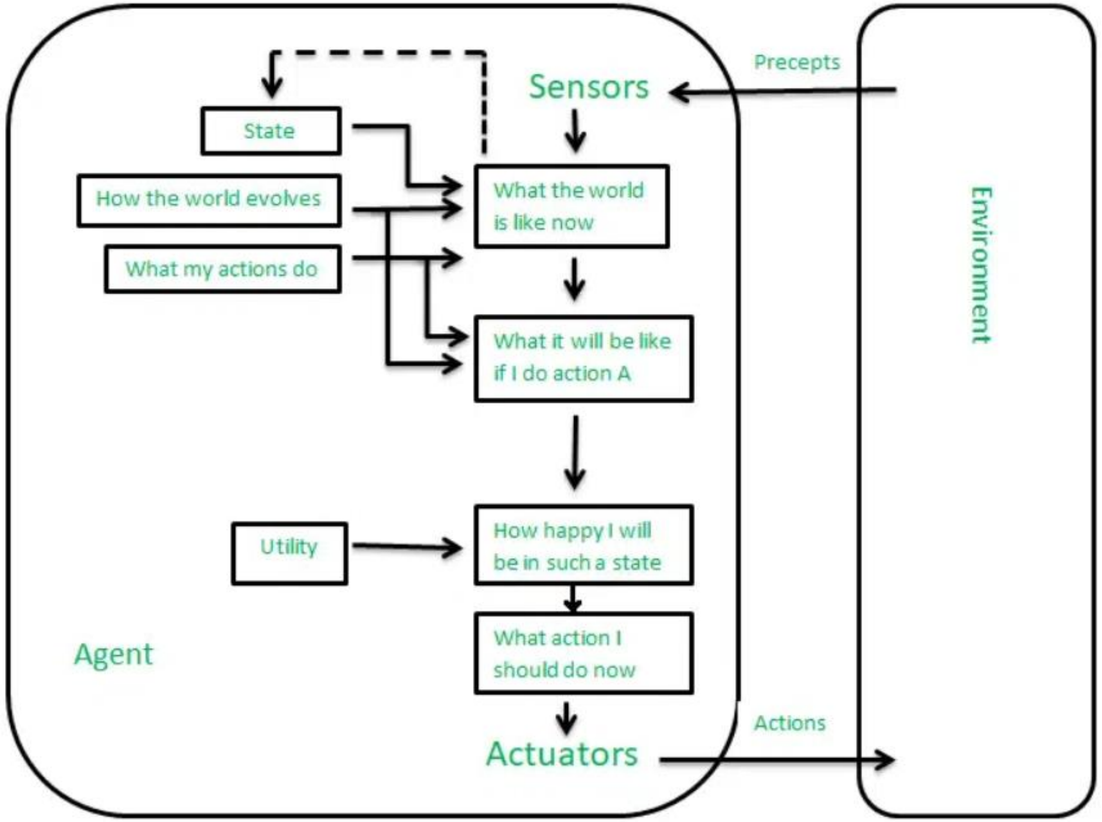
4. Utility-Based Agents

- **Utility-based agents** go beyond basic goal-oriented methods by taking into account not only the accomplishment of goals, but also the quality of outcomes. They use utility functions to value various states, enabling detailed comparisons and trade-offs among different goals. These agents optimize overall satisfaction by maximizing expected utility, considering uncertainties and partial observability in complex environments. Even though the concept of utility-based agents may seem simple, implementing them effectively involves complex modeling of the environment, perception, reasoning, and learning, along with clever algorithms to decide on the best course of action in the face of computational challenges.
- **Example:** An investment advisor algorithm suggests investment options by considering factors such as potential returns, risk tolerance, and liquidity requirements, with the goal of maximizing the investor's long-term financial satisfaction.

Utility-Based Agents

- **Characteristics of Utility-Based Agents:**
  - **Multi-criteria Decision-making:** Evaluates actions based on multiple criteria, such as utility, cost, risk, and preferences, to make balanced decisions.
  - **Trade-off Analysis:** Considers trade-offs between competing objectives to identify the most desirable course of action.
  - **Subjectivity:** Incorporates subjective preferences or value judgments into decision-making, reflecting the preferences of the decision-maker.
  - **Complexity:** Introduces complexity due to the need to model and quantify utility functions accurately, potentially requiring sophisticated algorithms and computational resources.

