Lecture 1: An Introduction to Artificial Intelligence and Intelligent Agents

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Grading Schema

- Quiz 1: 30
- Quiz 2: 30
- Lab Activity: 30
- Final Exam: 60

Agenda

- **Introduction**
- **Applications of Artificial Intelligence**
- **What is Artificial Intelligence?**
- **Intelligent Agents**
- **Agent Design**
- **Properties of task environments**
- **Kinds of agent program**

Introduction

- Artificial intelligence (AI) is an expansive branch of computer science that focuses on building smart machines, which able to perform tasks that normally require human intelligence.

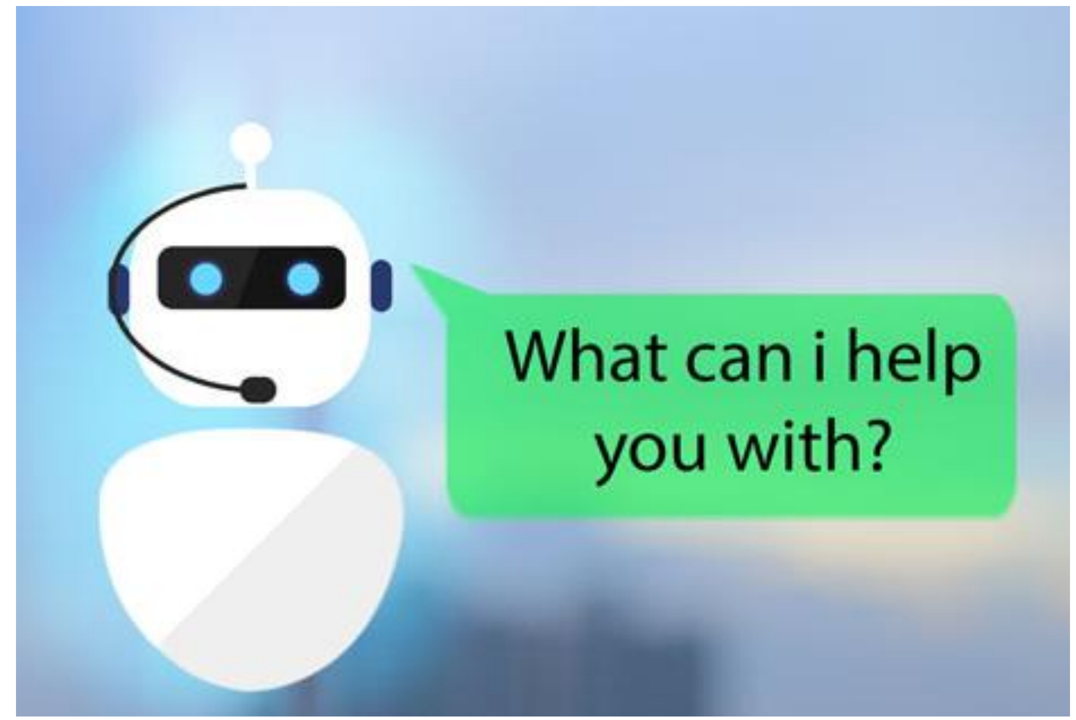
- Thanks to AI, these machines can learn from experience, adjust to new inputs, and perform human-like tasks. For example, chess-playing computers and self-driving cars.

AI Applications: Autonomous Vehicles

- For the longest time, self-driving cars have been a buzzword in the AI industry. The AI system collects data from the vehicles radar, cameras, GPS, and cloud services to produce control signals that operate the vehicle. Advanced algorithms can accurately predict what objects in the vehicle’s vicinity are likely to do. A famous example of an autonomous vehicle is Tesla’s self-driving car.

AI Applications: Chabot

- These days Virtual assistants have become a very common technology. Almost every household has a virtual assistant that controls the appliances at home. A few examples include Siri, Cortana,... which are gaining popularity because of the user experience they provide.



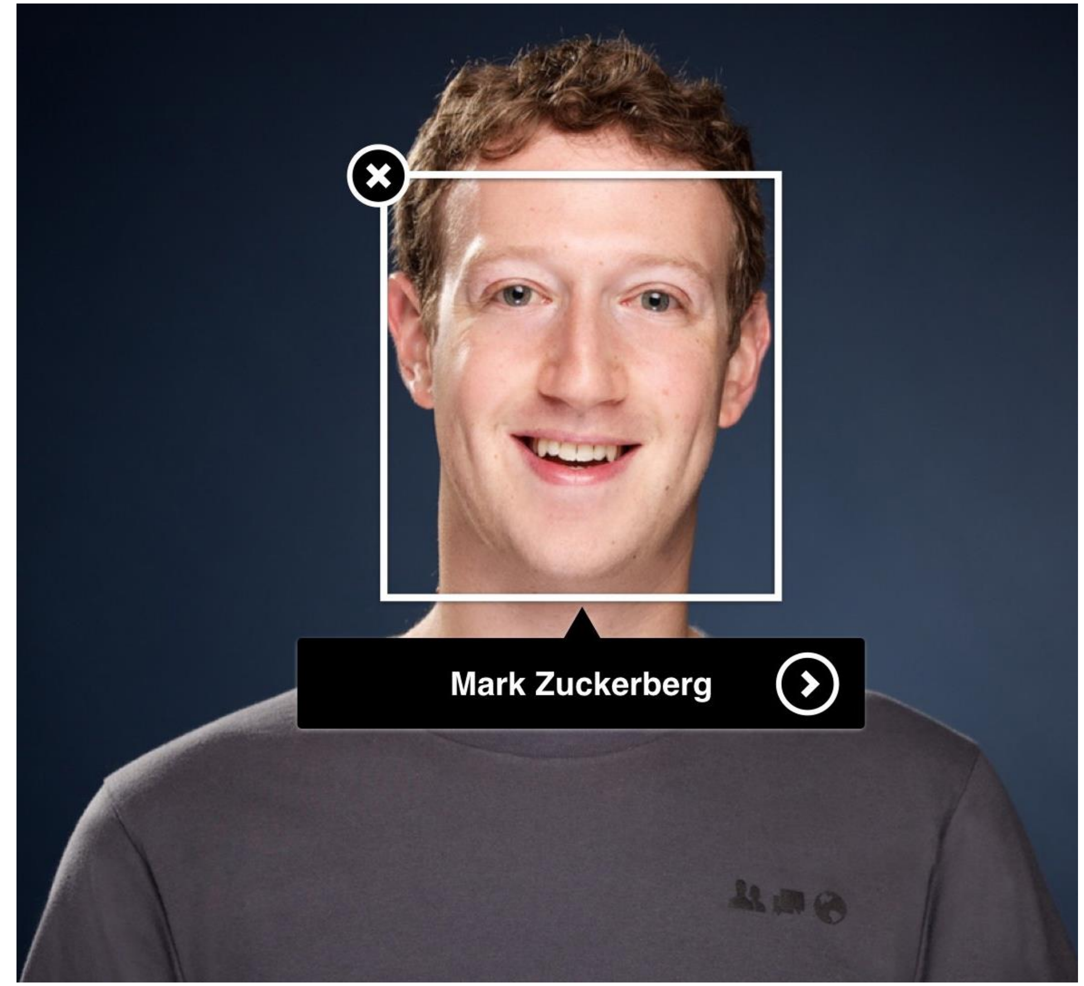
- More recently, another event that has pushed Chabot technology even further is the emergence of ChatGPT and deepseek.

AI Applications: Agriculture

- AI can help farmers get more from the land while using resources more sustainably. Issues such as climate change, population growth, and food security concerns have pushed the industry into seeking more innovative approaches to improve crop yield. Organizations are using automation and robotics to help farmers find more efficient ways to protect their crops from weeds.

AI Applications: Social Media

- In social media platforms like Facebook, AI is used for face verification wherein machine learning and deep learning concepts are used to detect facial features and tag your friends. Deep Learning is used to extract every minute detail from an image by using a bunch of deep neural networks. On the other hand, Machine learning algorithms are used to design your feed based on your interests.



