# Intelligent Agents

# Agents in Artificial Intelligence

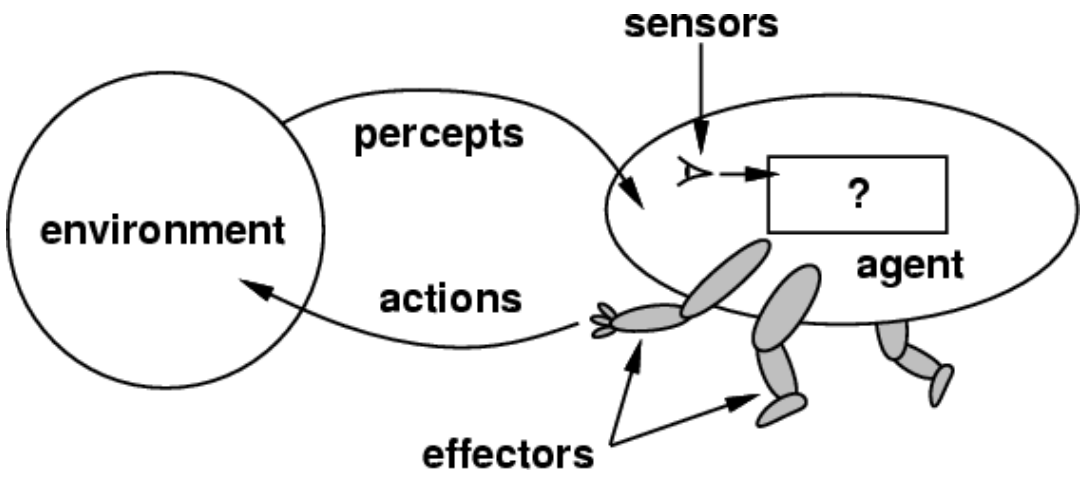
- An AI system can be defined as the study of the rational agent and its environment.
- The agents sense the environment through sensors and act on their environment through actuators.
- An AI agent can have mental properties such as knowledge, belief, intention, etc.

# 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.

# How do you design an intelligent agent?

- Definition: An **intelligent agent** perceives its environment via **sensors** and acts rationally upon that environment with its **effectors**.
- A discrete agent receives **percepts** one at a time, and maps this percept sequence to a sequence of discrete **actions**.
- Properties
  - –Autonomous
  - –Reactive to the environment
  - –Pro-active (goal-directed)
  - –Interacts with other agents via the environment



