Chapter-2 Intelligent agents

2.1*Introduction*

- An agent is anything that can be viewed as perceiving its environment through sensors and acting upon that environment through actuators.
- An AI system is composed of an agent and its environment. The agents act in their environment. The environment may contain other agents.

Examples:

- 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.

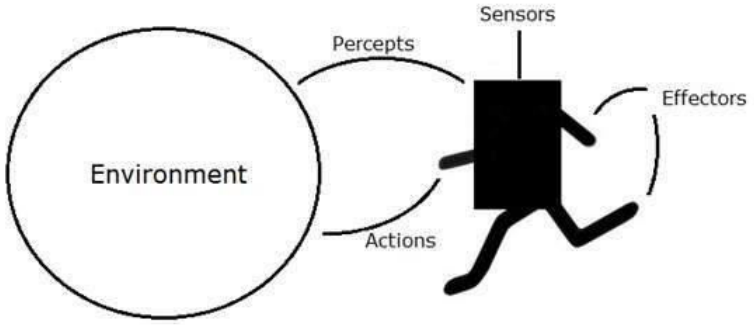


Fig: Architecture of an agent

What do you mean, sensors/percepts and effectors/actions?

For Humans

- **Sensors**: Eyes (vision), ears (hearing), skin (touch), tongue (gestation), nose (olfaction), neuromuscular system (proprioception)
- ***Percepts:***
  - At the lowest level – electrical signals from these sensors
  - After preprocessing – objects in the visual field (location, textures, colors, …), auditory streams (pitch, loudness, direction), …
- **Effectors or actuators**: limbs, digits, eyes, tongue, …..
- **Actions**: lift a finger, turn left, walk, run, carry an object, …

2.2 *Properties of the agent*

i. **Rationality:**

Rational agent

A rational agent is one which chooses the action which will make it most successful. In order to complete that definition we need to have a way of measuring how successful a course of action is. The criteria for measuring the degree of successfulness is performance measure and it varies from agent to agent. Rationality of an agent is restricted by its percepts since it can only respond to the percept sequence, that is the history of things it has sensed from the environment. It is also limited by its effectors (motors in the case of robots).

Ideal rational agent

"For each possible percept sequence an ideal rational agent should do whatever action is expected to maximize its performance measure, on the basis of the evidence provided by the sensors and built in knowledge the agent has."

ii. **Autonomous:** "A system is autonomous to the extent that its behavior is determined by its own experience" If actions depend entirely on built in knowledge without considering percepts the agent lacks autonomy. Autonomy is achieved by giving to the agent built in knowledge together with the ability to learn, just as in nature animals have instincts but also learn from the environment.

A truly autonomous intelligent agent should be able to operate successfully in a wide variety of environments given sufficient time to adapt.

iii. **Flexibility:**

An intelligent agent is a computer system capable of flexible action in some dynamic environment.

iv. **Reactiveness:** In order to define reactivity we shall first define the notion of logical agent and consider what Knowledge Based Agents are.

Concept of Logical Agent.

"An agent that can form representations of the world, use a process of inference to derive new references of the world and use these new representatives to decide what to do.

v. **Proactiveness:**

- Generating and attempting to achieving goals
- Executing actions /giving advice/making recommendations /making suggestions without an explicit user request.
- Exhibit goal directed behavior.

2.3 *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.

2.4 The Nature of Environments

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.

In contrast, some software agents (software robots or softbots) exist in rich, unlimited softbots domains. The simulator has a very detailed, complex environment. The software agent needs to choose from a long array of actions in real time. A softbot designed to scan the online preferences of the customer and show interesting items to the customer works in the real as well as an artificial environment.

The most famous artificial environment is the Turing Test environment, in which one real and other artificial agent are tested on equal ground. This is a very challenging environment as it is highly difficult for a software agent to perform as well as a human.

2.5 Properties / types of environment

The range of task environments that might arise in Ai is obviously vast. We can, however, identify a fairly small number of dimensions along which task environments can be categorized. These dimensions determine, to a large extent, the appropriate agent design and the applicability of each of the principal families of techniques for agent implementation.