AI Applications: Search and Recommendation Algorithms

- When you want to watch a movie or shop online, have you noticed that the items suggested to you are often aligned with your interests or recent searches? These smart recommendation systems have learned your behavior and interests over time by following your online activity. The data is collected at the front end (from the user) and stored and analyzed through machine learning and deep learning. It is then able to predict your preferences, usually, and offer recommendations for things you might want to buy or listen to next.

AI Applications: Medical Diagnosis

- AI is transforming the practice of medicine. It’s helping doctors diagnose patients more accurately, make predictions about patients’ future health, and recommend better treatments.

Some Foundations of Artificial Intelligence (1/3)

- **Philosophy**
  - ✓ Can formal rules be used to draw valid conclusions?
  - ✓ How does the mind arise from a physical brain?
  - ✓ How does knowledge lead to action?

- **Mathematics**
  - ✓ What are the formal rules to draw valid conclusions?
  - ✓ What can be computed?
  - ✓ How do we reason with uncertain information?

Some Foundations of Artificial Intelligence (2/3)

- **Neuroscience**
  - ✓ How do brains process information?

- **Psychology**
  - ✓ How do humans and animals think and act?

- **Economics**
  - ✓ How should we make decisions so as to maximize payoff?
  - ✓ How should we do this when others may not go along?
  - ✓ How should we do this when the payoff may be far in the future?

Some Foundations of Artificial Intelligence (3/3)

- **Computer Engineering**
  - ✓ How can we build an efficient computer?

- **Linguistics**
  - ✓ How does language relate to thought?

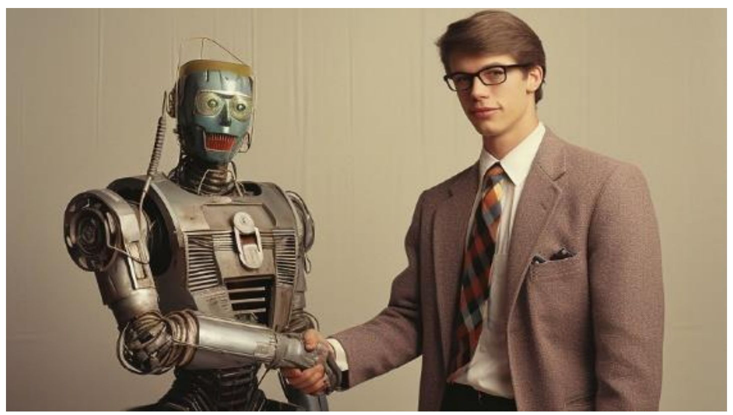
What is Artificial Intelligence? (1/4)

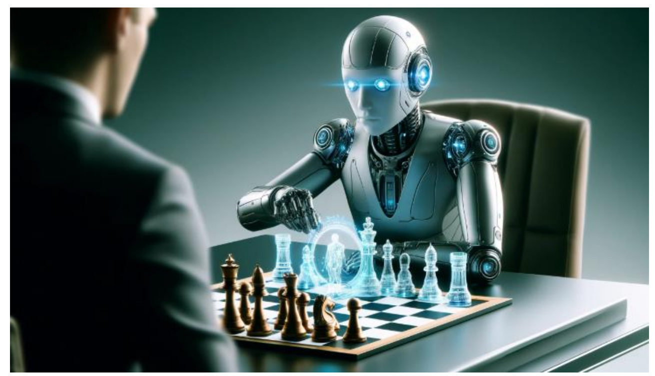
- The science of making machines that:

Think like human

Think rationally

Act like human



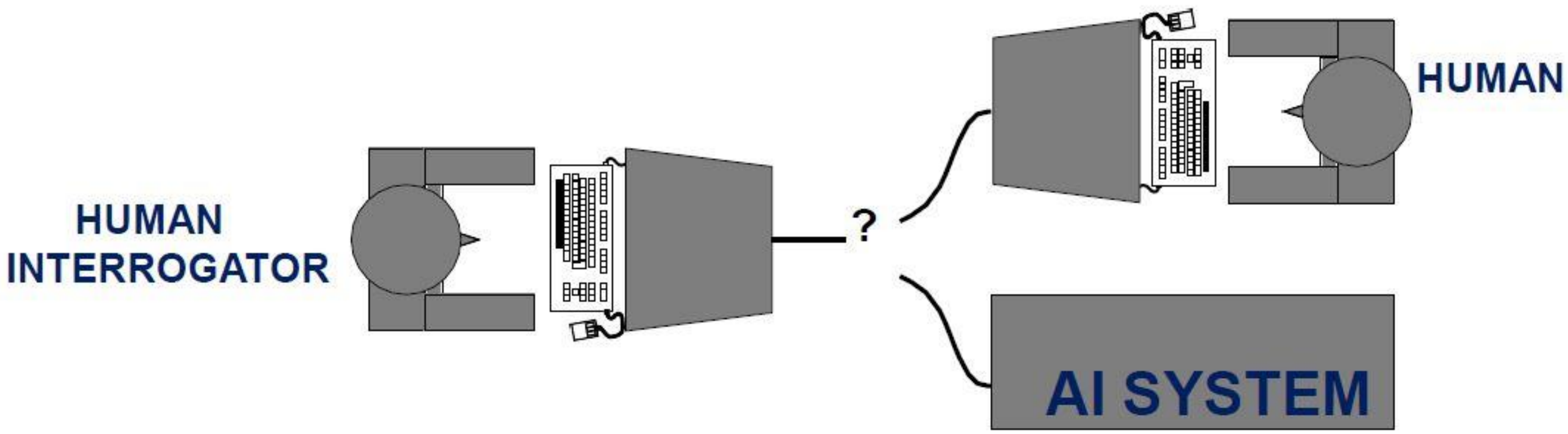


Act rationally

What is Artificial Intelligence? (2/4)

- **Acting humanly:** The Turing Test approach

- Turing test (Alan Turing 1950): A computer passes the test of intelligence, if it can fool a human interrogator.



What is Artificial Intelligence? (3/4)

- **What would a computer need to pass the Turing test?**

✓ Natural language processing (NLP): to communicate with examiner.

✓ Knowledge representation: to store and retrieve information provided before or during interrogation.

✓ Automated reasoning: to use the stored information to answer questions and to draw new conclusions.

✓ Machine learning: to adapt to new conditions and to detect and diagnosis patterns.

✓ Vision (for Total Turing test): to recognize the examiner's actions and various objects presented by the examiner.

✓ Motor control (total test): to act upon objects as requested. Other senses (total test): such as audition, smell, touch, etc.

What is Artificial Intelligence? (4/4)

