Chapter-Two

Intelligent Agents

Basic topics in Chapter 2

- **Intelligent Agents**
  - Introduction to agent in AI
  - Agents and Environments
  - Acting of Intelligent Agents (Rationality)
  - Structure of Intelligent Agents
  - ***PEAS*** Description & Environment Properties
- **Agent Types**
  - ***Simple reflex agent***
  - ***Model-based reflex agent***
  - ***Goal-based agent***
  - ***Utility-based agent***
  - ***Learning agent***
- Important Concepts and Terms

Introduction to agents in AI

- 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.**

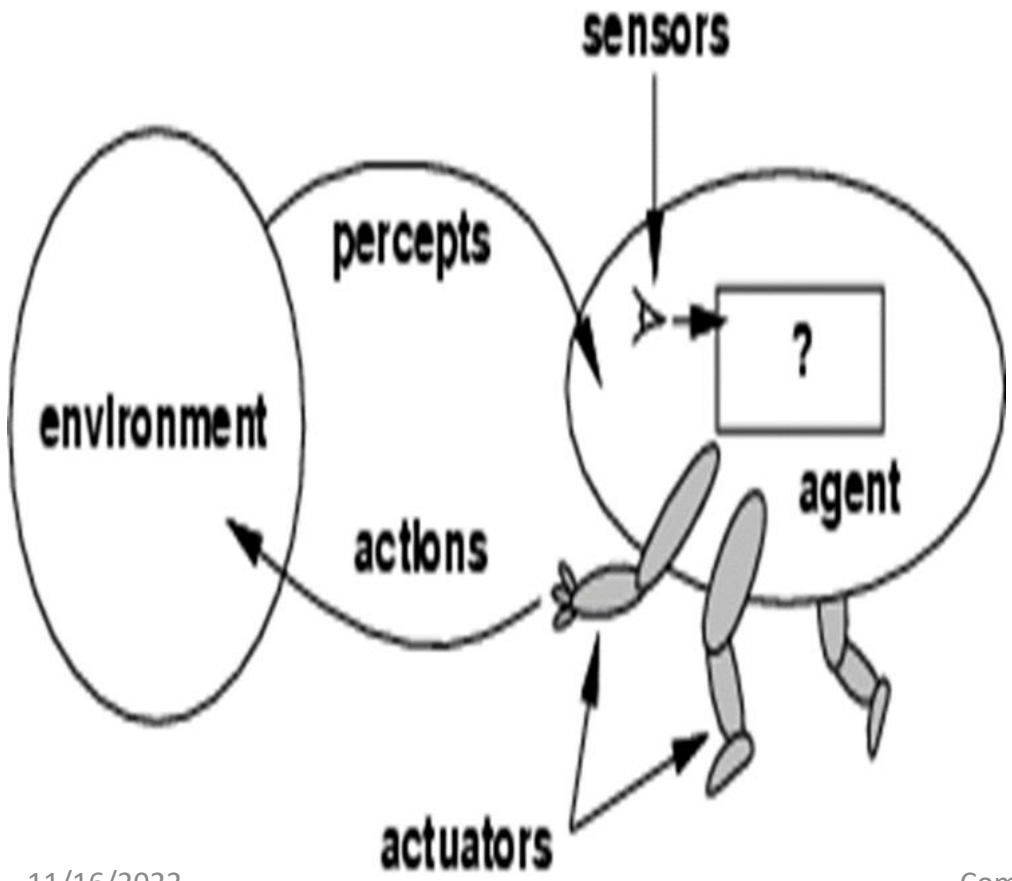
What is an Agent?

- An **agent** can be anything that ***perceiving*** its environment through ***sensors*** and ***acting*** 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 others work for **actuators.**
- **Robotic Agent:**
  - A robotic agent can have ***cameras, infrared range finder***, 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.

Agents and its Environments

- **Agents** interact with **environments** through **sensors** and **actuators**.



Sensor: a device that detects the change in the environment and sends the information to other electronic devices.

- ✓ An agent observes its environment through ***sensors***.

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.

What is Intelligent Agent?

- 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.

- 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.

Structure of an AI Agent

- The structure of an intelligent agent is a combination of architecture and an agent program.
- It can be viewed as: **Agent = Architecture + Agent program**

- **There are three main structures of an AI agent:**

  i. Architecture: is machinery that an AI agent executes on.

  ii. Agent Function: is used to map a percept to an action. [**f:P* → A**]

  iii. Agent program: is an implementation of agent function.