- **Discrete / Continuous** − If there are a limited number of distinct, clearly defined, states of the environment, the environment is discrete (For example, chess); otherwise it is continuous (For example, driving).
- **Fully Observable / Partially Observable** − If it is possible to determine the complete state of the environment at each time point from the percepts it is fully observable (e.g. Image Recognition); otherwise it is only partially observable (e.g. Self driving).
- **Static / Dynamic** − If the environment does not change while an agent is acting, then it is static(e.g. Chess); otherwise it is dynamic(e.g Taxi driving).
- **Single agent / Multiple agents** − the environment may contain other agents which may be of the same or different kind as that of the agent. For example: ,an agent solving a crossword puzzle by itself is clearly in a single agent environment, whereas an agent playing chess is in a two agent environment.
- **Accessible / Inaccessible** − If the agent's sensory apparatus can have access to the complete state of the environment, then the environment is accessible to that agent(e.g. Chess),otherwise it is inaccessible (e.g. medical diagnosis system).
- **Deterministic / Non-deterministic** − If the next state of the environment is completely determined by the current state and the actions of the agent, then the environment is deterministic (e.g. Chess); otherwise it is non-deterministic (e.g. Taxi driving).
- **Episodic / Non-episodic** − In an episodic environment, each episode consists of the agent perceiving and then acting. The quality of its action depends just on the episode itself. Subsequent episodes do not depend on the actions in the previous episodes. Episodic environments are much simpler because the agent does not need to think ahead.(e.g. Image analysis); In non-episodic environment , the current decision could affect all future decisions e.g. chess.

Environment	Accessible	Deterministic	Episodic	static	Discrete
Chess with a clock	Yes	Yes	No	Semi	Yes
Poker	No	No	No	Yes	Yes
Taxi driving	Yes	No	No	Yes	Yes
Medical diagnosis system	No	No	No	No	No
Image analysis system	Yes	Yes	Yes	Semi	No
Interactive English tutor	No	No	No	No	Yes

2.6 Rationality and Omniscience

Rationality:

Rationality is nothing but status of being reasonable, sensible, and having good sense of judgment.

Rationality is concerned with expected actions and results depending upon what the agent has perceived. Performing actions with the aim of obtaining useful information is an important part of rationality.

What is rational at any given time depends on four things:

- 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.
- This leads to the definition of a rational agent:

  For each possible percept sequence, a rational agent should select an action that is expected to maximize it's performance measure, given the evidence provided by the percept sequence and whatever built-in knowledge the agent has.

Omniscience:

An omniscient agent knows the actual outcome of it's actions and can act accordingly; but omniscience is impossible in reality.

2.7 Structure of Agents/Types of agents

Agents can be grouped into five classes based on their degree of perceived intelligence and capability. All these agents can improve their performance and generate better action over the time. These are given below:

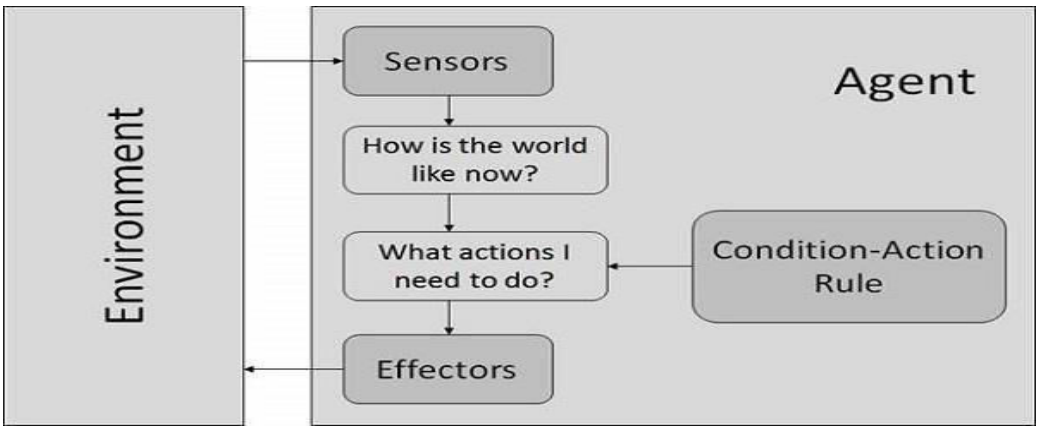
1. Simple Reflex Agents

- 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.
- 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.
- For example: the vaccum agent is simplex reflex ,because it's decision is based only on the current location and on whether that location contains dirt.

