

# Intelligent Agents

## Chapter 2

# Agent

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

# Agents

- An **agent** is anything that can be viewed as **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:

**1. Human-Agent:** A human agent has eyes, ears, and other organs which work for sensors and hand, legs, mouth, vocal tract work and other body parts for actuators.

# Agents

**2. Robotic Agent:** A robotic agent can have cameras, infrared range finder, NLP for sensors and various motors for actuators.

- Cog-MIT, Aibo-Sony

**3. Software Agent:** Software agent can have keystrokes, file contents as sensory input and act on those inputs and display output on the screen.

- Hence the world around us is full of agents such as thermostat, cellphone, camera, and even we are also agents.

# Agent Terminology

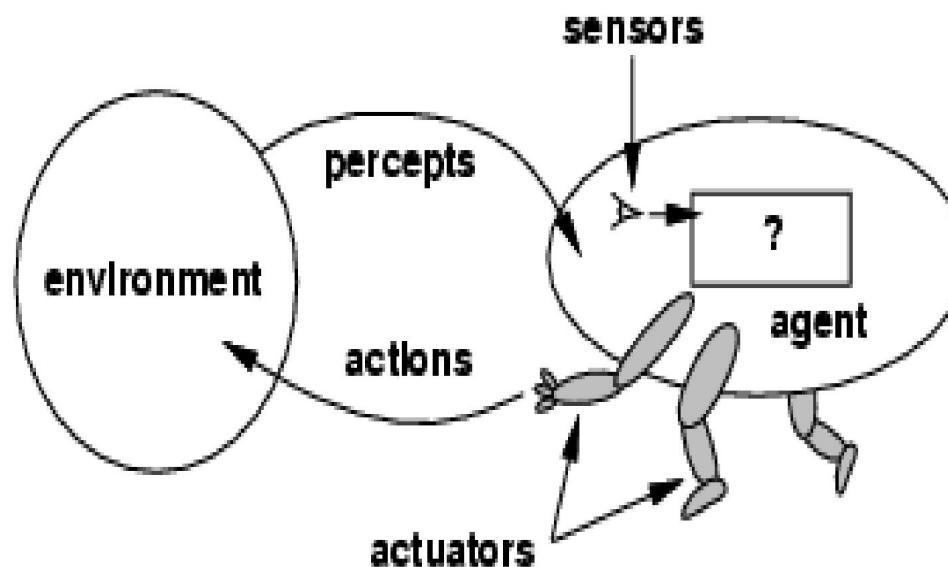
- **Performance Measure of Agent** – It is the criteria, which determines how successful an agent is.
- **Behavior of Agent** – It is the action that agent performs after any given sequence of percepts.
- **Percept** – It is agent's perceptual inputs at a given instance.
- **Percept Sequence** – It is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

# Agents and Environments

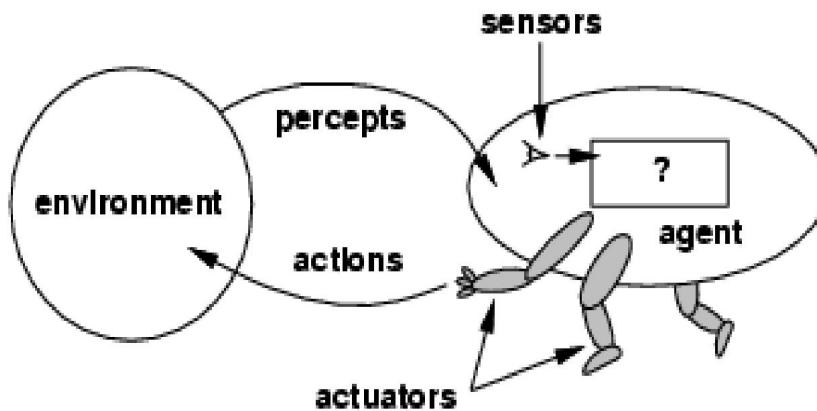
**Sensor:** Sensor is a device which **detects the change in the environment** and sends the information to other electronic devices. An agent observes its environment through sensors.