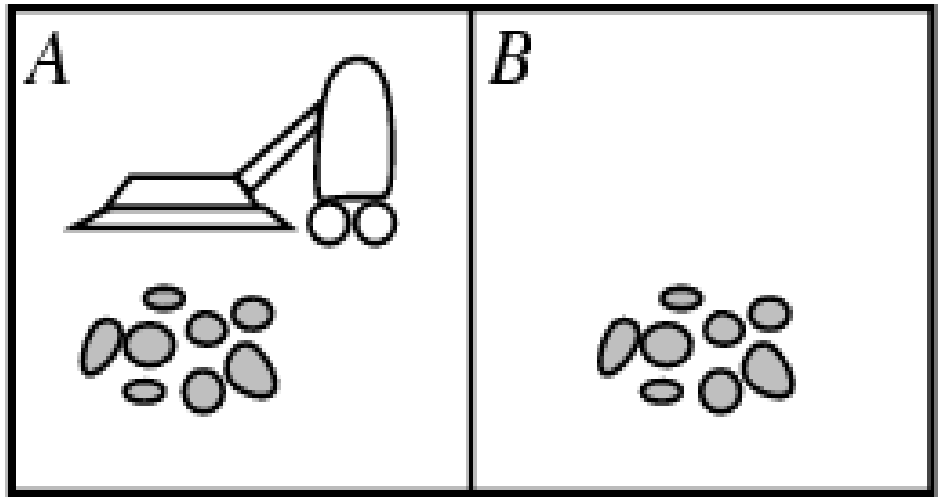
  ✓ An agent program executes on the physical architecture to produce function f.

  - Agents everywhere!

  For example: *Vacuum cleaners, Thermostat, Cell phones, Robot, Alexa Echo, Self-driving cars, Humans etc.*

Vacuum-Cleaner World

- **Figure -** A vacuum-cleaner world with just two locations.



- Percepts: location and contents, e.g., [A, Dirty]
- **Actions:** *Left*, *Right*, *Suck*, ……

- A vacuum-cleaner agent

Percept	Action
[A, Clean]	Right
[A, Dirty]	Suck
[B, Clean]	Left
[B,Dirty]	Suck

- **Note:** this only uses the last percept of the percept history, so **this agent can not learn from experience.**

Rational agents

- A **rational 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.**

- **Performance measure:** An objective **criterion for the success** of an agent's behavior.
- **E.g.**, the performance measure of a **vacuum-cleaner agent** could be:
  - *Amount of dirt cleaned up*,
  - *Amount of time taken*,
  - *Amount of electricity consumed*,
  - *Amount of noise generated*, *etc.*

Rational agents (1)

- **What is a 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.

Rationality is distinct from **omniscience**.

Omniscience (all-knowing with infinite knowledge).

An omniscient agent **knows the *actual* outcome of its actions** and, Can act accordingly;

But **omniscienc**e is impossible in reality.

Rational agents (2)

- **Agents can perform actions** in order to modify future percepts so as to obtain useful information **(information gathering, exploration).**
- An agent is autonomous if its behavior is determined by its own experience ***(with ability to learn and adapt).***
  - **Rationality:** The **rationality** of an agent is measured by its performance measure.

Rationality can be judged on the basis of following four points:

- *The **performance measure** that defines the criterion of success.*
- *The agent's **prior knowledge** of the environment.*
- *The **actions** that the agent can perform.*
- *The **agent's percept sequence** to date.*

PEAS Description

- 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.

- **PEAS stands for:**
  - **Performance measure:** *A measure of **how good the behavior of agents** operating in the environment is?*
  - **Environment:** *What **things are considered** to be a part of the environment and what **things are excluded**?*
  - **Actuators:** *How can an **agent perform actions** in the environment?*
  - **Sensors:** *How can the **agent perceive the environment**?*
- Must first specify the setting for intelligent agent design

Ex #1: What is PEAS for a self-driving car?

- **Performance:** *Safety, time, legal drive, comfort,* maximize profits
- **Environment:** *Roads, other cars, pedestrians(*walkers), customers
- **Actuators:** *Steering wheel, accelerator, brake, signal,* indicators, horn(alert or alarm)
- **Sensors:** *Camera, sonar, GPS, Speedometer, odometer, accelerometer, engine sensors, keyboard.*

Ex #2 : What is PEAS for a vacuum cleaner?

iRobot Roomba series

- **Performance:** cleanness, efficiency: distance traveled to clean, battery life, security.
- **Environment:** room, table, wood floor, carpet, different obstacles.
- **Actuators:** wheels, different brushes, vacuum extractor.
- **Sensors:** camera, dirt detection sensor, cliff sensor, bump sensors, infrared wall sensors.

