بسم الله الرحمن الرحيم

BISMILLAH ARRAHMAN ARRAHEEM

Artificial Intelligence (CS-401)

Lecture 2: Intelligent Agents

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Intelligent Agents

Agents and environments

- Rationality
- PEAS (Performance measure, Environment, Actuators, Sensors)
- Environment types
- Agent types

Agents

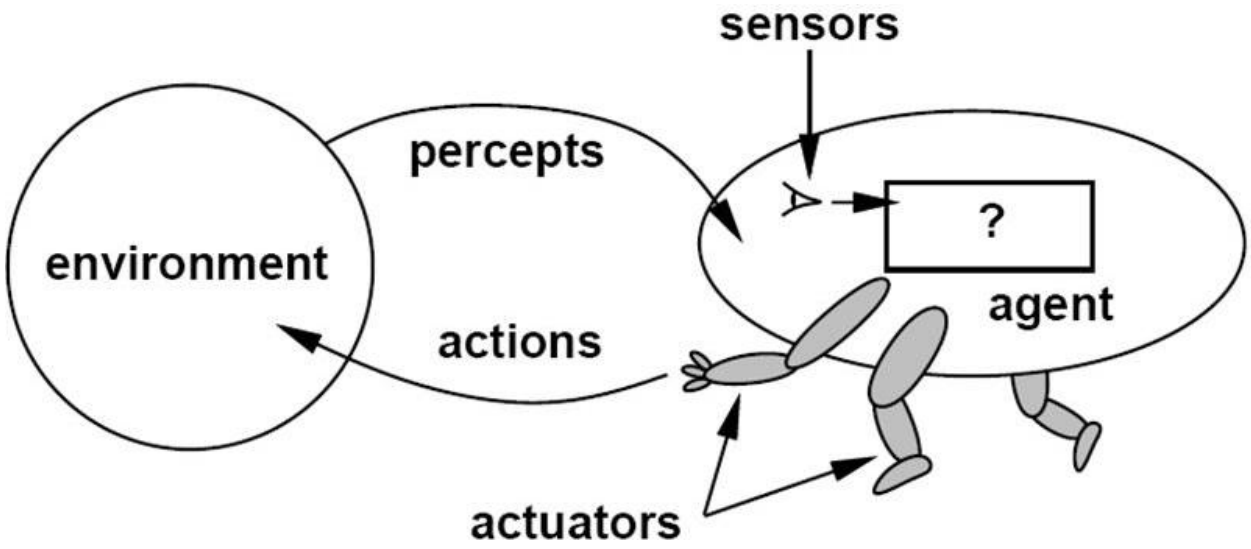
An agent is anything that can be viewed as perceiving its environment through sensors and acting upon that environment through actuators.

Human agent: Eyes, ears, and other organs for sensors; hands, legs, mouth, and other body parts for actuators

Robotic agent: Cameras and infrared range finders for sensors; various motors for actuators.

Software agent: Software agent is a computer program that acts for a user or other program: an agreement to act on one's behalf.

Agents and Environments



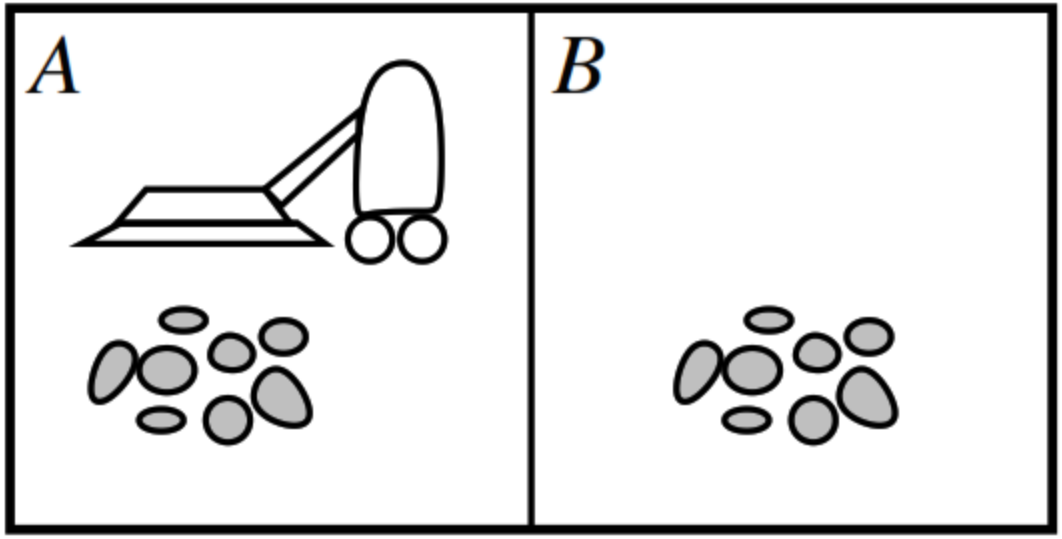
The agent function maps from percept histories to actions:

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

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

Agent = Architecture + Program

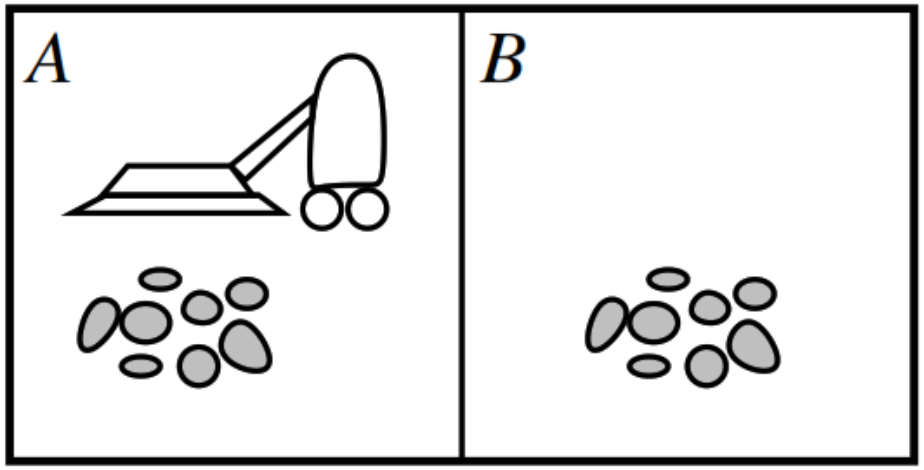
Vacuum-cleaner world



Percepts: location and contents, e.g., [A, Dirty]

Actions: *Left*, *Right*, *Suck*, *DoNothing*

A vacuum-cleaner Agent



Tabulation of an agent function of the vacuum-cleaner

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

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*

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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 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 amount of dirt cleaned up, amount of time taken, amount of electricity consumed, 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, learn).

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

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PEAS

When designing a rational/intelligent agent, we keep in mind PEAS.

PEAS: **P**erformance measure, **E**nvironment, **A**ctuators, **S**ensors

Consider, e.g., the task of designing an automated taxi driver:

- Performance measure
- Environment
- Actuators
- Sensors

PEAS

Agent: automated taxi driver

- Performance measure: *Safe, fast, legal, comfortable trip, maximize profits*
- Environment: *Roads, other traffic, people and objects in/around the street*
- Actuators: *Steering wheel, accelerator, brake, signal, horn*
- Sensors: *Cameras, sonar, speedometer, GPS, odometer, engine sensors, keyboard*

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: Part-picking robot

- Performance measure: Percentage of parts in correct bins
- Environment: Conveyor belt with parts, bins
- Actuators: Jointed arm and hand
- Sensors: Camera, joint angle sensors

PEAS

Agent: Interactive English tutor

- Performance measure: Maximize student's score on test
- Environment: Set of students
- Actuators: Screen display (exercises, suggestions, corrections)
- Sensors: Keyboard