**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.

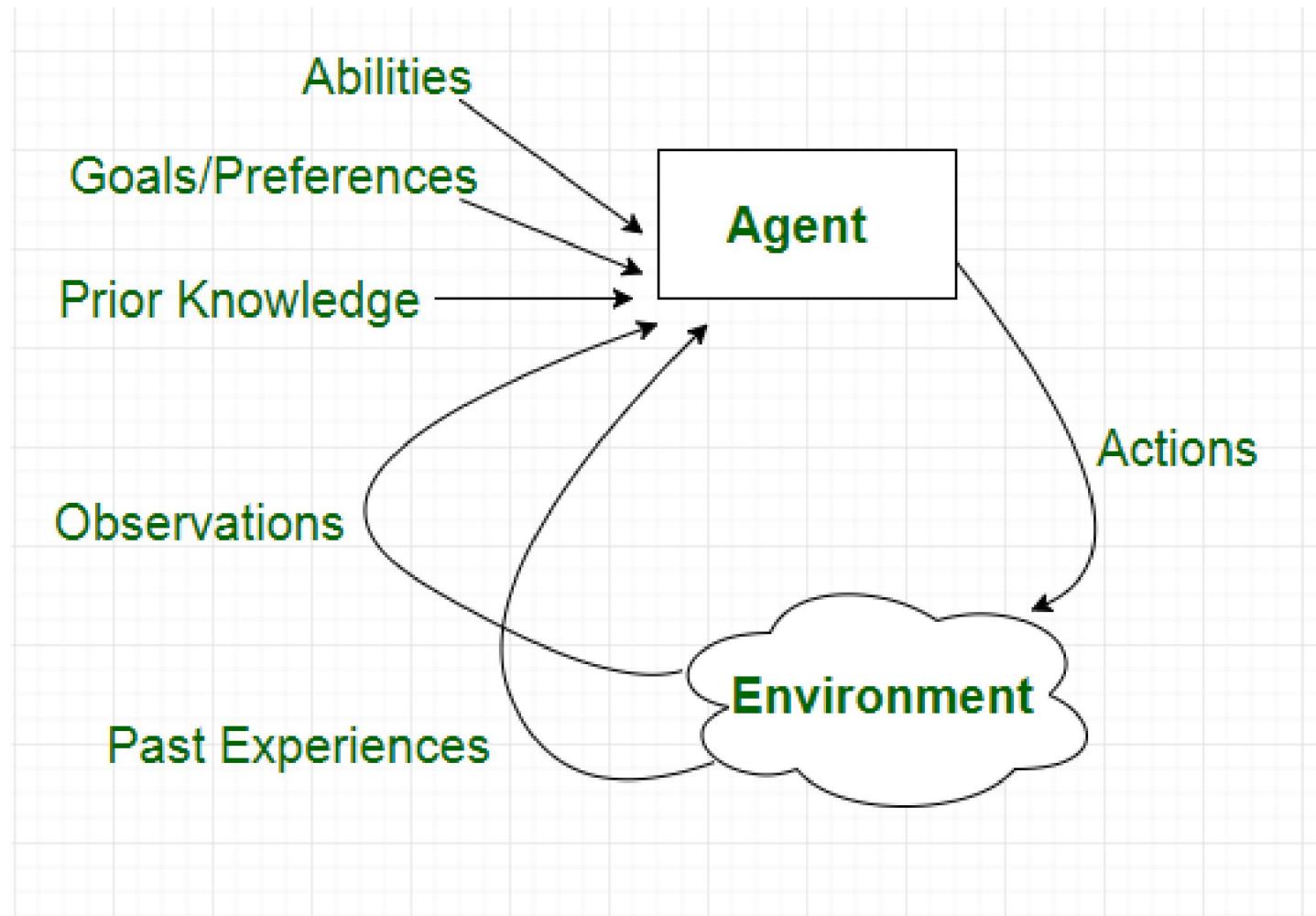


# Agents and Environments



- The **agent function** maps from percept histories to actions:  
 $[f: \mathcal{P}^* \rightarrow \mathcal{A}]$
- The **agent program** runs on the physical **architecture** to produce the function ( $f$ )
- Agent = architecture + program

# Agent



# Intelligent Agent

- 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.
- **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**.