PEAS Example 3: Medical Diagnosis System

Agent: Medical diagnosis system

- **Performance measure:**
  - Healthy patient, minimize costs, *avoid lawsuits*(charges).
- **Environment:**
  - Patient, hospital, staff
- **Actuators:**
  - Screen display (questions, tests, diagnoses, treatments, referrals)
- **Sensors:**
  - Keyboard (entry of symptoms, findings, patient's answers)

PEAS-Example3: Interactive English tutor

Agent: Interactive English tutor

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

Agent Environment in AI

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

•**There a major types of environments:**

– *Fully Observable & Partially Observable, Episodic & Sequential, Static & Dynamic, Discrete & Continuous, Deterministic & Stochastic,* Single agent vs. multi-agent and Known vs. Unknown

Fully observable vs. partially Observable

–In **full observable** an agent's sensors give it **access to the** complete state of the environment at each point in time.

–*If they give it **partial access** then the environment is **partially observable.***

–An environment is called **unobservable** when the agent has no sensors in all environments.

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

Deterministic vs. Stochastic

- **Deterministic Environment-**
  - The environment deterministic if the next state of the environment is completely determined by the current state and the action executed by the agent.
- **Stochastic Environment**
  - is random in nature which is not unique and cannot be completely determined by the agent.
  - *If there are apparently **"random" events** that can make **the next state unpredictable**.*

- **Example:**
  - **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.

Episodic vs. Sequential

- **Episodic-**
  - The agent's experience is **divided into atomic "episodes"** (each episode consists of the agent perceiving and then performing a single action), and **the choice of action in each episode depends only on the episode itself.**
    - ***An episode=*** *agent's single pair of perception and action*
  - The quality of the agent's action does not depend on other episode.
    - Every episode is independent each other
  - Episodic environment is simpler
    - The agent does not need to think ahead

- **Sequential:** Current action may affect all future decisions
  - Ex: taxi driving and chess

Static vs. Dynamic

- ***Static:***
  - *If the **environment stays unchanged** whilst the agent is thinking about what action to take, it is a **static environment.***
- ***Dynamic:***
  - *If it is **continually changing**, even whilst the agent is thinking, it is **dynamic**.*
  - ***For example:** the number of people in the street*
- ***Semi-Dynamic:***
  - *If the **environment remains unchanged** but the **agent's performance score changes**, it is **semi-dynamic.***

Discrete vs. continuous

- ***Discrete:***
  - *If the agent has a **limited number** of possible actions and percept's, it is a **discrete** environment.*
- ***Continuous:***
  - *If the number of actions and/or percept's is **effectively unlimited** it is a **continuous** environment.*
- ***Examples:***
  - *Chess has finite number of discrete states and has discrete set of percept and actions.*
  - *Taxi driving has discrete set of percept and actions.*

Single-agent vs. Multi-agent

- An agent operating by itself in an environment.
- ***Single agent:***
  - *If there are* ***no other agents in the environment*** *we say it is a* ***single-agent environment.***
  - ***For example: playing a crossword puzzle***
- ***Multi-agent:***
  - *If there are other agents it is a multi-agent environment.*
  - ***For example chess playing***

Note: The agent design problems in the multi-agent environment are different from single agent environment.

Known vs. Unknown

•The designer of the agent may or may not have knowledge about the environment makeup.

•**Known:**

– In known environment, the outcomes for all actions are given

– For example: Solitaire card games

- **Unknown :**

– If the environment is unknown the agent will need to know how it works in order to make good decisions

– For example: new video game

Examples of task environments

The environment type largely determines the agent design:

The easiest type of environment is fully-observable, deterministic, episodic, static, discrete and single agent.

The real world is (of course) partially observable, stochastic, sequential, dynamic, continuous, multi-agent.