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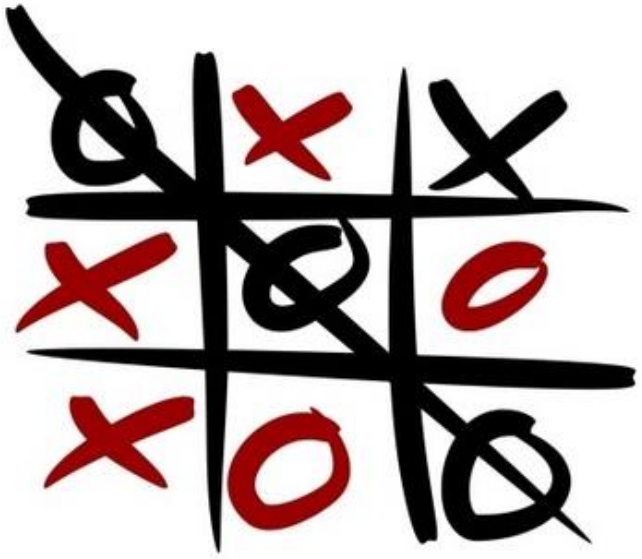
Environment Types

- 1) Fully observable vs. 2) Partially observable
  - Sensors capture all relevant information from the environment
- 3) Deterministic vs. 4) Stochastic (non-deterministic)
  - Changes in the environment are predictable
- 5) Episodic vs. 6) Sequential (non-episodic)
  - Independent perceiving-acting episodes
- 7) Static vs. 8) Dynamic
  - No changes while the agent is "thinking"
- 9) Discrete vs. 10) Continuous
  - Limited number of distinct percepts/actions
- 11) Single vs. 12) Multiple agents
  - Interaction and collaboration among agents
  - Competitive, cooperative

Environment Types

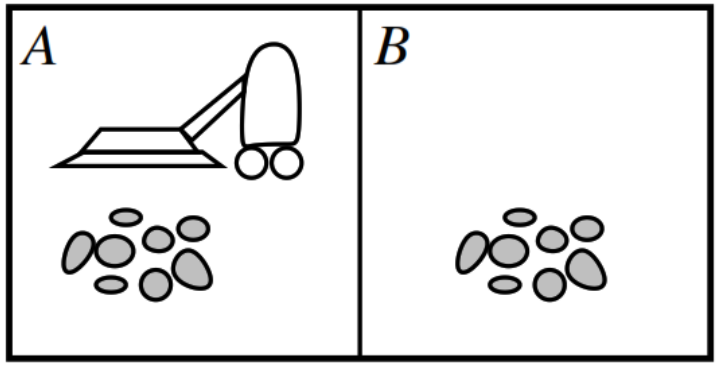
❖Fully observable (vs. partially observable): An agent's sensors can measure all relevant aspects of the environment at each point in time.



Tic Tac Toe is Fully Observable. Cards are Partially Observable.

Environment Types

- Deterministic (vs. stochastic): The next state of the environment is completely determined by the current state and the action executed by the agent.



Vacuum is deterministic. Taxi driver is stochastic.

Environment Types

❖Episodic (vs. sequential): The agent's experience is divided into atomic "episodes" (each episode consists of the agent perceiving and then performing a single action), and the choice of action in each episode depends only on the episode itself.

Robot is Episodic. Taxi driver is sequential.

Environment Types

❖Static (vs. dynamic): The environment is unchanged while an agent is thinking. (The environment is semidynamic if the environment itself does not change with the passage of time but the agent's performance score does).

Taxi driver is dynamic. Chess is static.

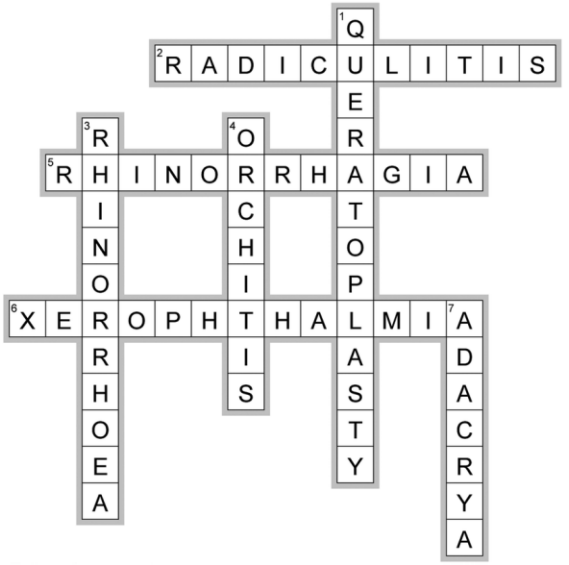
Environment Types

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

Chess has a finite number of distinct states. thus it is discrete; however the Taxi-driving is not.