- **Acting rationally: The rational agent approach**

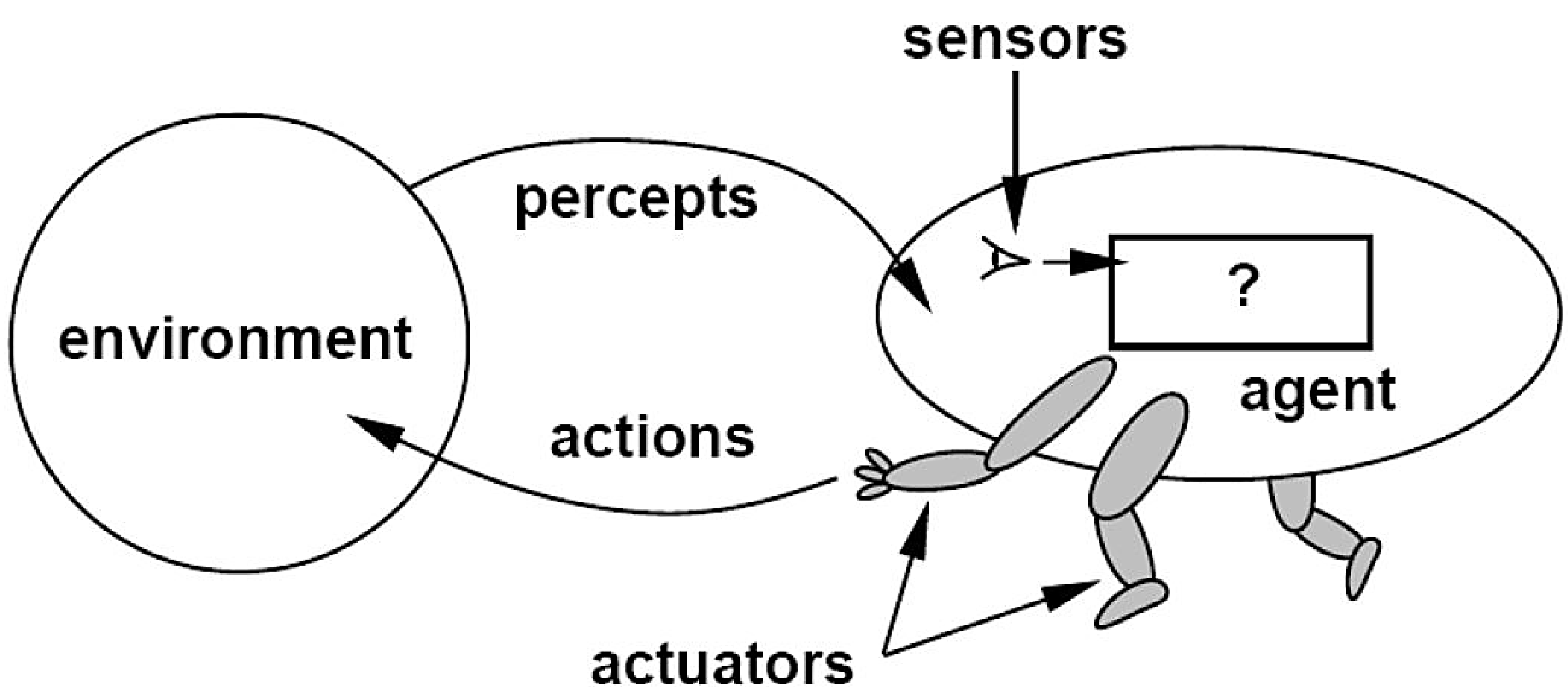
- Agent is just something that acts (agent comes from the Latin agere, to do).

- Computer agents are expected to have other attributes that distinguish them from mere "programs," such as perceiving their environment, persisting over a prolonged time period, adapting to change, and being capable of taking on another's goals.

- A rational agent is one that acts so as to achieve the best outcome or the best expected outcome when there is uncertainty.

Intelligent Agents

- Agent: An agent is anything that can be viewed as:
  - ✓ perceiving its environment through sensors and
  - ✓ acting upon that environment through actuators



Intelligent Agents

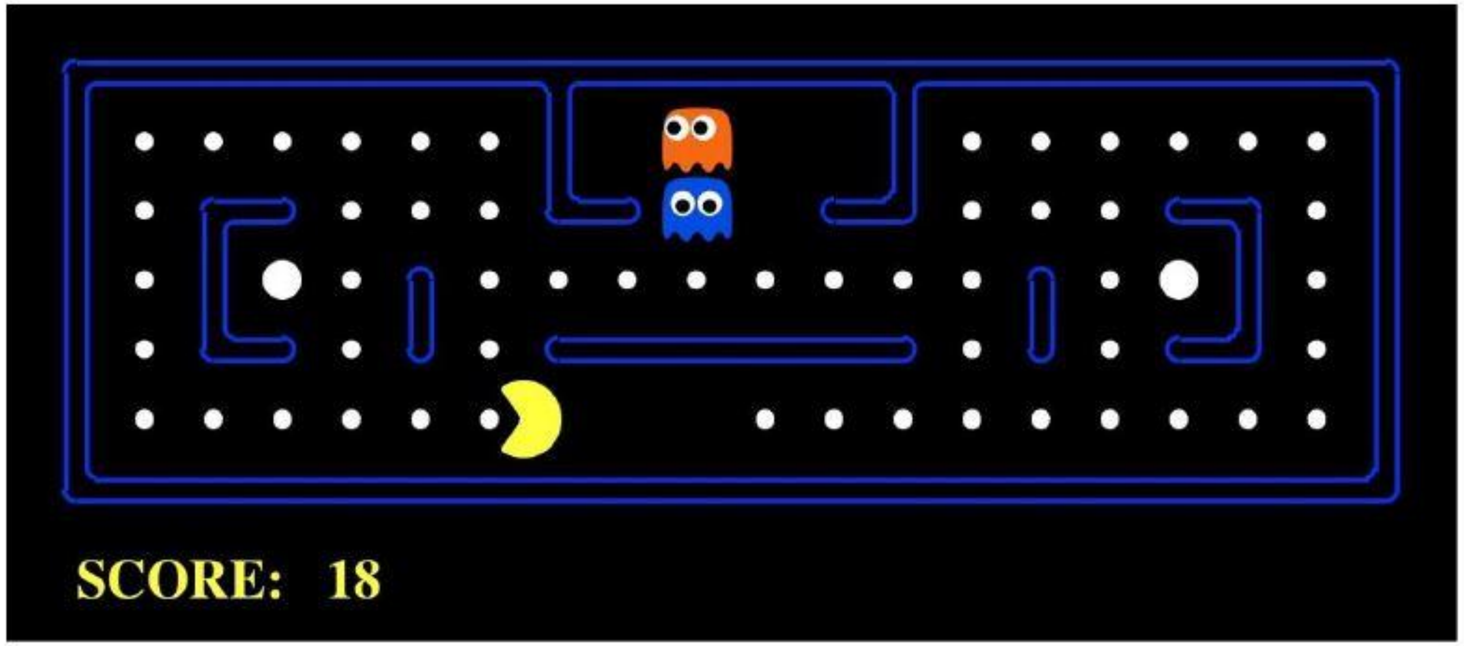
- In AI, artificial agents that have a physical presence in the world are usually known as Robots.

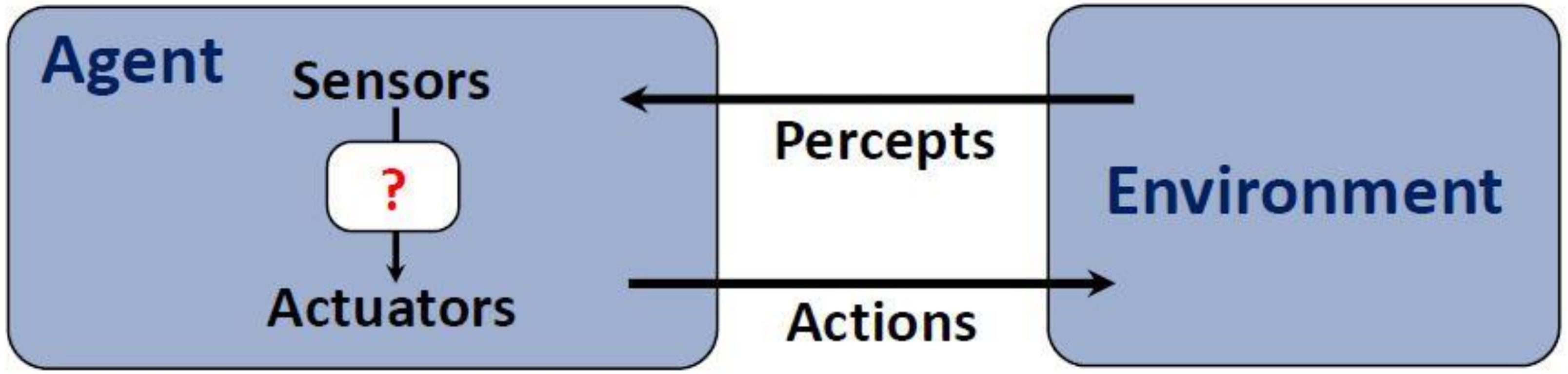
- Another class of artificial agents include interface agents for either stand alone or Web based applications (such as intelligent desktop, and recommender systems).