# Rational Agent

- A rational agent is an agent which has clear preference, models uncertainty, and acts in a way to maximize its performance measure with all possible actions.
- A rational agent is said **to perform the right things**. AI is about creating rational agents to use for game theory and decision theory for various real-world scenarios.
- For an AI agent, the **rational action** is most **important because in AI reinforcement learning algorithm**, for each best possible action, agent gets the positive reward and for each wrong action, an agent gets a negative reward.

# Rationality

- The rationality of an agent is measured by its **performance measure**.
- Rationality can be judged on the basis of following points:
  - Performance measure which defines the success criterion.
  - Agent prior knowledge of its environment.
  - Best possible actions that an agent can perform.
  - The sequence of percepts.

# Features of Environment

- As per Russell and Norvig, an environment can have various features from the point of view of an agent:
  - Fully observable vs Partially Observable
  - Static vs Dynamic
  - Discrete vs Continuous
  - Deterministic vs Stochastic
  - Single-agent vs Multi-agent
  - Episodic vs sequential
  - Known vs Unknown
  - Accessible vs Inaccessible

# Fully observable vs Partially Observable

- If an agent sensor **can sense** or access the **complete state of an environment** at each point of time then it is **a fully observable** environment, else it is **partially observable**.
- A fully observable environment is easy as there is no need to maintain the internal state to keep track history of the world.
- An agent with no sensors in all environments then such an environment is called as **unobservable**.

# Deterministic vs Stochastic

- If an agent's current state and selected action can **completely determine the next state** of the environment, then such environment is called a deterministic environment.
- A stochastic environment is **random in nature** and cannot **be determined completely** by an agent.
- In a deterministic, fully observable environment, agent does not need to worry about uncertainty.

# Episodic vs Sequential

- In an episodic environment, there is **a series of one-shot actions**, and only the **current percept** is required for the action.
- However, in sequential environment, an agent requires **memory of past actions** to determine the next best actions.

# Single-agent vs Multi-agent

- If only **one agent** is involved in an environment, and operating by itself then such an environment is called single agent environment.
- However, if **multiple agents** are operating in an environment, then such an environment is called a multi-agent environment.
- The agent design problems in the multi-agent environment are different from single agent environment.

# Static vs Dynamic

- If the environment can change itself while an agent is deliberating then such environment is called a dynamic environment else it is called a static environment.
- Static environments are easy to deal because an agent does not need to continue looking at the world while deciding for an action.
- However for dynamic environment, agents need to keep looking at the world at each action.
- Taxi driving is an example of a dynamic environment whereas Crossword puzzles are an example of a static environment.

# Discrete vs Continuous

- If in an environment there are **a finite number of percepts and actions** that can be performed within it, then such an environment is called a discrete environment **else** it is called continuous environment.
- A chess game comes under discrete environment as there is a finite number of moves that can be performed.
- A **self-driving car** is an example of **a continuous environment**.

# Known vs Unknown Accessible vs Inaccessible

- Known and unknown are not actually a feature of an environment, but it is an agent's state of knowledge to perform an action.
- In a known environment, the results for all actions are known to the agent. While in unknown environment, agent needs to learn how it works in order to perform an action.
- It is quite possible that a known environment to be partially observable and an Unknown environment to be fully observable.
- If an agent can obtain complete and accurate information about the state's environment, then such an environment is called an Accessible environment else it is called inaccessible.
- An empty room whose state can be defined by its temperature is an example of an accessible environment.
- Information about an event on earth is an example of Inaccessible environment.

# Types of Agent

- 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 Agent

- 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**.
- It **does not** consider any part of **percepts history** during their **decision and action process**.
- It 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.