Environment Types

❖Single agent (vs. multiagent): An agent operating by itself in an environment.



Crossword is Single agent, while Chess is a multi-agent environment.

Environment Types

Task Environment	Oberservable	Deterministic	Episodic	Static	Discrete	Agents
Crossword puzzle						
Chess with a clock						
Taxi driver						
mushroom-picking						

- The environment type largely determines the agent design
- The real world is (of course) partially observable, stochastic, sequential, dynamic, continuous, multi-agent

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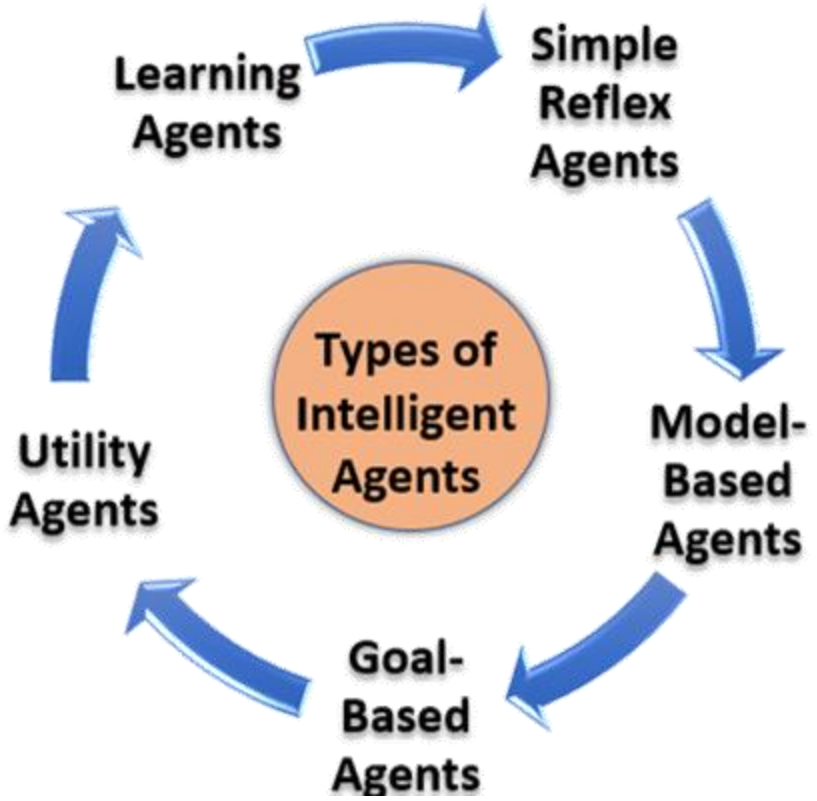
Agent Types

Agents can be divided in to five (05) basic types according to the degree of perceived intelligence and capacity to change the environment:

- Simple reflex agents
- Model-based reflex agents
- Goal-based agents
- Utility-based agents
- Learning Agents