- Interface agents don't have to worry about interaction with the physical environment but share all other fundamental components of intelligent behavior with robots.

Examples of Intelligent Agents

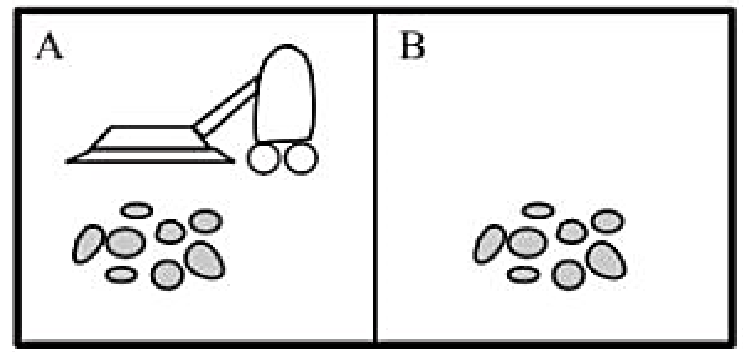
Pac Man .. as an Intelligent Agent





Examples of Intelligent Agents

Vacuum Cleaner .. as an Intelligent Agent



- Percepts: location and contents e.g., [A, Dirty]
- Actions: Left, Right, Suck, NoOp
- Agent function: mapping from percepts to actions.

Percept	Action
[A, clean]	Right
[A, dirty]	Suck
[B, clean]	Left
[B, dirty]	Suck

function REFLEX-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** $Left$

Examples of Intelligent Agents

- Banks: Automatic check readers, signature verification systems.
- Customer Service: Automatic voice recognition, speech recognition, & language recognition.
- Digital Cameras: Automated face detection and recognition.
- Computer Games: Intelligent characters/agents.
- Hospitals & Medical Centers: Automatic Cancer Detection, Automatic Prediction, and Grading of Diseases.

Well-behaved 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."

- Rationality is relative to a performance measure (utility function).

Agent Design: PEAS

- PEAS stands for:

✓ Performance: How is an agent evaluated?

✓ Environment: What is the nature of the environment in which the agent is located?

✓ Actuators: How can an agent make a change in the environment?

✓ Sensors: How can an agent discover the environment?

PEAS Example: Autonomous Taxi

- Performance measure
  - ✓ Safe, fast, legal, comfortable trip, maximize profits
- Environment
  - ✓ Roads, other traffic, pedestrians, customers
- Actuators
  - ✓ Steering wheel, accelerator, brake, signal, horn
- Sensors
  - ✓ Cameras, LIDAR, speedometer, GPS

PEAS Example: vacuum cleaner

- Performance measure
  - ✓ cleanness, battery life
- Environment
  - ✓ room, table, wood floor, carpet, different obstacles.
- Actuators
  - ✓ wheels, different brushes, vacuum extractor.
- Sensors
  - ✓ camera, dirt detection sensor

Properties of task environments

- Fully observable vs. partially observable
- Deterministic vs. stochastic
- Episodic vs. sequential
- Static vs, dynamic
- Discrete vs. continuous
- Single agent vs. multi-agent

Fully observable vs. partially observable.

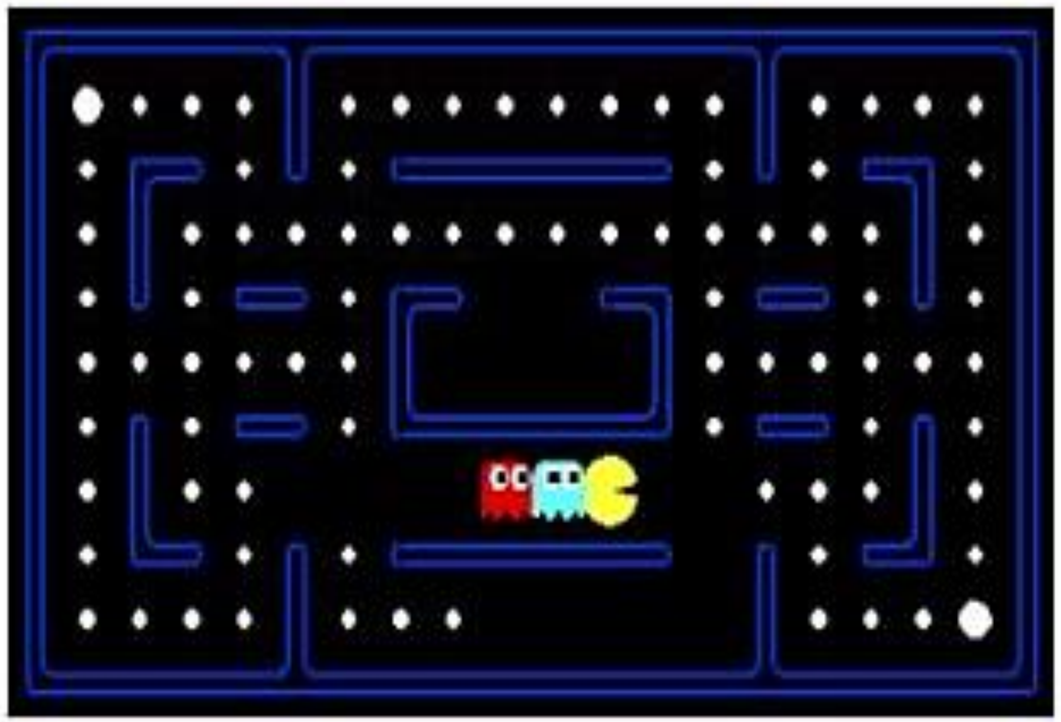
- An agent’s sensors give it access to the complete state of the environment at each point in time, then we say that the task environment is fully observable.

Deterministic vs. stochastic

- If the next state of the environment is completely determined by the current state and the action executed by the agent, then we say the environment is deterministic; otherwise, it is stochastic.
- If the environment is deterministic except for the actions of other agents, we say that the environment is strategic.

Episodic vs. sequential

- If the current decision doesn't affect the next decision, it's Episodic , In sequential environments, on the other hand, the current decision could affect all future decisions.



Static vs. dynamic

- If the environment can change while an agent is acting, then we can say the environment is dynamic for that agent; otherwise, it is static.
- If the environment itself does not change with the passage of time but the agent's performance score does, then we say the environment is Semi dynamic or Semi Static.

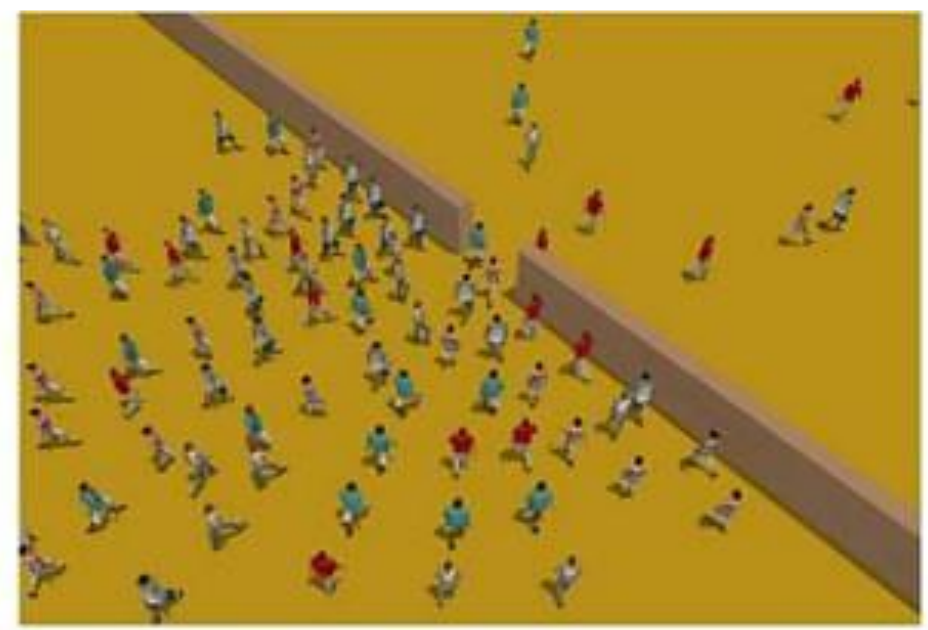
Discrete vs. Continuous

- Discrete (vs. continuous): A limited number of distinct, clearly defined percepts and actions.