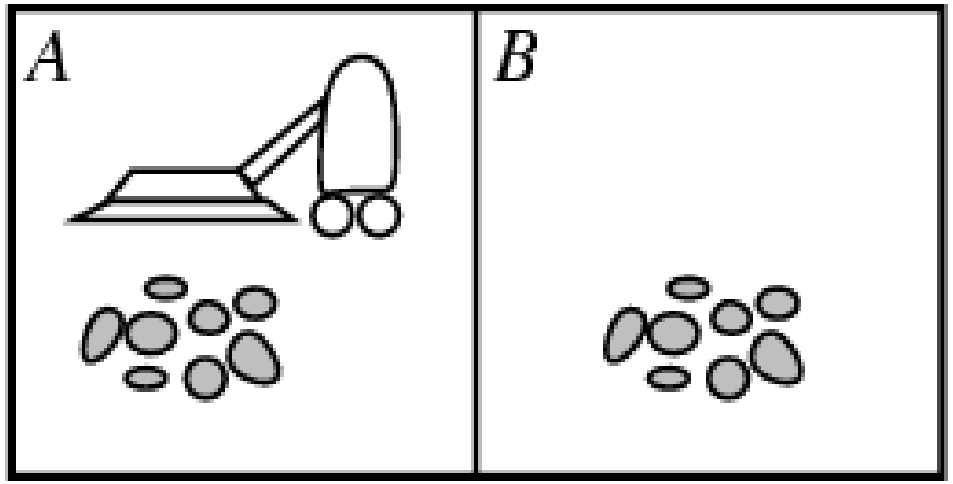
Task Environment	Observable	Deterministic	Episodic	Static	Discrete	Agents
Crossword puzzle	Fully	Deterministic	Sequential	Static	Discrete	Single
Chess with a clock	Fully	Strategic	Sequential	Semi	Discrete	Multi
Poker	Partially	Strategic	Sequential	Static	Discrete	Multi
Backgammon	Fully	Stochastic	Sequential	Static	Discrete	Multi
Taxi driving	Partially	Stochastic	Sequential	Dynamic	Continuous	Multi
Medical diagnosis	Partially	Stochastic	Sequential	Dynamic	Continuous	Single
Image-analysis	Fully	Deterministic	Episodic	Semi	Continuous	Single
Part-picking robot	Partially	Stochastic	Episodic	Dynamic	Continuous	Single
Refinery controller	Partially	Stochastic	Sequential	Dynamic	Continuous	Single
Interactive English tutor	Partially	Stochastic	Sequential	Dynamic	Discrete	Multi

Table-lookup agent

- Program **determines action by looking up percept sequence** in a table,
- e.g. vacuum cleaner

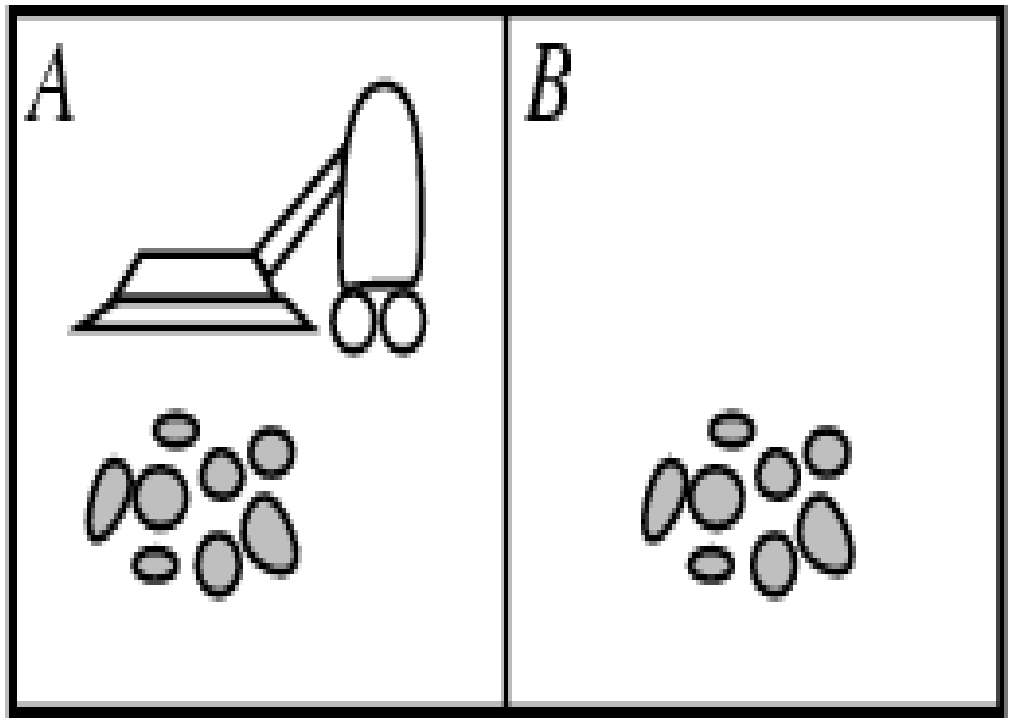
•Drawbacks

- Huge table
- Take a long time to build the table
- No autonomy (needs to be told everything)
- Even with learning, need a long time to learn the table entries