Condition-Action Rule − It is a rule that maps a state (condition) to an action.

```
function SIMPLE-REFLEX-AGENT(percept) returns an action
    persistent: rules,a set of condition-action rules
      state←INTERPRET-INPUT (percept)
      rule←RULE-MATCH(state,rules)
      action←rule.ACTION
      return action
```

Fig: A simple reflex agent. It acts according to a rule whose condition matches the current state,as defined by the percept.



2. 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:
  a. How the world evolves
  b. How the agent's action affects the world.

```
function REFLEX-AGENT-WITH-STATE(percept) returns an action  Static :
state, a description of the current world state
rules, a set of condition-action rules
action, the most recent action, initially none  state ←
UPDATE-STATE(state, action, percept)  rule ←
RULE-MATCH(state, rules)
action ← RULE-ACTION[rule]  return
action
```

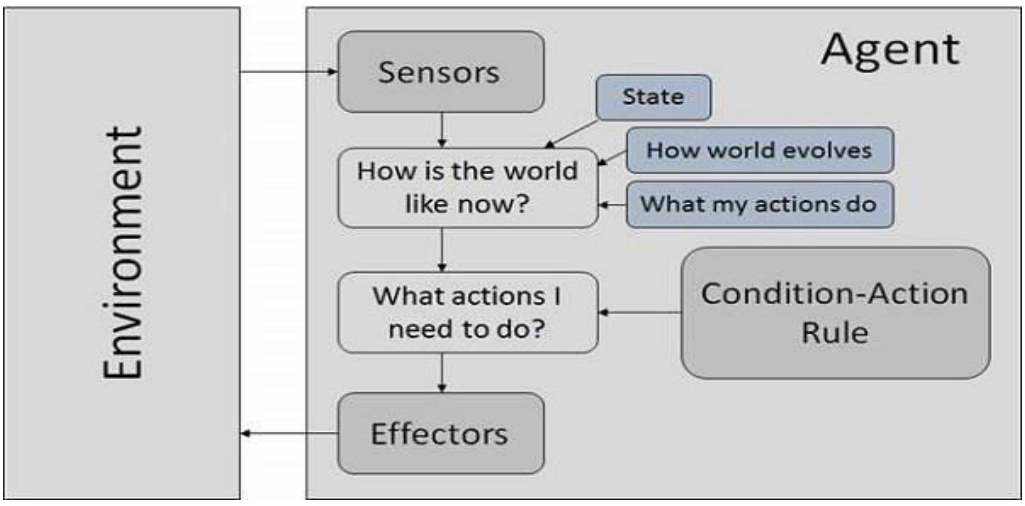
They use a model of the world to choose their actions. They maintain an internal state.

Model − knowledge about "how the things happen in the world".

Internal State − It is a representation of unobserved aspects of current state depending on percept history.

Updating the state requires the information about −

- How the world evolves.
- How the agent's actions affect the world.