Single agent vs. multiagent

- Single agent(vs. multi-agent): An agent operating by itself in an environment.

vs.

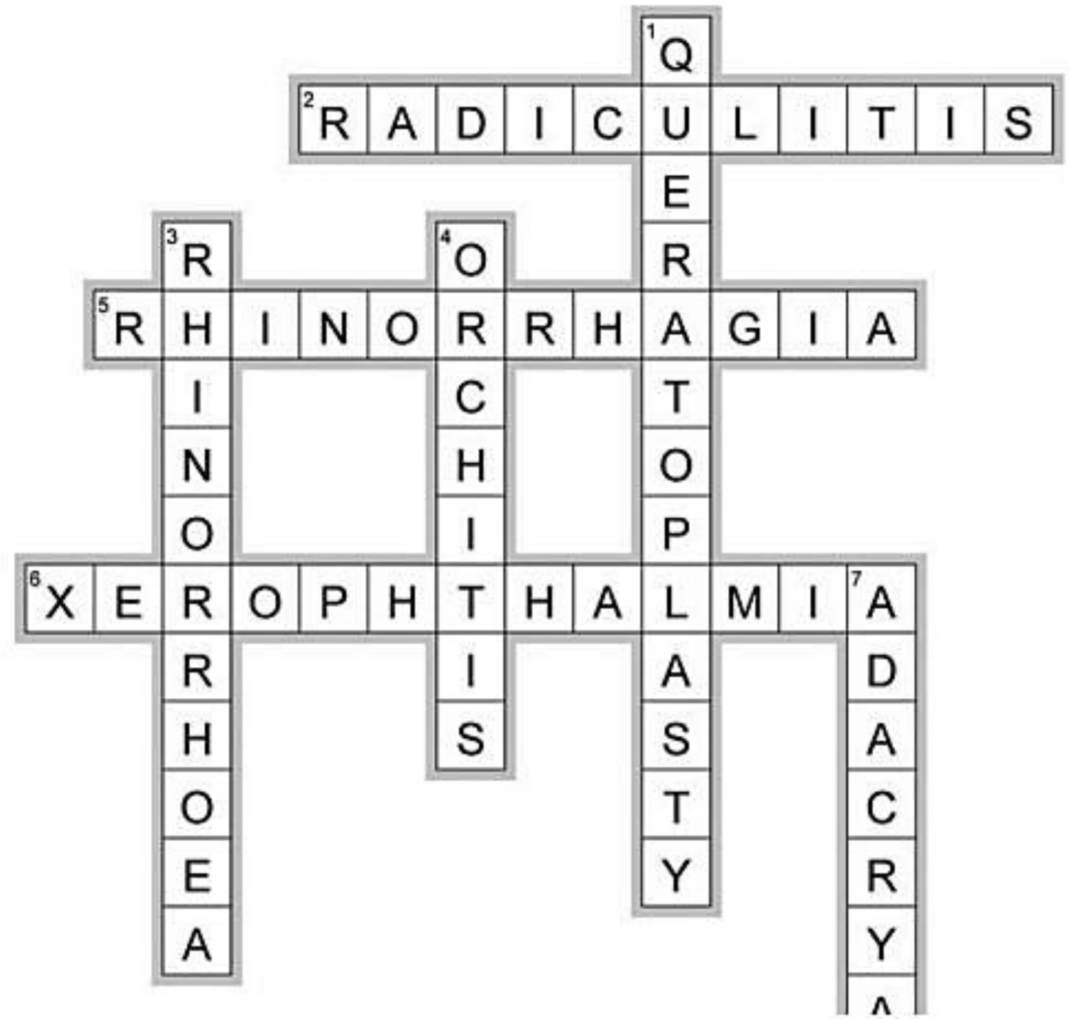


Test your knowledge

1. Fully or Partially observable
2. Deterministic or Stochastic.
3. Episodic or Sequential.
4. Static or Dynamic.
5. Discrete or Continuous.
6. Single or multi Agent.

Crossword puzzle

- Fully observable
- Deterministic
- Sequential
- Static
- Discrete
- Single Agent



Chess

- Fully observable
- Strategic
- Sequential
- Semi dynamic
- Discrete
- Multi-Agent

Backgammon

- Fully
- Stochastic
- Sequential
- Static
- Discrete
- Multi-Agent

Taxi Driving

- Partially
- Stochastic
- Sequential
- Dynamic
- Continuous
- Multi-Agent

Part-picking robot

- Partially
- Stochastic
- Episodic
- Dynamic
- Continuous
- Single

Agent Types

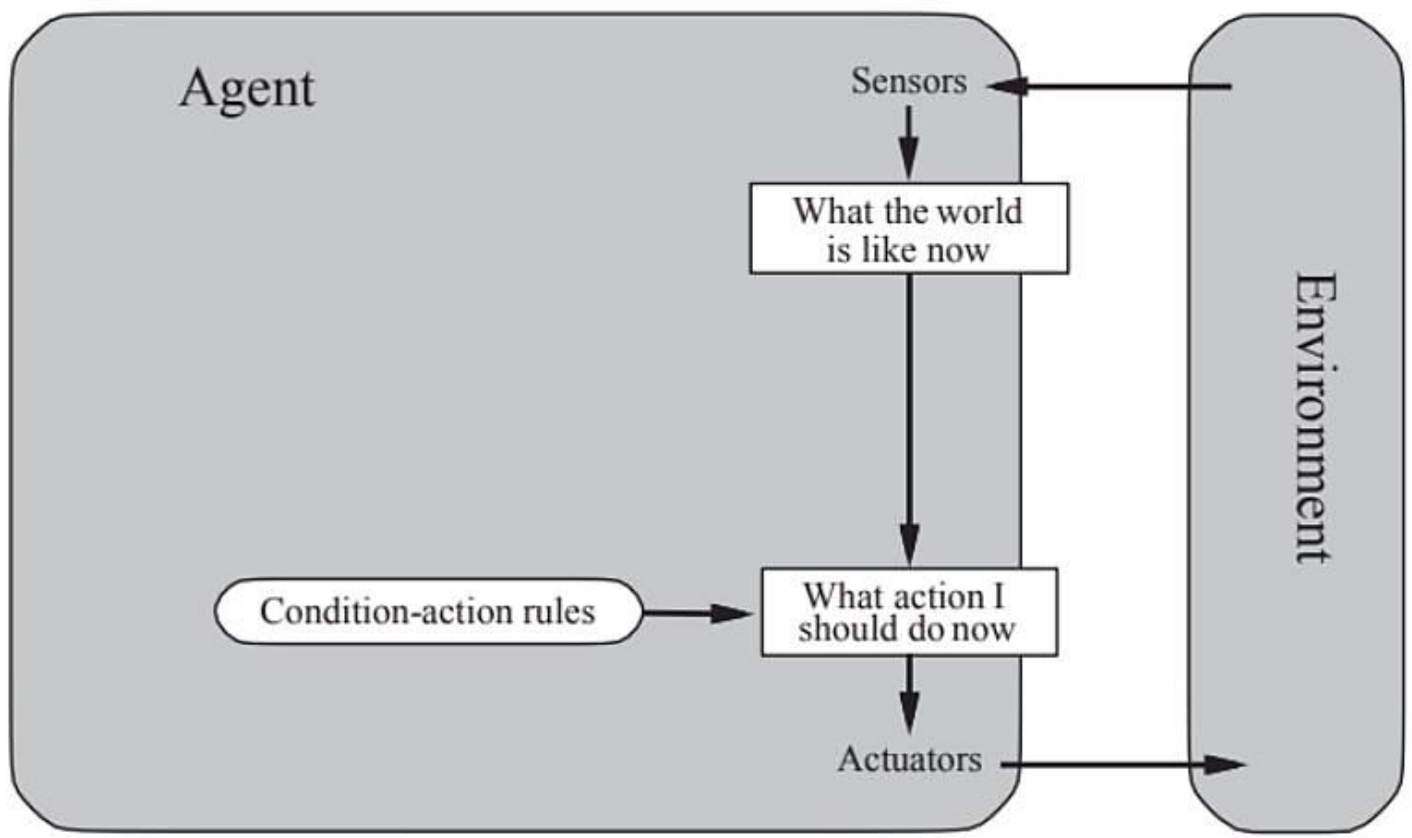
- Four basic types in order of increasing generality:

  - ✓ Simple reflex agents
  - ✓ Model-based reflex agents
  - ✓ Goal-based agents
  - ✓ Utility-based agents

- All of which can be generalized into learning agents that can improve their performance and generate better actions.

Agent Types: Simple reflex agents

- Simple reflex agents select an action based on the current state only (Condition - Action Rule), ignoring the percept history (no memory).
- Can only work if the environment is fully observable, that is the correct action is based on the current percept only.



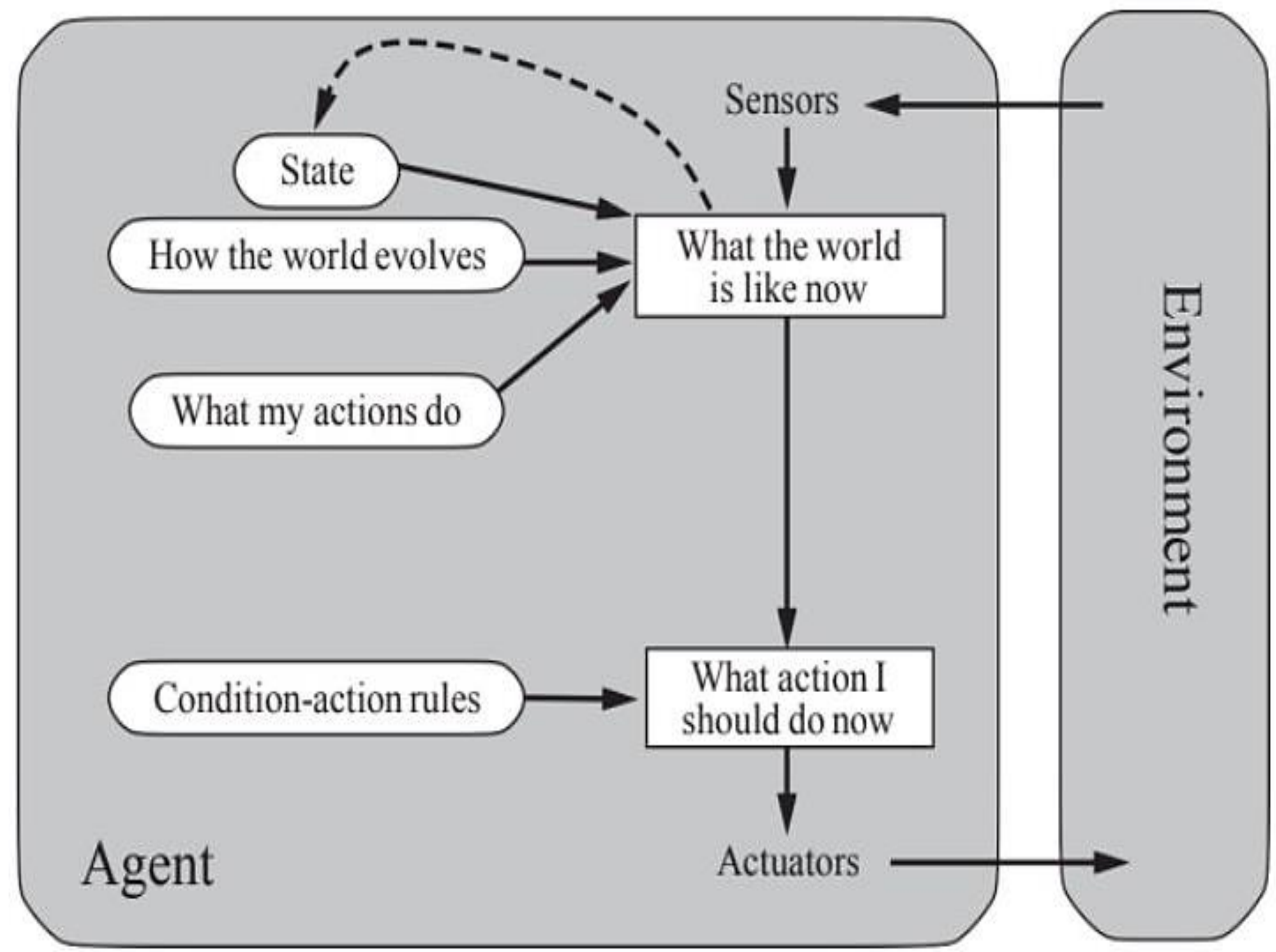
Simple reflex agents: Automatic Door Opener

- How it works:
  - ✓ A sensor detects motion near the door.
  - ✓ If motion is detected, the door opens.
  - ✓ If no motion is detected, the door remains closed.

- Why it's a simple reflex agent:
  - ✓ It reacts to the current percept (motion) without considering the history of motion or the state of the door.

Agent Types: Model-based reflex agents

- Handle partial observability by keeping track of the part of the world it can't see now.
- Internal state depending on the percept history (best guess).
- Model of the world based on (1) how the world evolves independently from the agent, and (2) how the agent actions affects the world.



Model based reflex agents: Vacuum agent

- Most modern robotic vacuums not simple reflex agents. Instead, they are more sophisticated and use advanced techniques such as:

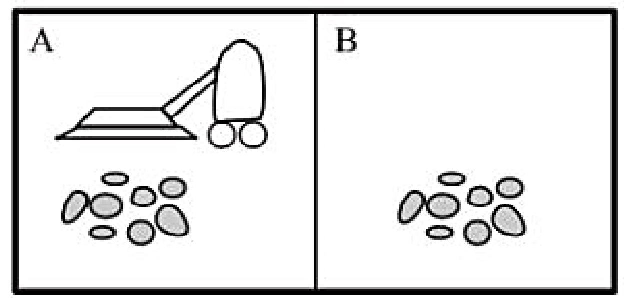
✓ Mapping and Localization: They create and update an internal map of the environment using sensors (e.g., LiDAR, cameras).They track their position within the map.

✓ Path Planning: They plan efficient cleaning paths to cover the entire area without unnecessary repetition.

✓ Memory: They remember where they have cleaned and where obstacles are located.

When a Vacuum Cleaner is a Simple Reflex Agent

- A vacuum cleaner can be a simple reflex agent if it operates based solely on current percepts (sensor inputs) and follows condition-action rules without maintaining any internal model or memory of the environment.