Percept	Action
[A, Clean]	Right
[A, Dirty]	Suck
[B,Clean]	Left
[B,Dirty]	Suck

Agent program for a vacuum-cleaner agent



Function Vacuum-Agent ([location,status])
returns an action

{

If status = Dirty then return Suck

Else if location = A then return Right

Else if location = B then return Left

}

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:
  - *i. Simple Reflex Agent*
  - *ii. Model-based reflex agent*
  - *iii. Goal-based agents*
  - *iv. Utility-based agent*
  - *v. Learning agent*

i. Simple reflex agents

- Is the **simplest kind of agent**
- These 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.
- These agents use only the current percept, so **have no memory of past precepts.**
- In particular, **they cannot base decisions on things** that they cannot directly perceive,
- **i.e. they have no *model* of the state of the world**.

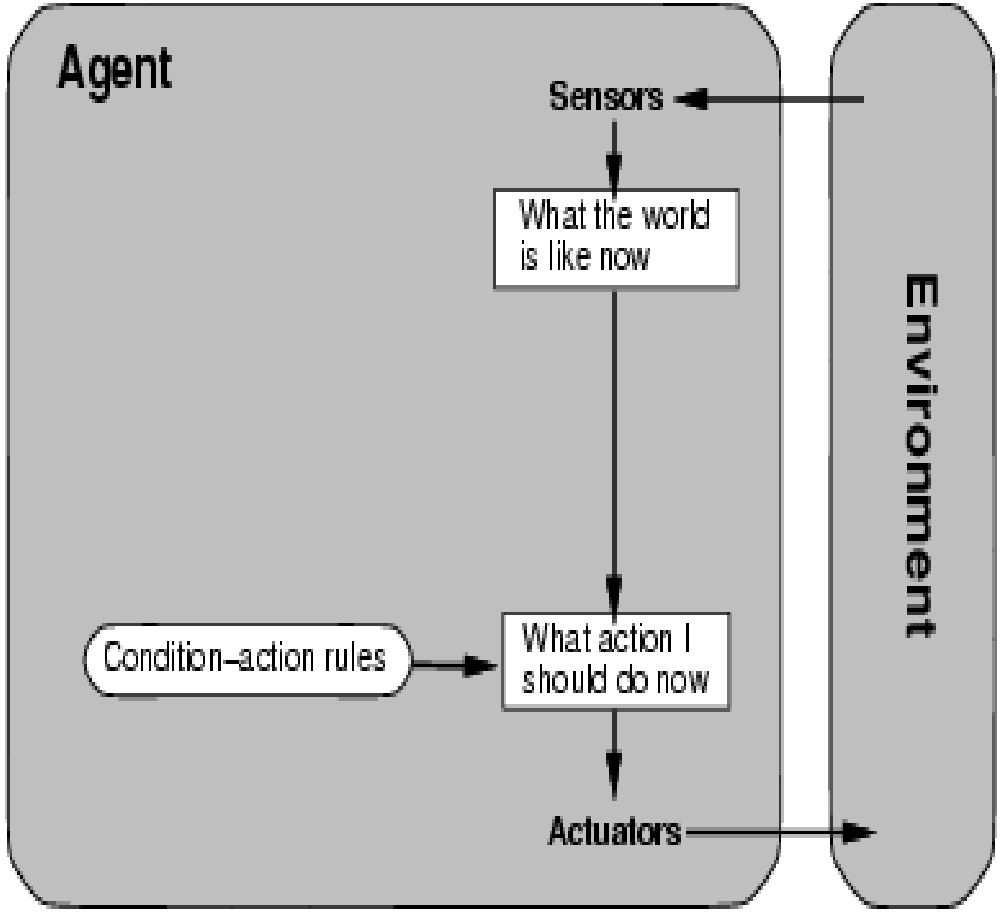


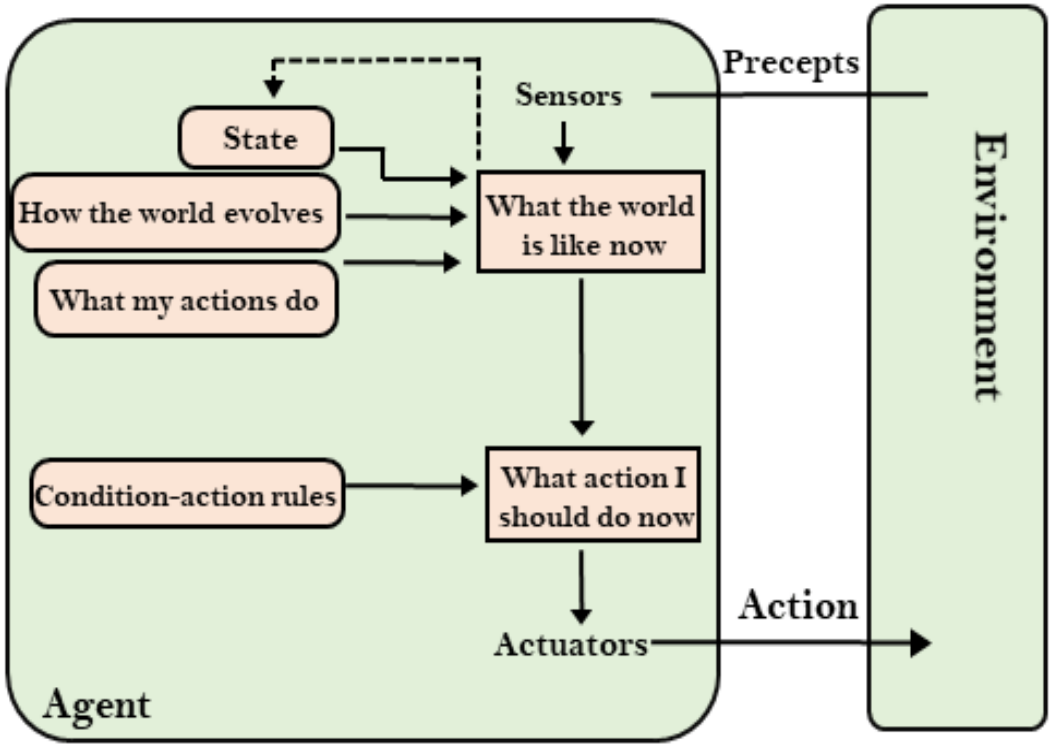
Figure - Schematic diagram of a simple reflex agent.

Problems for the simple reflex agent:

- 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.

ii. Model-based reflex agents

- 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.

iii. Goal-based agents

- **Goal based agents** are the same as **model based agents**, except
  - **They contain** an explicit statement of **the goals of the agent.**
  - These **goals are used to choose the best action** at any given time.
- Goal based agents can therefore **choose an action which does not achieve anything in the short term,** but in the long term may lead to a goal being achieved.