# Model-based Reflex 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.

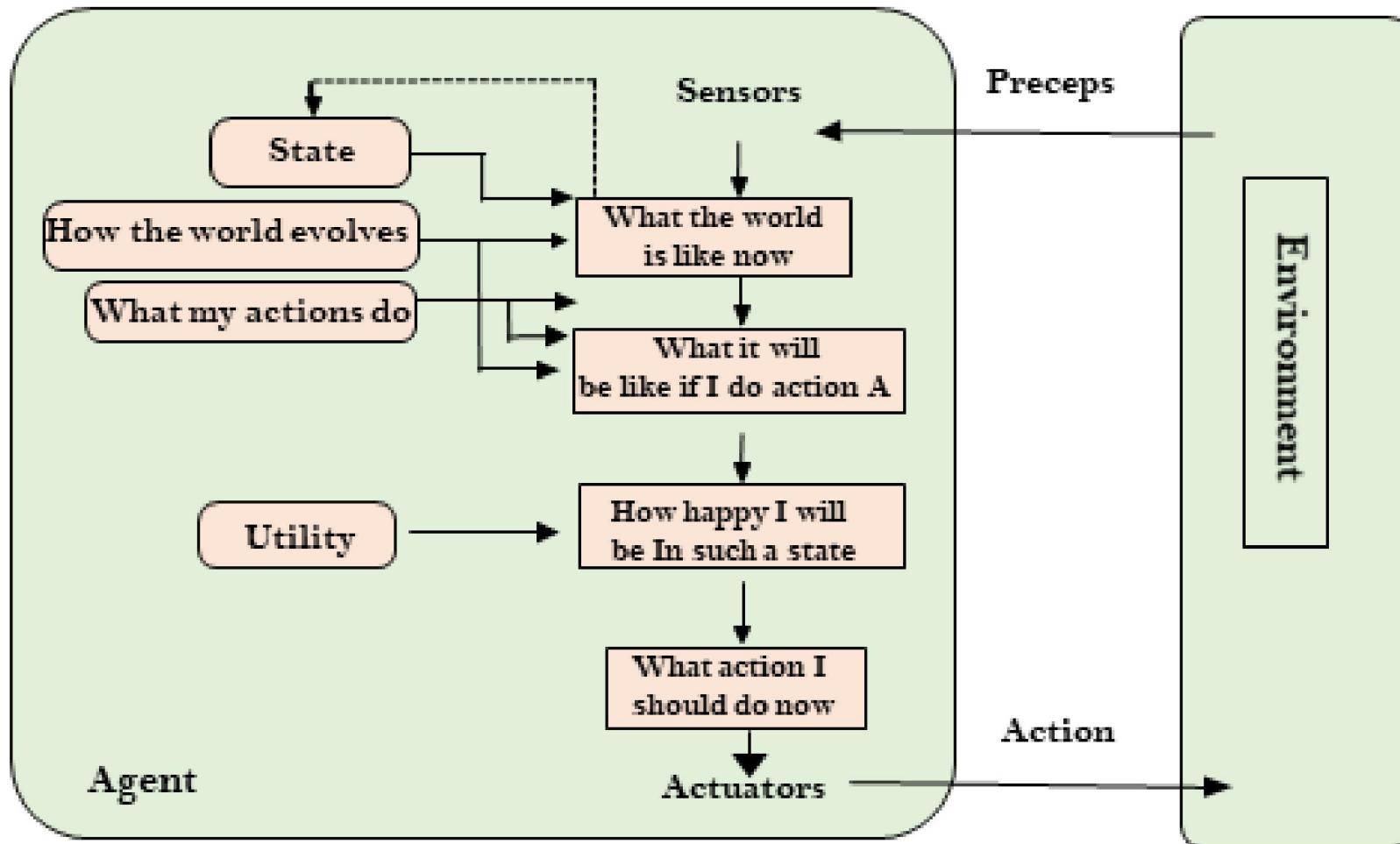
# Goal-based Agents

- 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.
- It **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.

# Utility-based 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.
- It act based on **not only goals** but also the best way to achieve that goal.
- 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.

