Elective Course

Course Code: CS4103

Autumn 2025-26

Lecture #03

Artificial Intelligence for Data Science

Week-1: INTRODUCTION TO ARTIFICIAL INTELLIGENCE (AI)

Intelligent Agents

Course Instructor:

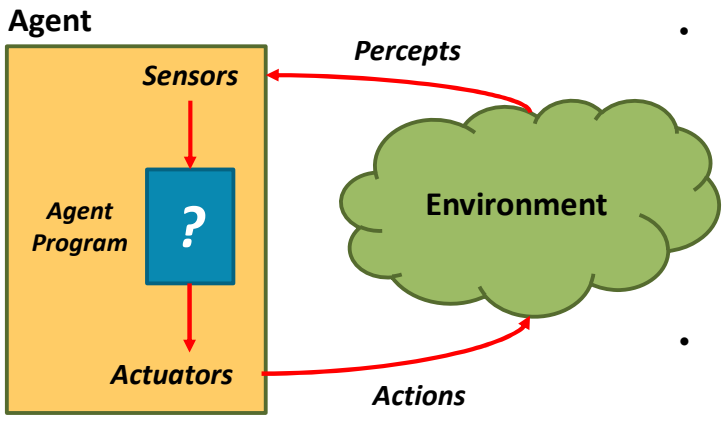
Dr. Monidipa Das

Assistant Professor

Department of Computational and Data Sciences

Indian Institute of Science Education and Research Kolkata, India 741246

Agent and Environment



- **Agent**
  - Operates in an environment
  - Perceives its environment through ***sensors***
  - Acts upon its environment through ***effectors/actuators***
  - ***Agent function*** maps percept sequence to actions (implemented by ***Agent Program***)
- **Environment**
  - Surrounding of the agent

Autonomous Agent: less relies on built-in knowledge…..
decides autonomously which action to take in the current situation to maximize the progress towards its goal

Example of Agents

- **Human**
  - ***Sensors:*** Eyes, Ears, Nose, Taste buds, Skin etc.
  - ***Actuators:*** Hands, Fingers, Legs, Vocal tract
- **Robot**
  - ***Sensors:*** Camera, Spectrometer, Infrared range finders
  - ***Actuators:*** Grippers, Wheels, Lights, Speakers, and various motors
- **Softbot (Software Agents)**
  - ***Sensors:*** Functions to receive keystrokes, file contents, network packets etc.
  - ***Actuators:*** Functions to display on the screen, writing files, sending network packets

Percepts, Actions, and Performance Measure

- ***Percepts*** refer to the agent's perceptual inputs at any given instant.
- ***Percept sequence*** is the complete history of everything the agent has ever perceived.
- Agent generates a sequence of ***actions*** according to the percepts it receives.
  - **An operation involving an actuator is called an action**
  - Actions can be grouped into **action sequences**
- The sequence of actions causes the environment to go through a sequence of states
- The desirability of the sequence is captured by ***performance measure***
- There is not one fixed performance measures for all tasks and all agents

Intelligent Agents

- **Intelligent Agent**
  - must sense
  - must act
  - must be autonomous (to some extent)
  - must be rational

Blind action is not characterization of intelligence.

In order to act, you must sense.

Environment: Observability

- **Fully Observable**
  - All of the environment relevant to the action being considered is observable. **Example:** Chess
  - Such environments are convenient, since the agent is freed from the task of keeping track of the changes in the environment
- **Partially Observable**
  - The relevant features of the environment are only partially observable
  - **Example:** Poker

Environment: Determinism

- **Deterministic:** The next state of the environment is completely described by the current state and agent's action.

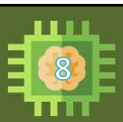
  Example: Crossword puzzle

- **Stochastic:** If an element of interference or uncertainty occurs then the environment is stochastic. Note that a deterministic yet partially observable environment will appear to be stochastic to the agent.