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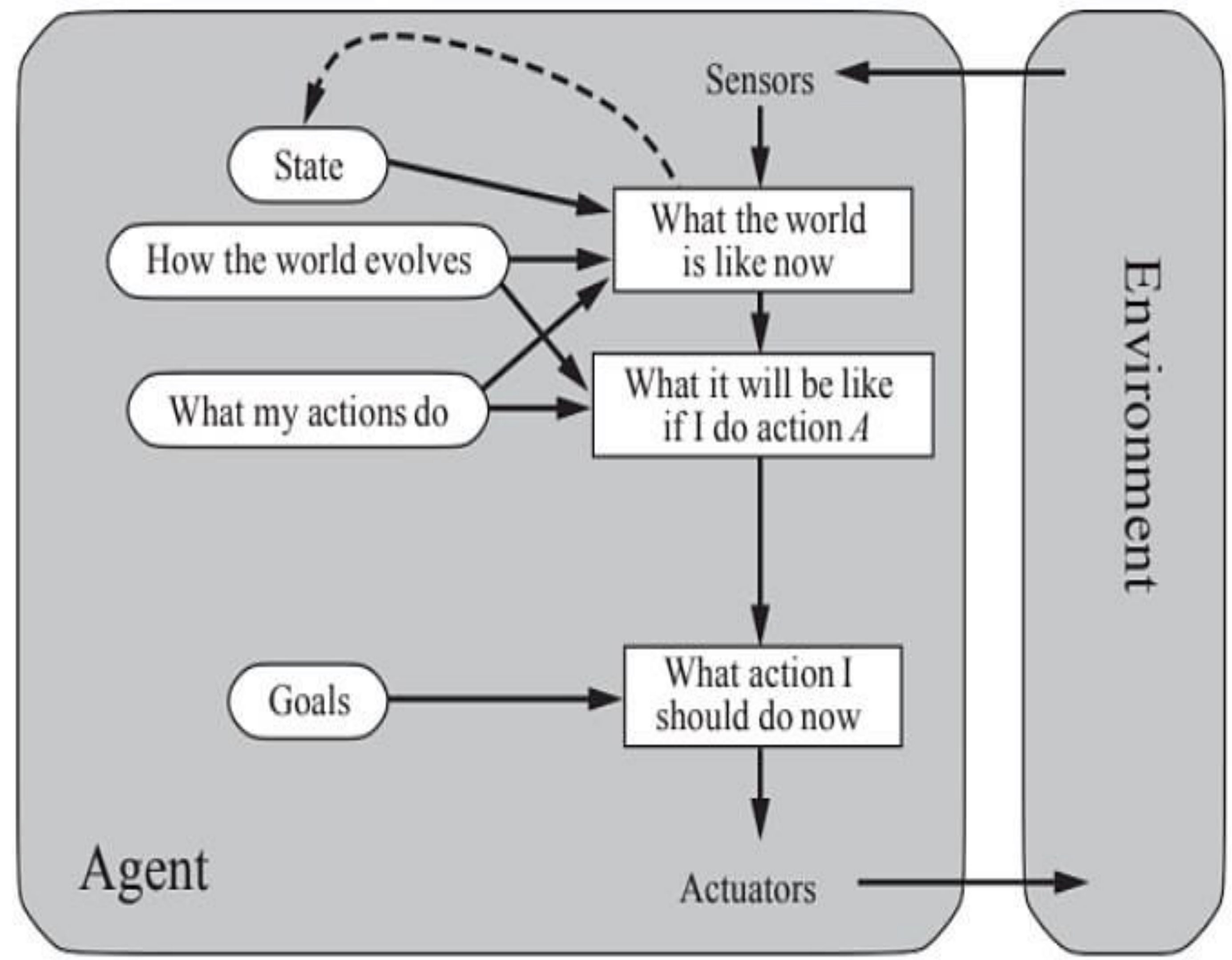
[B, dirty]	Suck

function REFLEX-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*

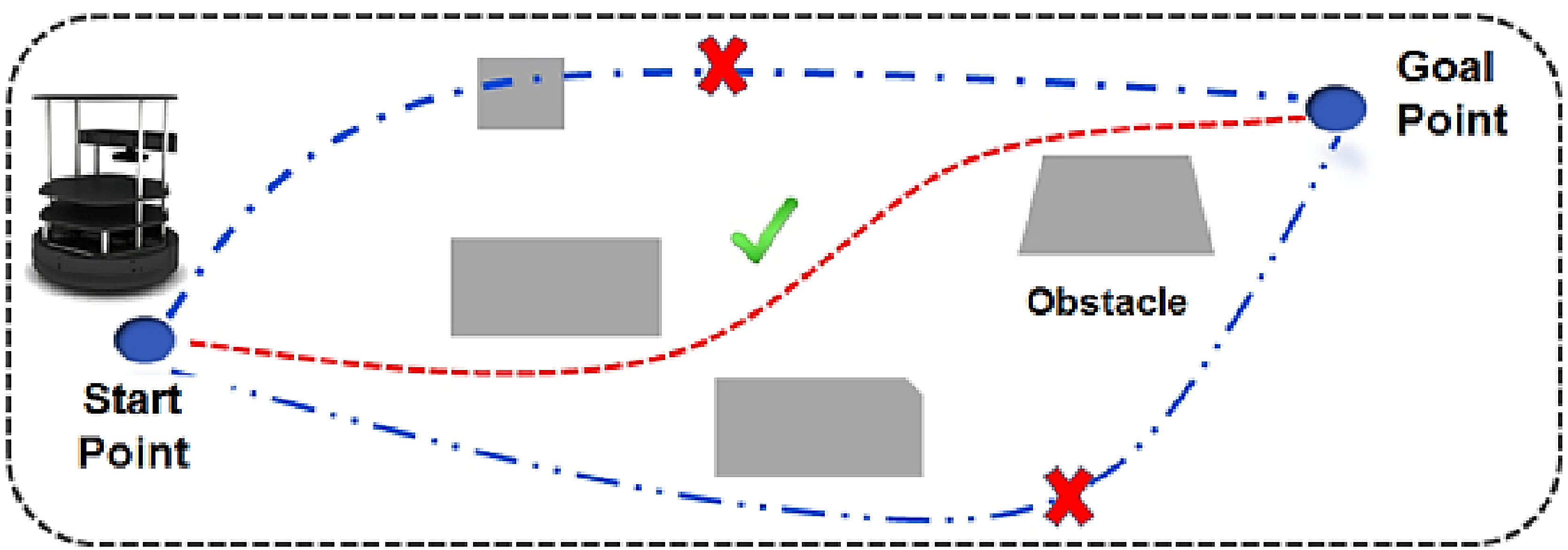
Agent Types: Goal-based agents

- Knowing the current state of the environment is not enough. The agent needs some goal information.
- Agent program combines the goal information with the environment model to choose the actions that achieve that goal.
- Consider the future with "What will happen if I do A?"
- Flexible as knowledge supporting the decisions is explicitly represented and can be modified.