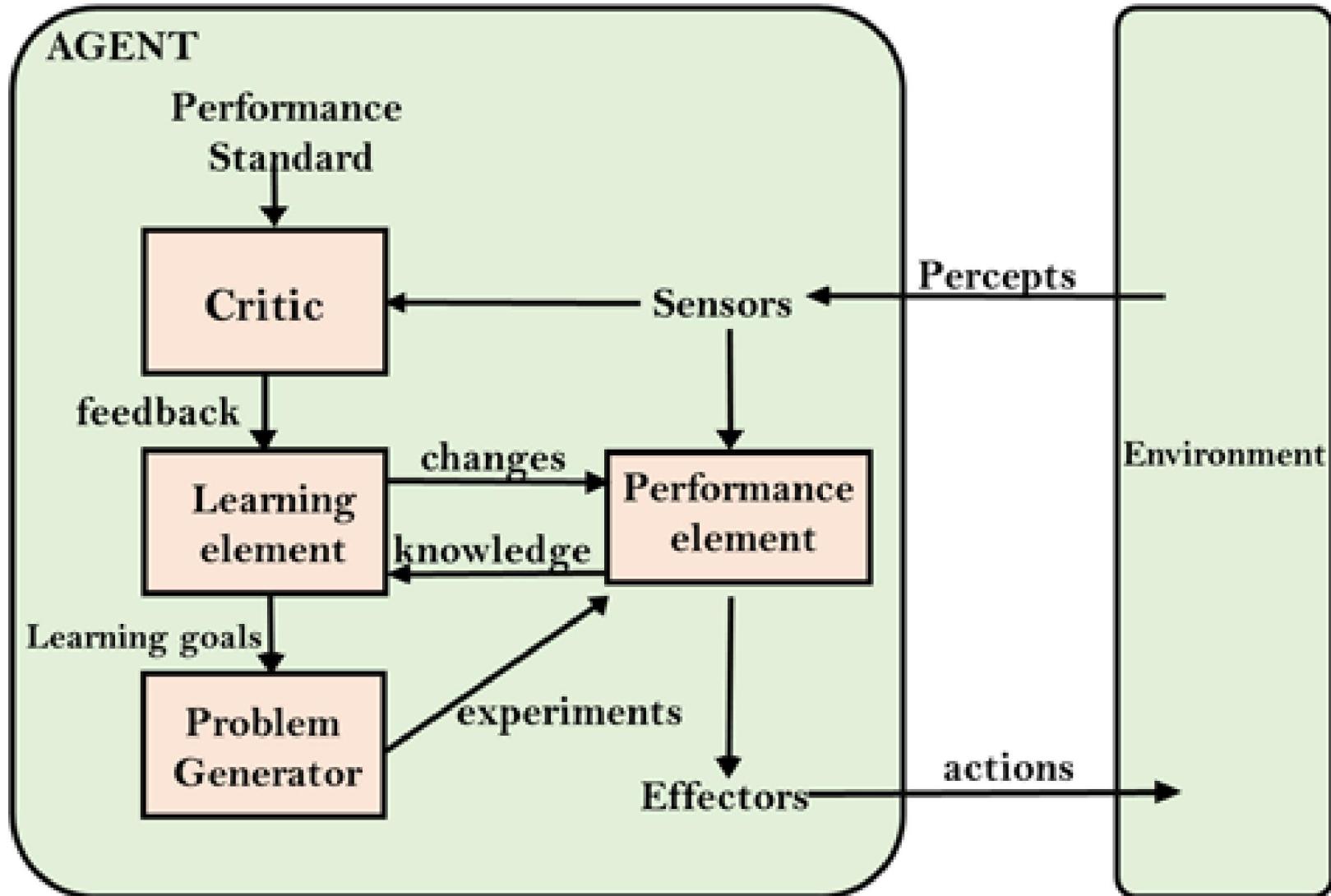
# Utility-based Agents



# Learning Agents

- It 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.
- Has mainly four conceptual components:
  - **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:** Responsible for suggesting actions that will lead to new and informative experiences.
- Hence, its able to learn, analyze performance, and look for new ways to improve the performance.

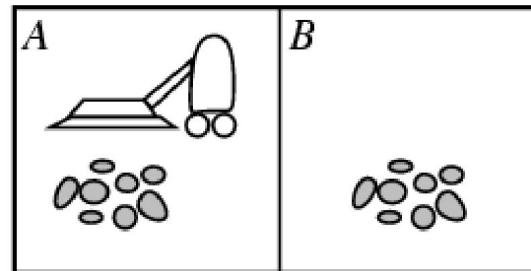
# Learning Agents



# 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.**

# Vacuum-cleaner World



- Percepts: location and contents, e.g., [A,Dirty]
- Actions: *Left*, *Right*, *Suck*, *NoOp*
- One very simple **agent function** is: if the current square is dirty, then suck; otherwise, move to the other square.