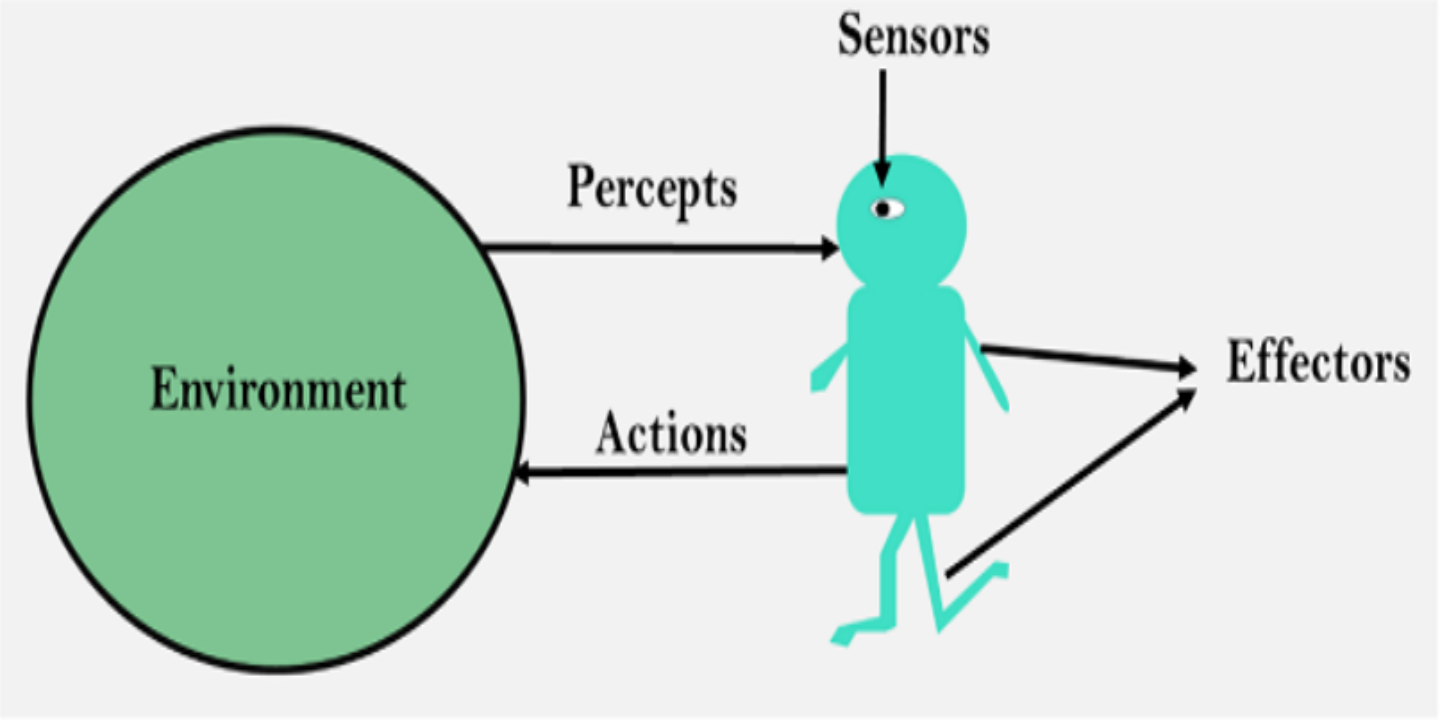
# Sensor, Actuators, Effectors

- **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.

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

- Humans
  - Sensors: Eyes (vision), ears (hearing), skin (touch), tongue (gustation), 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: limbs, digits, eyes, tongue, …
  - Actions: lift a finger, turn left, walk, run, carry an object, …
- The Point: percepts and actions need to be carefully defined, possibly at different levels of abstraction

# Continued..



# 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.

# 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

- An ideal **rational agent** should, for each possible percept sequence, do whatever actions which will maximize its expected performance measure based on

  (1) the percept sequence, and

  (2) its built-in and acquired knowledge.
- Rationality includes information gathering, not “rational ignorance.”
- Rationality => Need a performance measure to say how well a task has been achieved.
- Types of performance measures: false alarm (false positive) and false dismissal (false negative) rates, speed, resources required, effect on environment, etc.

# Continued..

- 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.

# Structure of an AI Agent

The task of AI is to design an agent program which implements the agent function.

The structure of an intelligent agent is a combination of architecture and agent program. It can be viewed as:

Agent = Architecture + Agent program

Following are the main three terms involved in the structure of an AI agent:

- **Architecture:** Architecture is machinery that an AI agent executes on.
- **Agent Function:** Agent function is used to map a percept to an action.
- **Agent program:** Agent program is an implementation of agent function. An agent program executes on the physical architecture to produce function f.

$$f:P^* \rightarrow A$$

# A more specific example: Automated taxi driving system

- **Percepts**: Video, sonar, speedometer, odometer, engine sensors, keyboard input, microphone, GPS, …
- **Actions**: Steer, accelerate, brake, horn, speak/display, …
- **Goals**: Maintain safety, reach destination, maximize profits (fuel, tire wear), obey laws, provide passenger comfort, …
- **Environment**: U.S. urban streets, freeways, traffic, pedestrians, weather, customers, …
- **Different aspects of driving may require different types of agent programs!**

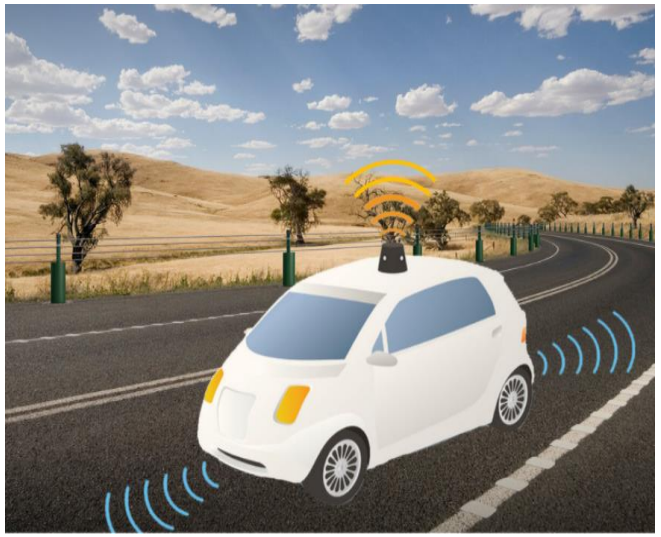
# PEAS Representation

- 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
- Here performance measure is the objective for the success of an agent's behavior.