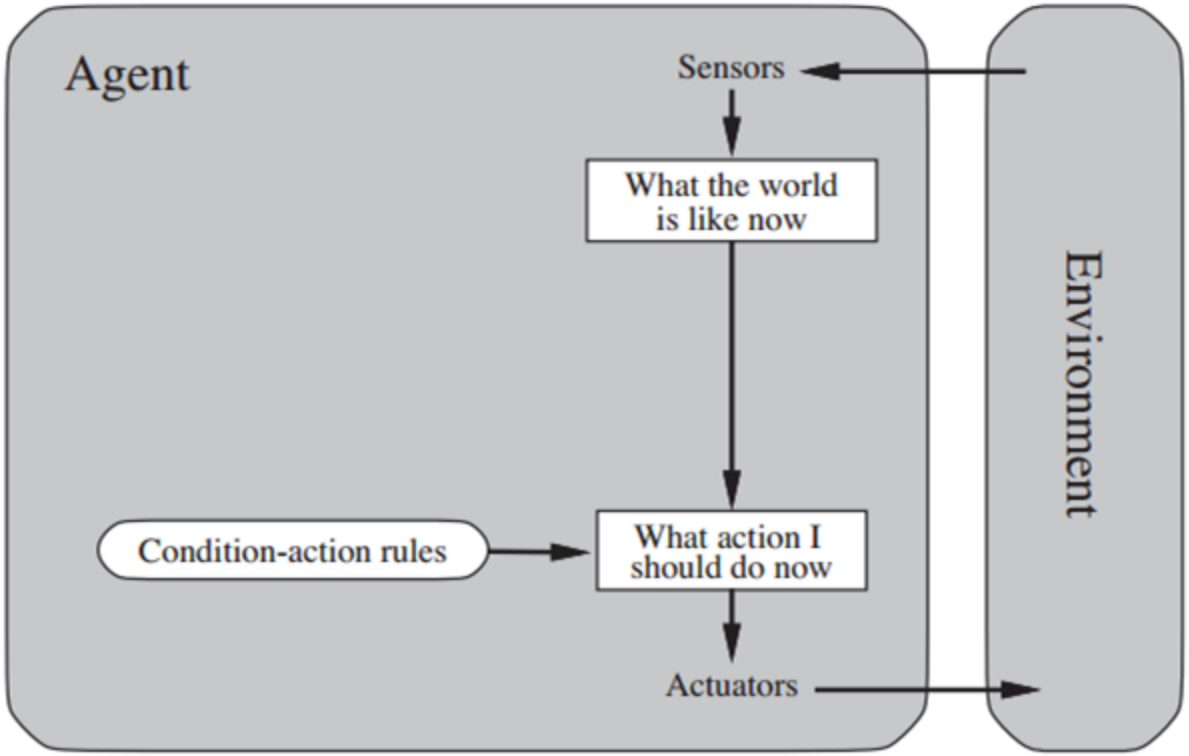


Simple Reflex Agents

The agent selects an action(s) based on the current precept and conditions, ignoring the rest of the precept history (previous state).

if x happens, do y

e.g., alarm clock



Simple Reflex Agents

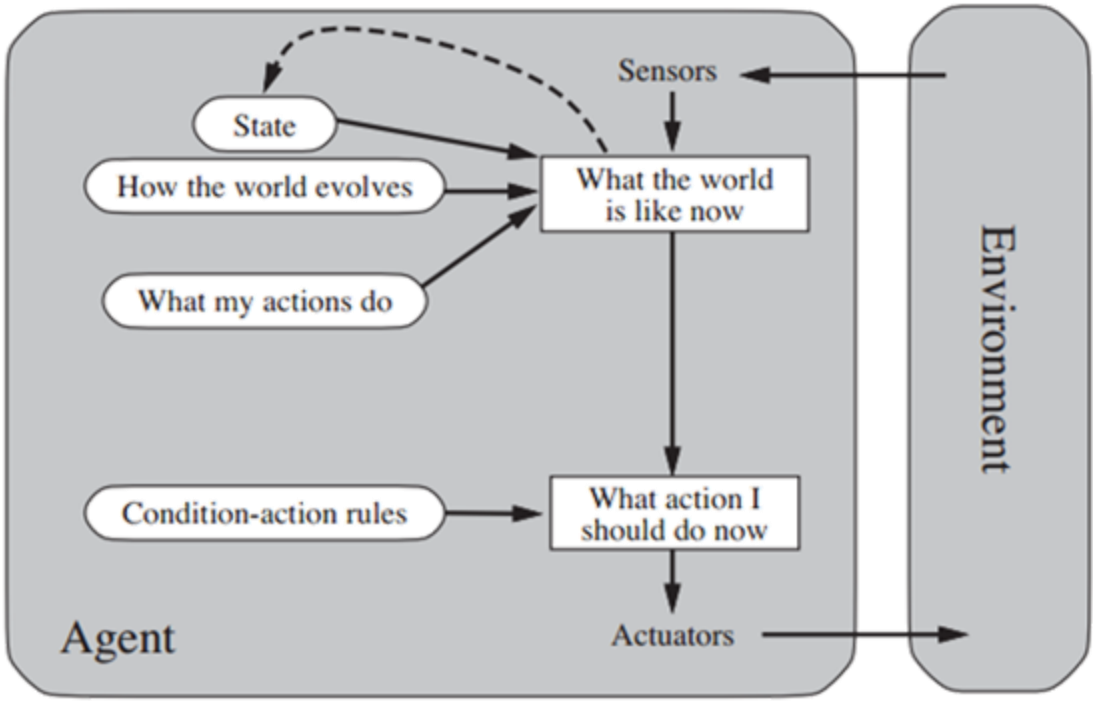
- Very limited Intelligence
- No Knowledge/Perception about the previous or next state
- Operates in Partially Observable Environments
- Infinite loops are unavoidable