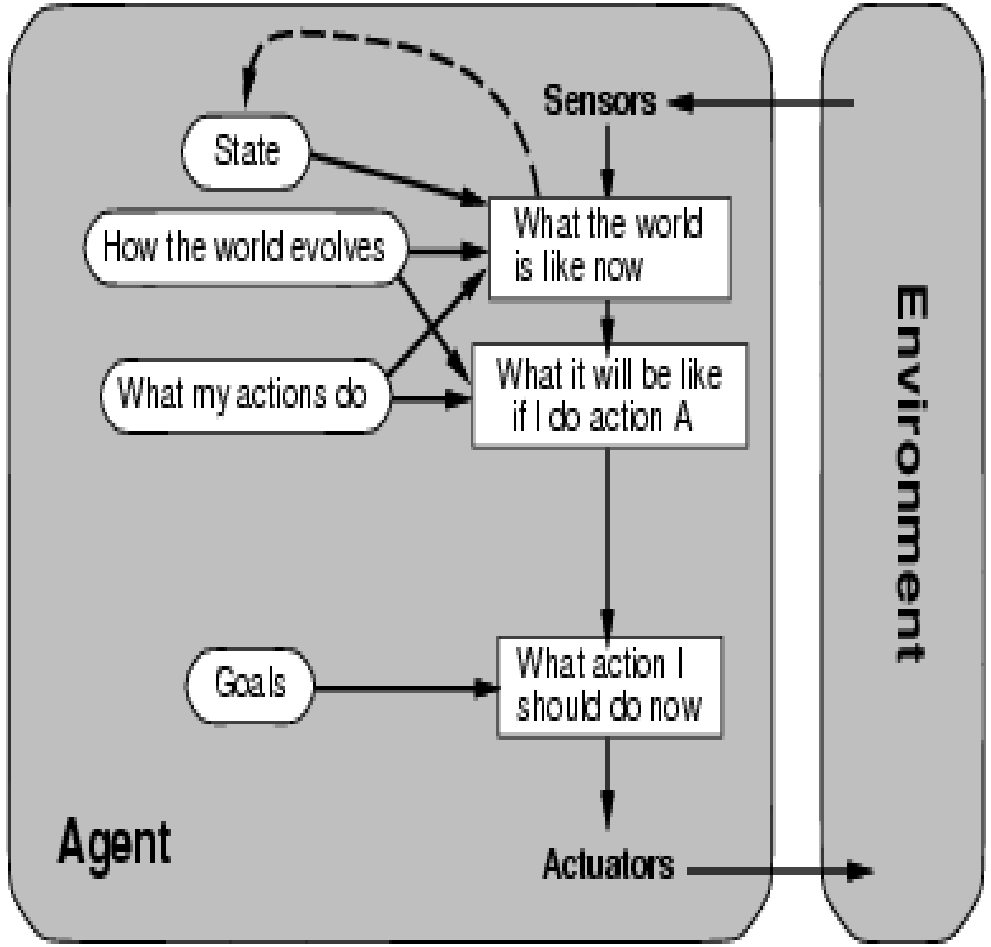


Fig - A model-based, goal-based agent.

iv. Utility-based agents

- These agents are similar to the goal-based agent but provide an extra component of utility measurement