  Example: Poker

- **Strategic:** Environment state wholly determined by the preceding state and the actions of multiple agents is called strategic. **Example:** Chess

Environment: Episodicity



- **Episodic/Sequential**
  - An **episodic** environment means that subsequent episodes do not depend on what actions occurred in previous episodes
  - **Example:** Defective part-picking robot
  - In a **sequential** environment, the agent engages in a series of connected episodes
  - **Example:** Chess

Environment: Dynamism

- **Static Environment**
  - Does not change from one state to the next while the agent is considering its course of action. The only changes to the environment as those caused by agent itself.
  - **Example:** Crossword puzzle, Poker
- **Dynamic Environment:**
  - Changes over time independent of the actions of the agent – and thus if an agent does not respond in a timely manner, this counts as a choice to do nothing
  - **Example:** Taxi driving

Environment: Continuity

- **Discrete/Continuous**
  - If the number of distinct percepts and actions is limited, the environment is discrete, otherwise it is continuous.
    - **Example:** Crossword Puzzle, Chess, Poker (Discrete)
    - **Example:** Taxi-driving, Part-picking robot (Continuous)

Environment: Other agents

- **Single-agent/Multi-agent**
  - If the environment contains other intelligent agents, the agent needs to be concerned about strategic, game-theoretic aspects of the environment (for either cooperative or competitive agents)
  - Most engineering environments don't have multi-agent properties, whereas most social and economic systems get their complexity from the interactions of (more or less) rational agents
  - **Example:** Part-picking robot (Single-agent), Crossword puzzle (Single-agent), Chess (Multi-agent), Taxi-driving (Multi-agent)

Complex Environments

- Complexity of the environment includes
  - **Knowledge rich:** enormous amount of information that the environment contains
  - **Input rich:** the enormous amount of input the environment can send to an agent
  - The agent must have a way of managing this complexity. Often such considerations lead to the development of
    - Sensing strategies and
    - Attention mechanisms
  - So that the agent may more readily focus its efforts in such rich environments

A Simple Vacuum-cleaner World

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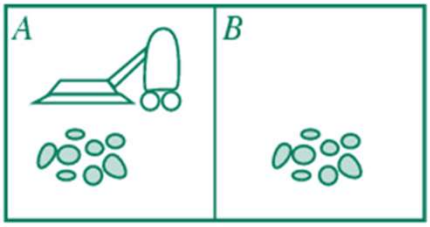
- **Agent:** vacuum cleaner
- **Environment:** Two floor tiles: A and B
- **Percepts:**
  - Location and Status
  - e.g. [A, Clean], [B, Dirty]
- **Actions:**
  - Left, Right, Suck, NoOp
- **Performance Measures:**
  - Maybe one point can be awarded for each clean square at each time step



It is better to design performance measures according to what one actually wants in the environment, rather than according to how one thinks the agent should behave

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

```
function REFLEX-VACUUM-AGENT([location,status]) returns action
  if status = Dirty then return Suck
  else if location = A then return Right
  else if location = B then return Left
```


AiBO: Artificial Intelligence RoBOt

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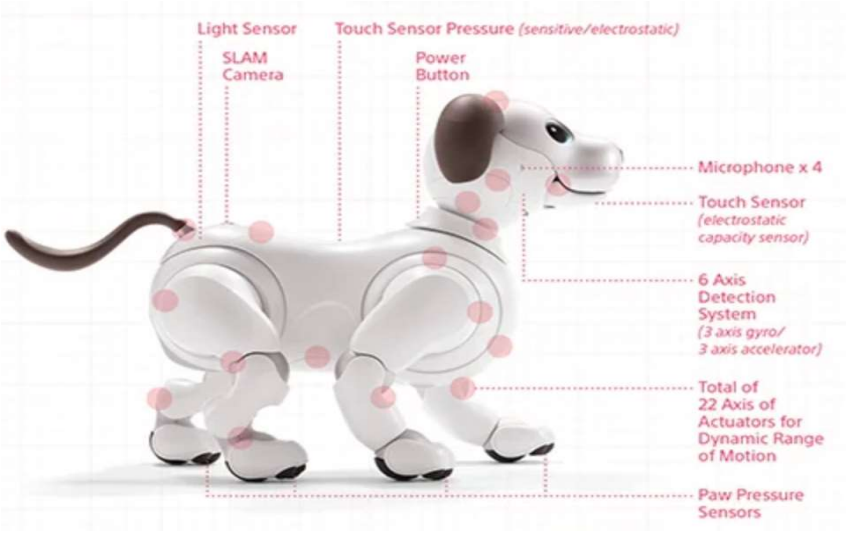
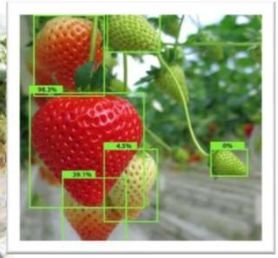


- Entertainment robot
- Designed and Manufactured by SONY

Sources: https://us.aibo.com/
https://milled.com/sony/see-what-makes-aibo-tick-tap-into-the-tech-AL1A4wkyDCcaP-Kn

BERRY - Automated Strawberry Harvesting Robot



- **Sensors**
  - computer vision camera
  - laser sensors
  - etc.
- **Actuators**
  - manipulator
  - coaxial grip
  - etc.