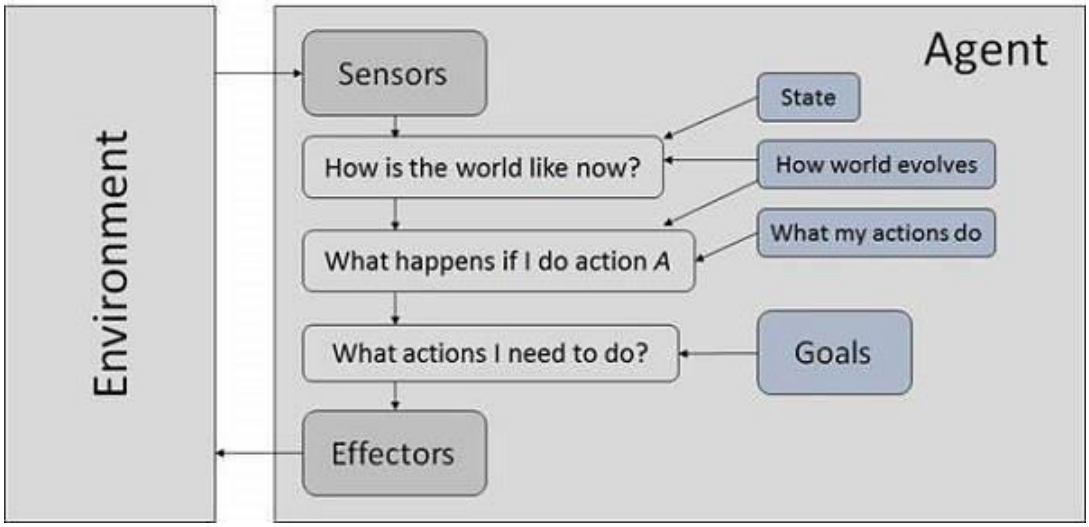


3. Goal Based Agents

- 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.

Goal − It is the description of desirable situations.



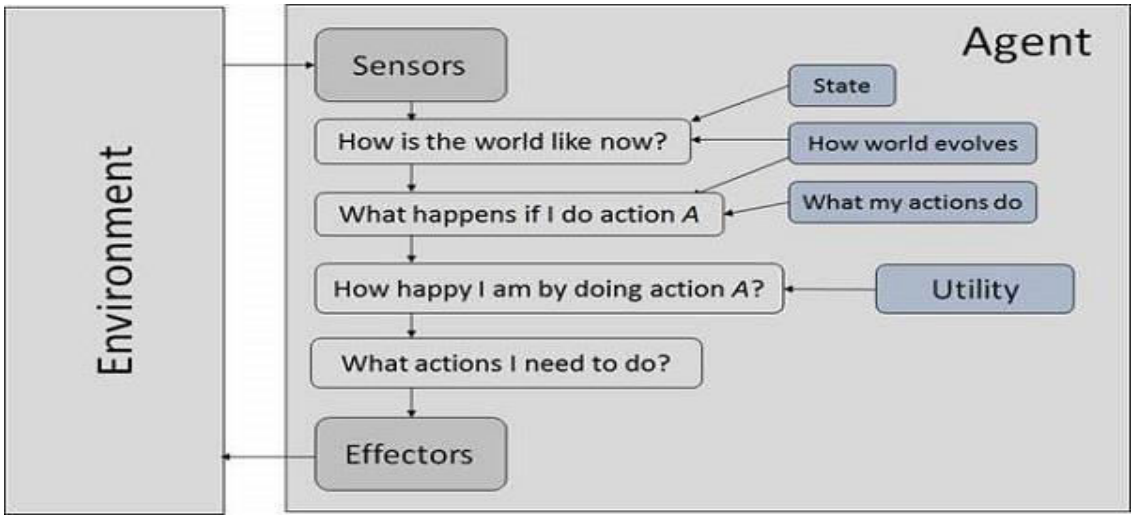
4. Utility Based Agents

An agent generates a goal state with high –quality behavior(utility) that is , if more than one sequence exists to reach the goal state then the sequence with more reliable,safer,quicker and cheaper than others to be selected.

- 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.