- **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.
- This **utility defines how "happy" the agent** will be in such a state.

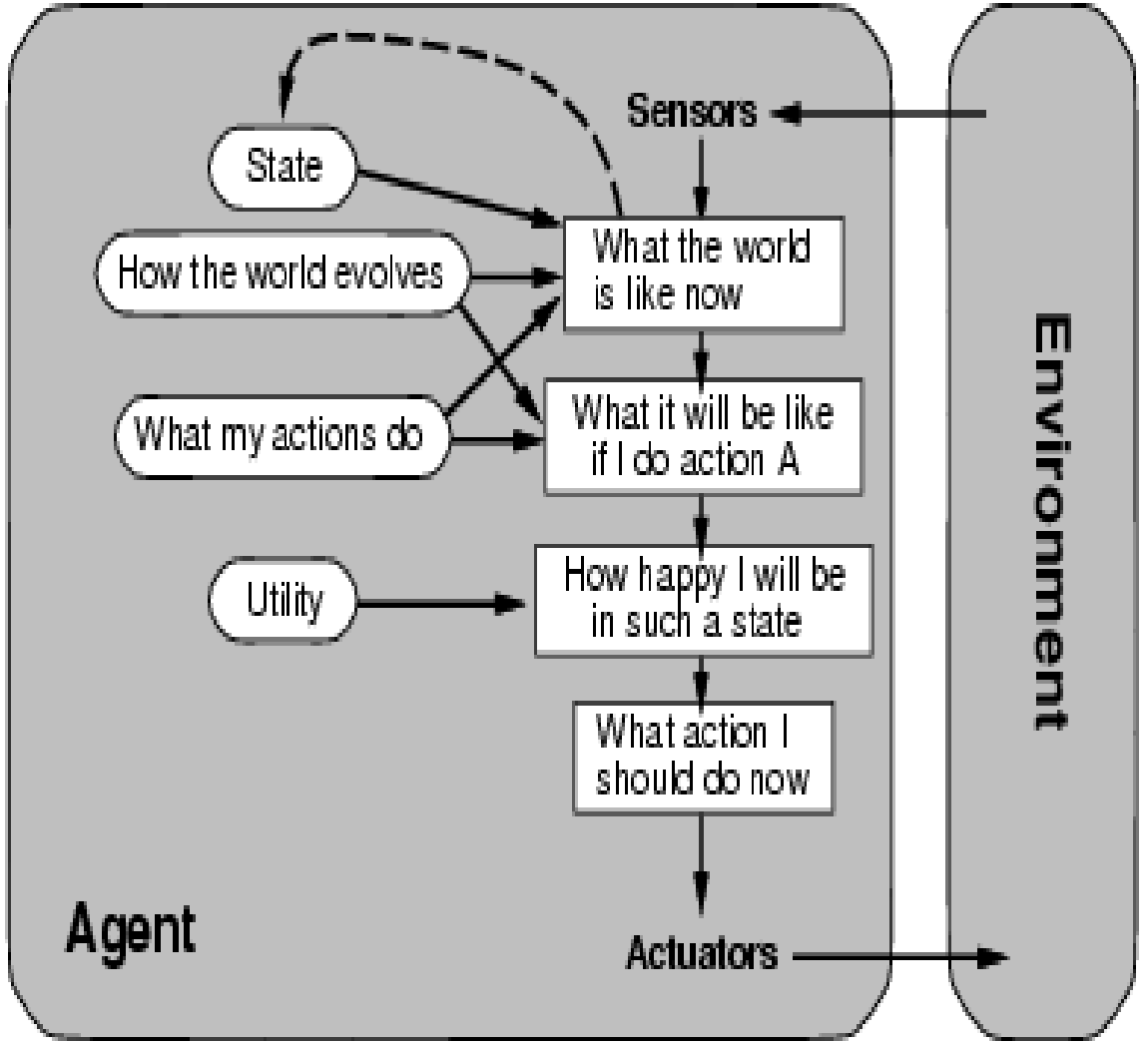


Fig- A model-based, utility-based agent.