Sources: https://www.organifarms.de/product
https://www.hortidaily.com/article/9487858/automated-strawberry-harvesting-to-come-in-2023/

Mars Exploration Rover (MER)

Curiosity (2012-Present)

- **Sensors**
  - Panoramic Mast Assembly
    a. panoramic cameras (Pancam)
    b. navigation cameras (Navcam)
    c. miniature thermal emission spectrometer
  - Mössbauer Spectrometer (MB)
  - Alpha Particle X-ray Spectrometer (APXS)
- **Actuators** (Primarily rotary actuators)
  - Drives the rover
  - Moves robotic arms

Source: https://mars.nasa.gov/msl/home/

Rational Agent

- What is rational at any given time depends on the four things
  - 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
- A rational agent always does the right thing
- AI is about building rational agents

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

- **Perfect Rationality**
  - Assumes that the rational agent knows all and will take the action that maximizes her utility.
  - Human beings do not satisfy this definition of rationality
- **Bounded Rationality (Herbert Simon, 1972)**
  - Because of the limitations of the human mind, humans must use approximate methods to handle many tasks.

Rationality [contd.]

- **Rational Action:** The action that ***maximizes the expected value*** of the performance measure given the percept sequence to date
  - Rational = Best?
    - Yes, the best of its knowledge
  - Rational = Optimal?
    - Yes, to the best of its abilities
    - And its constraints

Bounded Rationality

- Evolution did not give rise to optimal agents, but to agents which are in some senses locally optimal at best
- In 1957, Simon proposed the notion of **Bounded Rationality**:
  - that property of an agent that behaves in a manner that is nearly optimal with respect to its goals as its resources will allow

Rational Agent [contd.]

- In order to appropriately design a rational agent, we must specify the **PEAS:**
  - **P**erformance measure,
  - **E**nvironment,
  - **A**ctuators,
  - **S**ensors
- All these are together termed as **task environment**

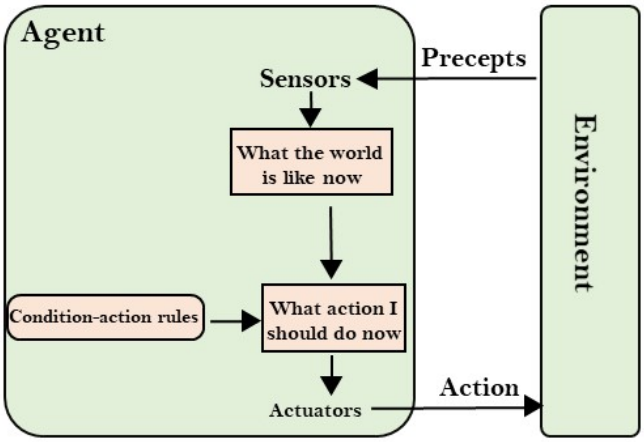
Table-based Agent

- **A table is simply way of mapping from percepts to actions**
  - Tables may become very large
  - All work done by the designer
  - No autonomy, all actions are pre-determined
  - Learning might take a very long time

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

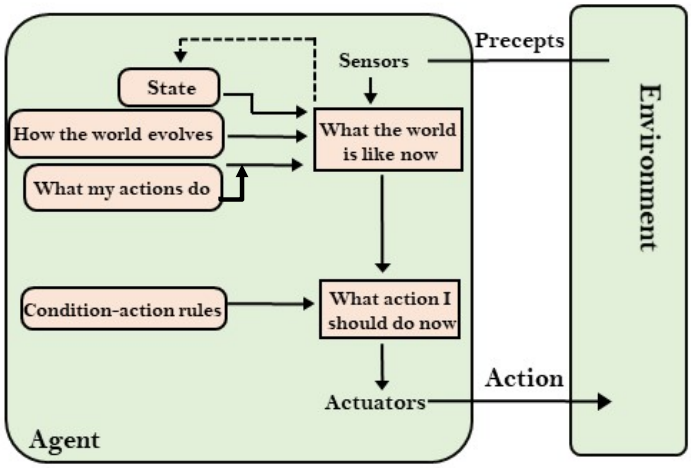
Simple Reflex Agent

- These agents select actions on the basis of the current percept, ignoring the rest of the percept history
- Limited intelligence
- Can only work intelligently when the environment is fully observable