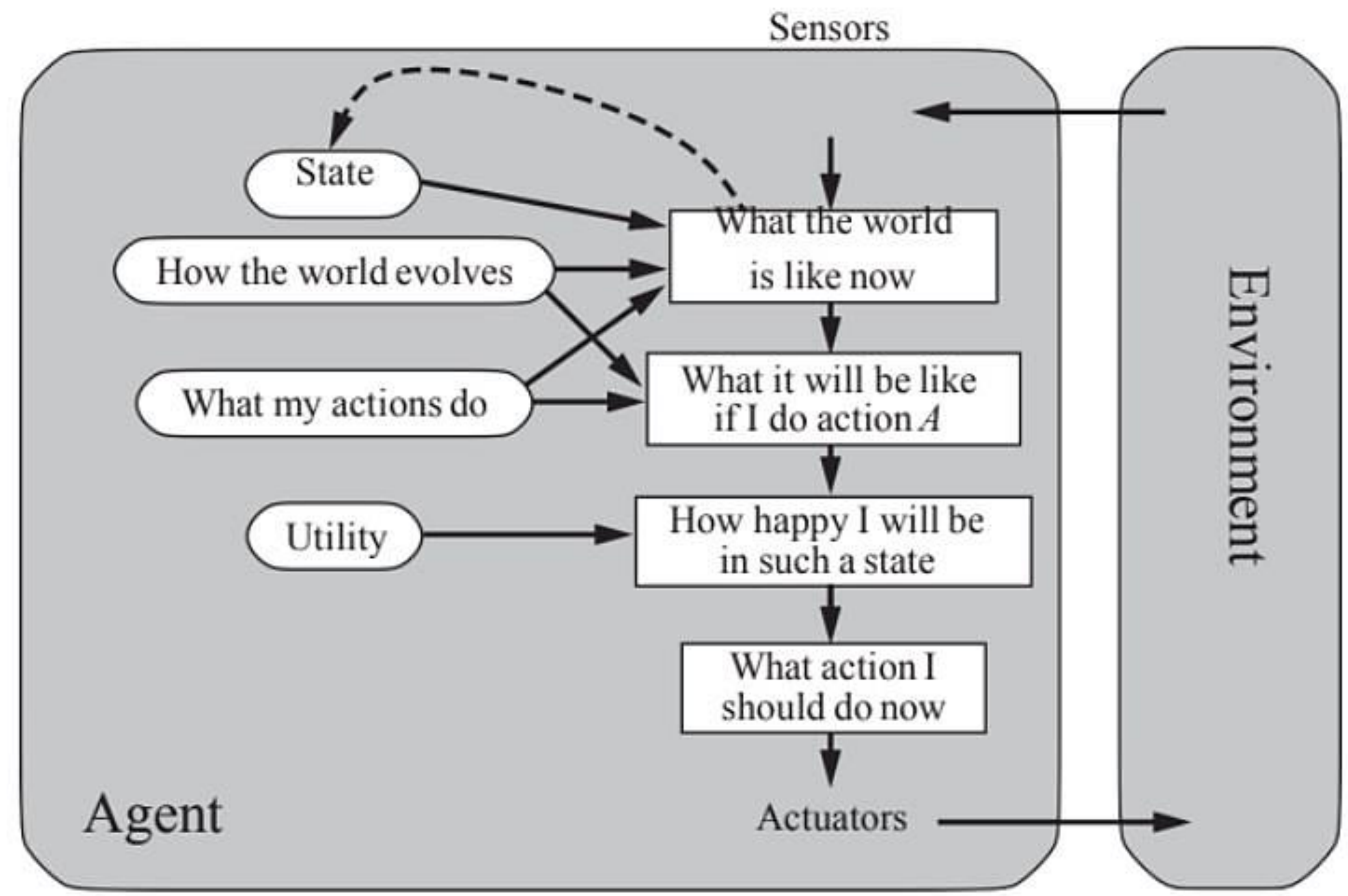
Goal-based agents: Pathfinding Robots

- Goal: Navigate from point A to point B in a warehouse.
- The robot uses sensors to detect obstacles and a map of the warehouse.
- It uses algorithms like A* or Dijkstra's to find the shortest path to the goal.
- It dynamically adjusts its path if obstacles are encountered.
- Why it's goal-based agents: The agent's actions are driven by the goal of reaching the target location.



Agent Types: Utility-based agents

- Sometimes achieving the desired goal is not enough. We may look for multiple goals (such as quicker, safer, cheaper trip) to reach a destination.
- Agent happiness should be taken into consideration. We call it utility.
- A utility function is the agent's performance measure
- Because of the uncertainty in the world, a utility agent choses the action that maximizes the expected utility.



Utility-based agents: Self-Driving Cars

- Utility Function: Maximize safety, efficiency, and passenger comfort.

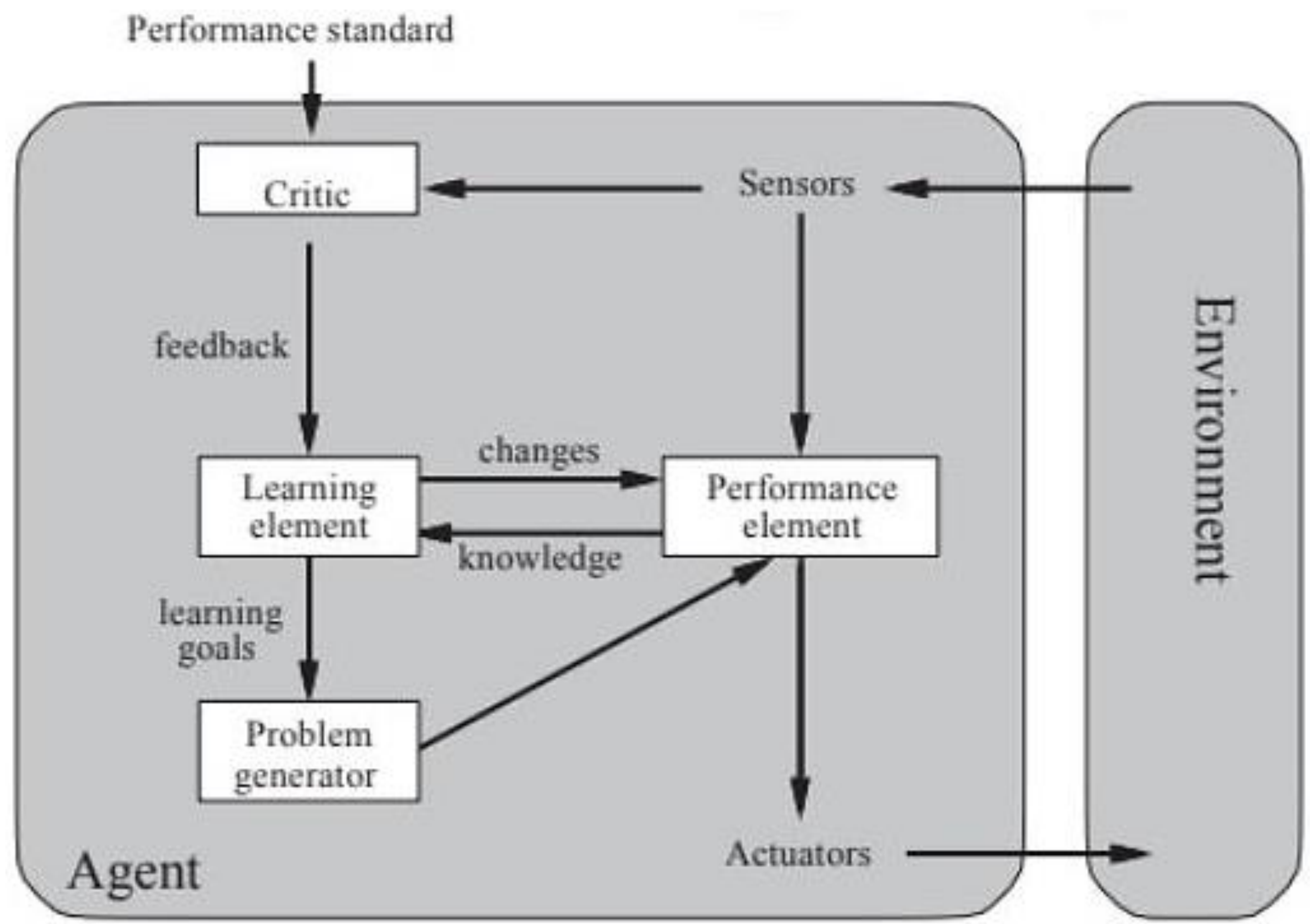
- The car evaluates different actions (e.g., accelerating, braking, changing lanes) based on their impact on safety, travel time, and comfort.
- It chooses the action that maximizes overall utility, balancing factors like speed, fuel efficiency, and collision risk.

- Why it's utility-based: The agent makes decisions by optimizing a combination of factors rather than focusing on a single goal.

Agent Types: Learning Agents

Four conceptual components:

- Learning element: responsible for making improvements
- Performance element: responsible for selecting external actions. It is what we considered as agent so far.
- Critic: How well is the agent is doing with regard to a fixed performance standard.
- Problem generator: allows the agent to explore.




Any Questions ?