v. 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.

v. Learning agents…

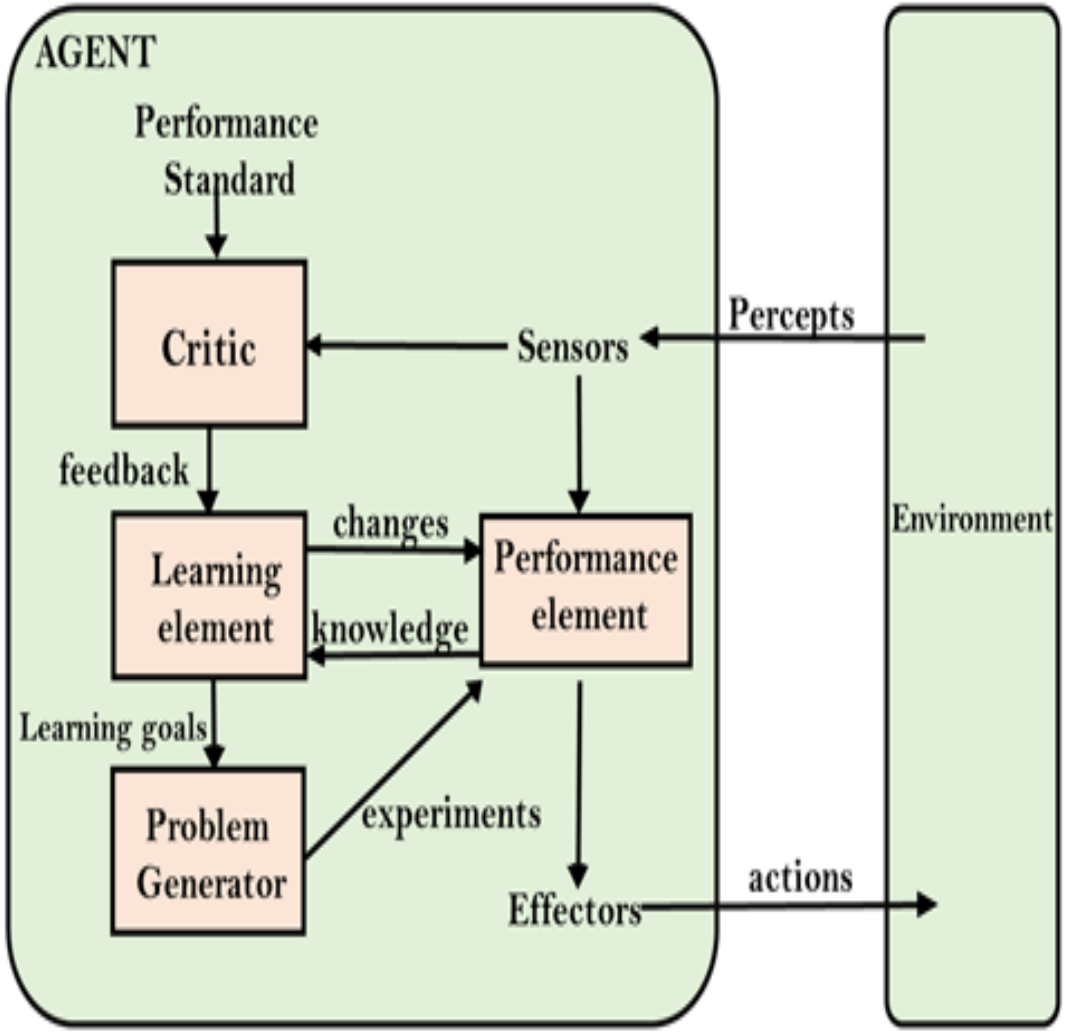
Performance element:

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 performance.



Summary

- How to define the AI problem?
  - PEAS description of environments
- Categories of AI environment:
  - Fully-observable, partially-observable, etc.
- Basic agent types:
  - Simple reflex, model-based, goal-based, utility-based, learning agents

The End of Chapter –Two!