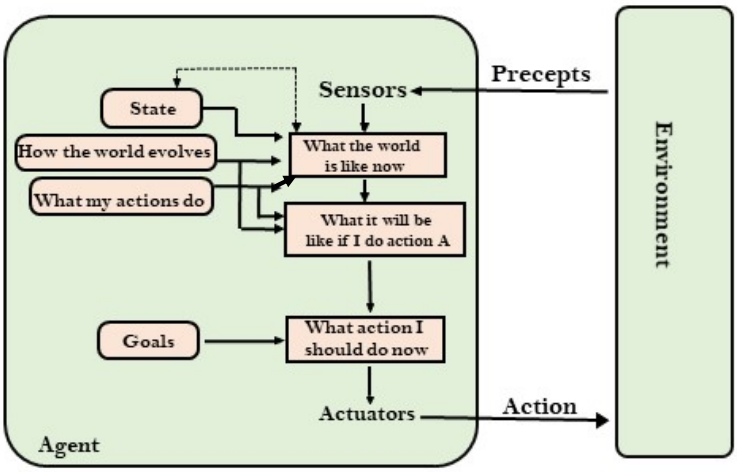
Model-based Reflex Agent

- 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.



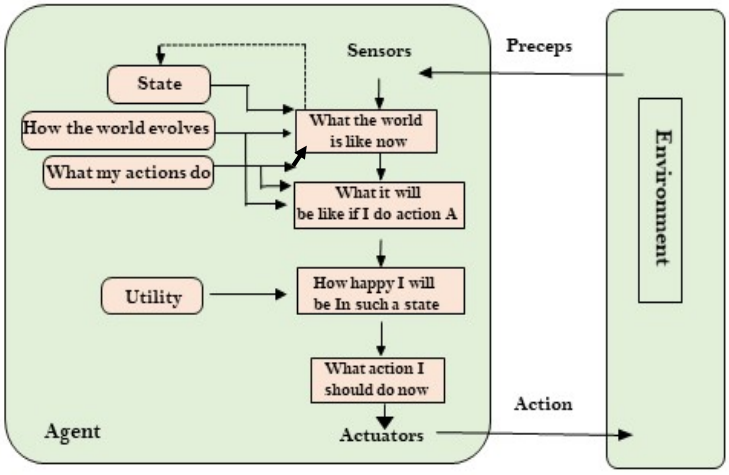
Goal-based Agent

- 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.



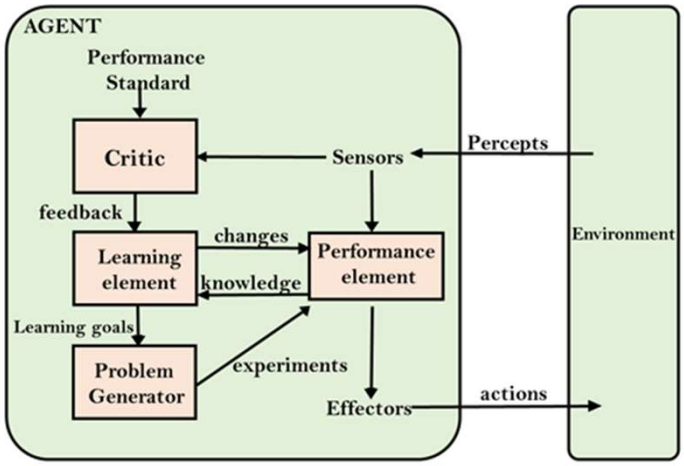
Utility-based Agent

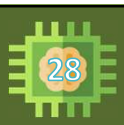
- Utility-based agent act based on not only goals but also the best way to achieve the goal.
- The Utility-based agent is useful when there are multiple possible alternatives, and an agent has to choose in order to perform the best action.
- The utility function maps each state to a real number to check how efficiently each action achieves the goals.



Learning Agent

- 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.
- Learning agents are able to learn, analyze performance, and look for new ways to improve the performance.





Questions?