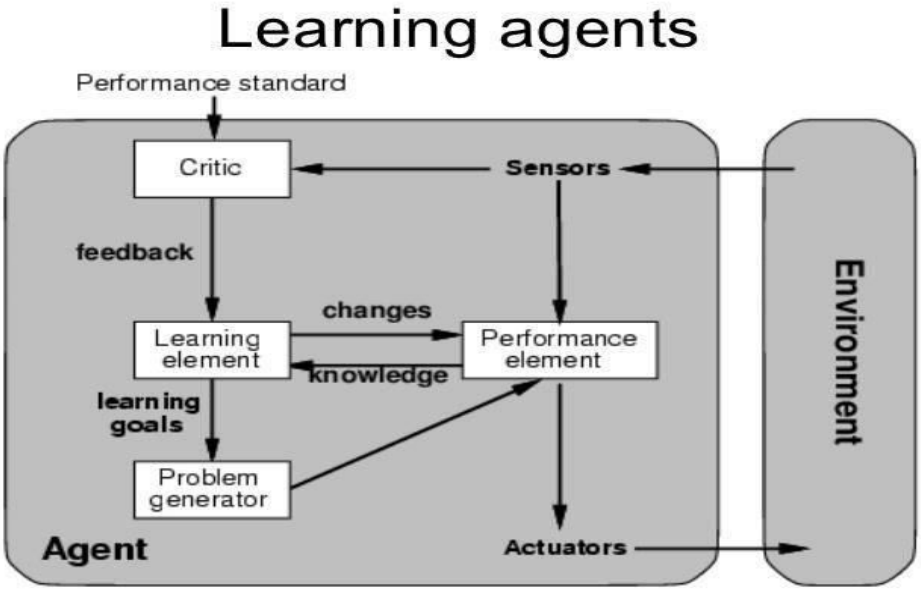
Goals are inadequate when −

- There are conflicting goals, out of which only few can be achieved.
- Goals have some uncertainty of being achieved and you need to weigh likelihood of success against the importance of a goal.



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:
    a. **Learning element:** It is responsible for making improvements by learning from environment
    b. **Critic:** Learning element takes feedback from critic which describes that how well the agent is doing with respect to a fixed performance standard.
    c. **Performance element:** It is responsible for selecting external action.
    d. **Problem generator:** This component is responsible for suggesting actions that will lead to new and informative experiences.
- Hence, learning agents are able to learn, analyze performance, and look for new ways to improve the performance.



2.8 *PEAS: Agents and Environments*

What's an agent?

Agents include humans, robots, softbots, thermostats, etc. The agent function maps from percept histories to actions:

$f : P^* \rightarrow A.$

The agent program runs on the physical architecture to produce f.

PEAS

PEAS stand for performance, Environment, Actuators, and Sensors. Based on these properties of an agent, they can be grouped together or can be differentiated from each other. Each agent has these following properties defines for it.

Performance: The output which we get from the agent .All the necessary results that an agent gives after processing comes under its performance.

Environment: All the surrounding things and conditions of an agent fall in this section. It basically consists of all things under which the agent works.

Actuators: The devices, hardware or software through which the agent performs any actions or processes any information to produce a result.

Sensors: The device or components through which the agent observes and perceives it's environment are the sensors of the agent.

Agent Type	Performance Measure	Environment	Actuators	Sensors
Taxi driver	Be safe, reach destination, maximize profits, obey laws, . . .	Urban streets, freeways, traffic, pedestrians, weather, customers, . . .	Steering wheel, accelerator, brake, horn	Video, accelerometers, gauges, engine sensors, keyboard, GPS,

Figure: PEAS description of task environment for an automated taxi.

PEAS description of the task environment

Agent Type	Performance Measure	Environment	Actuators	Sensors
Medical diagnosis system	Healthy patient, reduced costs	Patient, hospital, Staff, pharmacy	Display of questions, tests, diagnoses, treatments, referrals. Display to user, follow URL, fill in form	Keyboard entry of symptoms, findings, patient's answers, Web pages (text, graphics, scripts. . .)
Self driving car	Safety, time, legal drive, comfort	Roads, other card , pedestrians , traffic signs etc.	Steering, sonar, GPS, speedometer, ,keyboard etc.	Camera, Sonar, GPS, speedometer , accelerometer, engine sensor, keyboard
Interactive English Tutor	Student's score on test	Set of students, testing agency	Display of exercises, suggestions, corrections	Keyboard entry

Fig: Examples of agent types and their PEAS description