# Vacuum-cleaner World

Percept sequence	Action
$[A, Clean]$	$Right$
$[A, Dirty]$	$Suck$
$[B, Clean]$	$Left$
$[B, Dirty]$	$Suck$
$[A, Clean], [A, Clean]$	$Right$
$[A, Clean], [A, Dirty]$	$Suck$
$\vdots$	$\vdots$
$[A, Clean], [A, Clean], [A, Clean]$	$Right$
$[A, Clean], [A, Clean], [A, Dirty]$	$Suck$
$\vdots$	$\vdots$

**Figure 2.3** Partial tabulation of a simple agent function for the vacuum-cleaner world shown in Figure 2.2.

# Vacuum-cleaner World

- It's seen that various vacuum-world agents can be defined simply by filling in the right-hand column in various ways.
- The obvious question, then, is this: *What is the right way to fill out the table?*
- In other words, what makes an agent **good or bad, intelligent or stupid?**

# Rational Agents

- An agent should strive to "**do the right thing**", based on what it can perceive and the actions it can perform.
- The **right action** ( $\neq$  perfect action) is the one that will cause the agent to be most successful.
- **Performance measure**: An objective criterion for success of an agent's behavior
- E.g., performance measure of a vacuum-cleaner agent could be:
  1. amount of dirt cleaned up
  2. amount of time taken
  3. amount of electricity consumed
  4. amount of noise generated, etc.

# Rational Agents

- **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.

# Rational Agents

- 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)
- An agent is **autonomous** if its behavior is determined by its own experience (with ability to learn and adapt)

# PEAS of Rational Agent

- **PEAS:** Performance measure, Environment, Actuators, Sensors
- Must first specify the setting for intelligent agent design
- Consider, e.g., the task of designing an automated taxi driver:
  - Performance measure
  - Environment
  - Actuators
  - Sensors

# PEAS

- Must first specify the setting for intelligent agent design
- Consider, e.g., the task of designing an **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

# PEAS

- Agent: Medical diagnosis system
- 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)

# PEAS

Agent	Performance measure	Environment	Actuators	Sensors
1. Medical Diagnose	<ul style="list-style-type: none"> <li>◦ Healthy patient</li> <li>◦ Minimized cost</li> </ul>	<ul style="list-style-type: none"> <li>◦ Patient</li> <li>◦ Hospital</li> <li>◦ Staff</li> </ul>	<ul style="list-style-type: none"> <li>◦ Tests</li> <li>◦ Treatments</li> </ul>	Keyboard (Entry of symptoms)
2. Vacuum Cleaner	<ul style="list-style-type: none"> <li>◦ Cleanliness</li> <li>◦ Efficiency</li> <li>◦ Battery life</li> <li>◦ Security</li> </ul>	<ul style="list-style-type: none"> <li>◦ Room</li> <li>◦ Table</li> <li>◦ Wood floor</li> <li>◦ Carpet</li> <li>◦ Various obstacles</li> </ul>	<ul style="list-style-type: none"> <li>◦ Wheels</li> <li>◦ Brushes</li> <li>◦ Vacuum Extractor</li> </ul>	<ul style="list-style-type: none"> <li>◦ Camera</li> <li>◦ Dirt detection sensor</li> <li>◦ Cliff sensor</li> <li>◦ Bump Sensor</li> <li>◦ Infrared Wall Sensor</li> </ul>
3. Part -picking Robot	<ul style="list-style-type: none"> <li>◦ Percentage of parts in correct bins.</li> </ul>	<ul style="list-style-type: none"> <li>◦ Conveyor belt with parts,</li> <li>◦ Bins</li> </ul>	<ul style="list-style-type: none"> <li>◦ Jointed Arms</li> <li>◦ Hand</li> </ul>	<ul style="list-style-type: none"> <li>◦ Camera</li> <li>◦ Joint angle sensors,</li> </ul>

# Thank You