Schematic Diagram of Utility-Based Agents



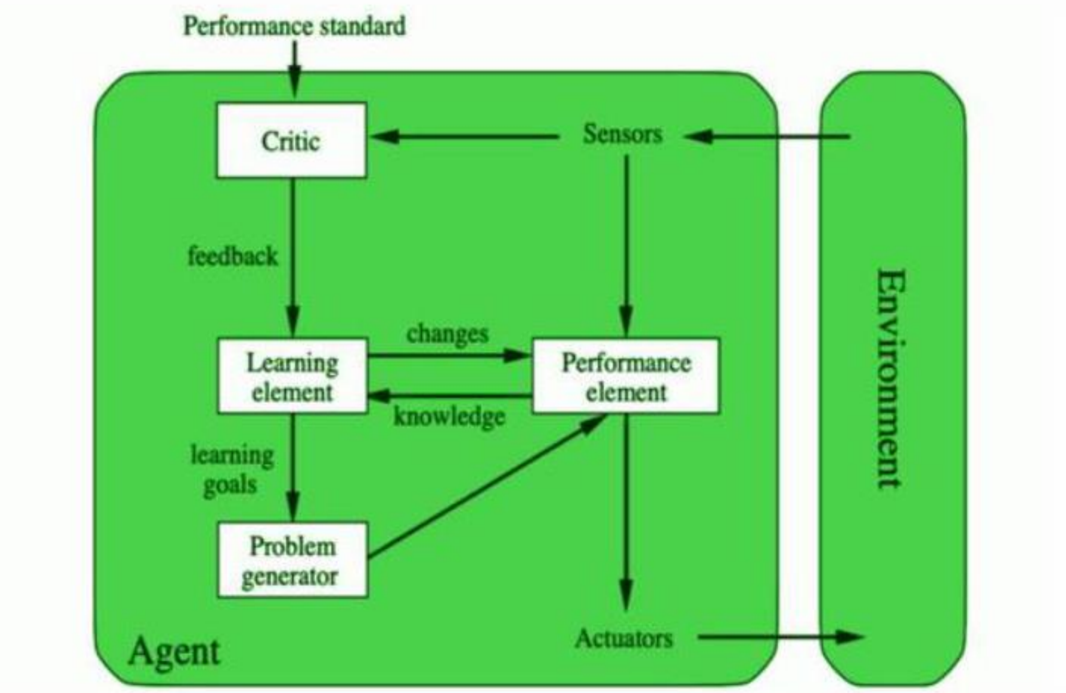
5. Learning Agents

- **Learning agents** are a key idea in the field of artificial intelligence, with the goal of developing systems that can improve their performance over time through experience. These agents are made up of a few important parts: the learning element, performance element, critic, and problem generator.
- The learning component is responsible for making **enhancements based on feedback received from the critic**, which evaluates the agent's performance against a fixed standard. This feedback allows the learning aspect to adjust the behavior aspect, which chooses external actions depending on recognized inputs.
- **Example:** An e-commerce platform employs a recommendation system. Initially, the system may depend on simple rules or heuristics to recommend items to users. However, as it collects data on user preferences, behavior, and feedback (such as purchases, ratings, and reviews), it enhances its suggestions gradually. By utilizing machine learning algorithms, the agent constantly enhances its model by incorporating previous interactions, thus enhancing the precision and significance of product recommendations for each user. This system's adaptive learning process improves anticipating user preferences and providing personalized recommendations, ultimately boosting the user experience and increasing engagement and sales for the platform.

Characteristics of Learning Agents:

- **Adaptive Learning:** Acquires knowledge or improves performance over time through experience, feedback, or exposure to data.
- **Flexibility:** Capable of adapting to new tasks, environments, or situations by adjusting internal representations or behavioral strategies.
- **Generalization:** Extracts general patterns or principles from specific experiences, allowing for transferable knowledge and skills across different domains.
- **Exploration vs. Exploitation:** Balances exploration of new strategies or behaviors with exploitation of known solutions to optimize learning and performance.

Schematic Diagram of Learning Agents



THANK YOU !!!