# PEAS for self-driving cars

Let's suppose a self-driving car then PEAS representation will be:

- **Performance:** Safety, time, legal drive, comfort
- **Environment:** Roads, other vehicles, road signs, pedestrian
- **Actuators:** Steering, accelerator, brake, signal, horn
- **Sensors:** Camera, GPS, speedometer, odometer, accelerometer, sonar.



# Example of Agents with their PEAS representation

| Agent | Performance measure | Environment | Actuators | Sensors |
|---|---|---|---|---|
| **1. Medical Diagnose** | ◦ Healthy patient<br>◦ Minimized cost | ◦ Patient<br>◦ Hospital<br>◦ Staff | ◦ Tests<br>◦ Treatments | Keyboard<br>(Entry of symptoms) |
| **2. Vacuum Cleaner** | ◦ Cleanness<br>◦ Efficiency<br>◦ Battery life<br>◦ Security | ◦ Room<br>◦ Table<br>◦ Wood floor<br>◦ Carpet<br>◦ Various obstacles | ◦ Wheels<br>◦ Brushes<br>◦ Vacuum Extractor | ◦ Camera<br>◦ Dirt detection sensor<br>◦ Cliff sensor<br>◦ Bump Sensor<br>◦ Infrared Wall Sensor |
| **3. Part -picking Robot** | ◦ Percentage of parts in correct bins. | ◦ Conveyor belt with parts,<br>◦ Bins | ◦ Jointed Arms<br>◦ Hand | ◦ Camera<br>◦ Joint angle sensors. |

# Autonomy

- A system is autonomous to the extent that its own behavior is determined by its own experience.
- Therefore, a system is not autonomous if it is guided by its designer according to a priori decisions.
- To survive, agents must have:
  - Enough built-in knowledge to survive.
  - The ability to learn.

# Some agent types

- **(0) Table-driven/deliberative agents**
  - use a percept sequence/action table in memory to find the next action. They are implemented by a (large) **lookup table**.
- **(1) Reactive-Simple reflex agents**
  - are based on **condition-action rules**, implemented with an appropriate production system. They are stateless devices which do not have memory of past world states.
- **(2) Learning Agents with memory**
  - have **internal state**, which is used to keep track of past states of the world.
- **(3) Goal-driven-Agents with goals**
  - are agents that, in addition to state information, have **goal information** that describes desirable situations. Agents of this kind take future events into consideration.
- **(4) Utility-driven agents**
  - base their decisions on **classic utility theory** in order to act rationally. This theory states that if there exist multiple alternative solutions for a problem, then how to decide which is most suitable.

# Properties of Environments

- **Accessible/Inaccessible.**
  - If an agent's sensors give it access to the complete state of the environment needed to choose an action, the environment is **accessible**.
  - Such environments are convenient, since the agent is freed from the task of keeping track of the changes in the environment.
- **Deterministic/Nondeterministic**.
  - An environment is **deterministic** if the next state of the environment is completely determined by the current state of the environment and the action of the agent.
  - In an accessible and deterministic environment, the agent need not deal with uncertainty.
- **Episodic/Nonepisodic**.
  - An **episodic** environment means that subsequent episodes do not depend on what actions occurred in previous episodes.
  - Such environments do not require the agent to plan ahead.

# Properties of Environments

- **Static/Dynamic.**
  - A **static** environment does not change while the agent is thinking.
  - The passage of time as an agent deliberates is irrelevant.
  - The agent doesn't need to observe the world during deliberation.
- **Discrete/Continuous.**
  - If the number of distinct percepts and actions is limited, the environment is **discrete**, otherwise it is **continuous**.
- **With/Without intelligent adversaries.**
  - If the environment contains intelligent, adversarial agents, the agent needs to be concerned about strategic, game-theoretic aspects of the environment
  - Most engineering environments don't have rational adversaries, whereas most social and economic systems get their complexity from the interactions of (more or less) rational agents.