Model-based Reflex Agents

The agent decides its action(s) based on a predefined set of condition-action rules.

Depending on the state of the world, different actions are appropriate.

State is evaluated in terms of how it changed from the previous state.



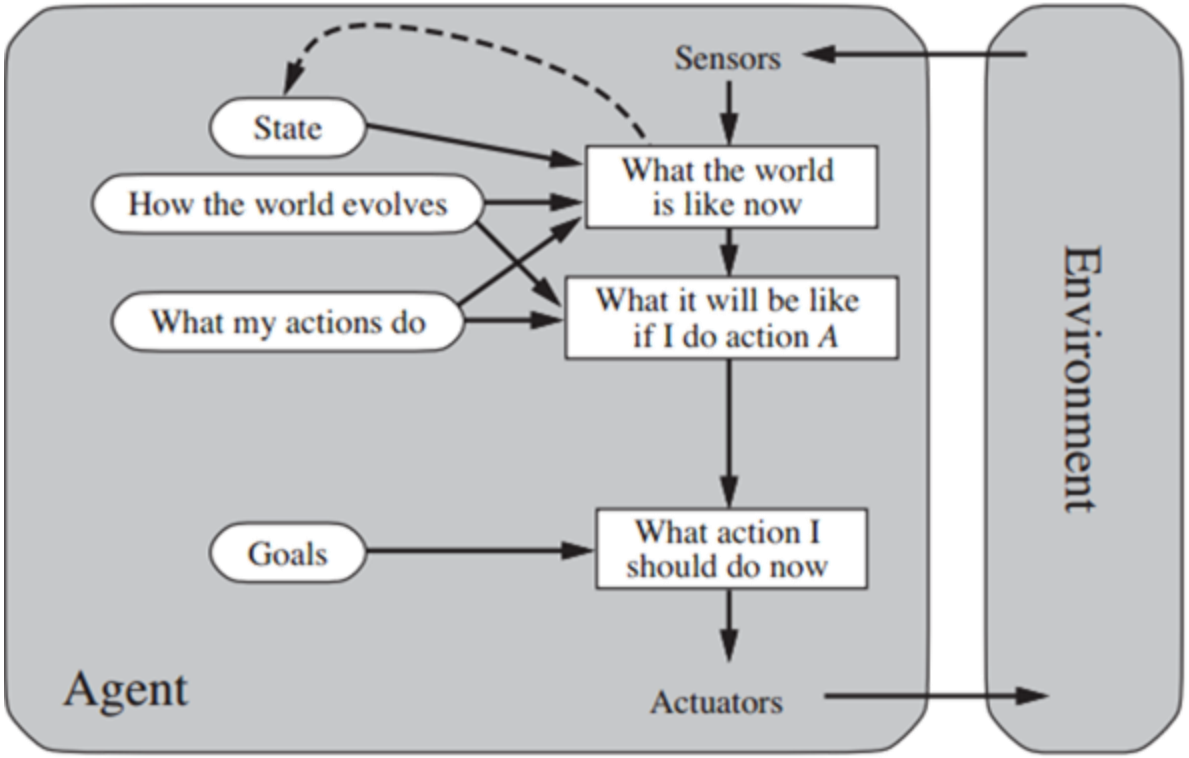
e.g., A Roomba Cleaner Robot, a telephone operator/answering machine.

Goal-based Agents

The agent decides its action(s) based on a known goal.

These agents have all of the above and goal.

Involves consideration of the previous and future states.

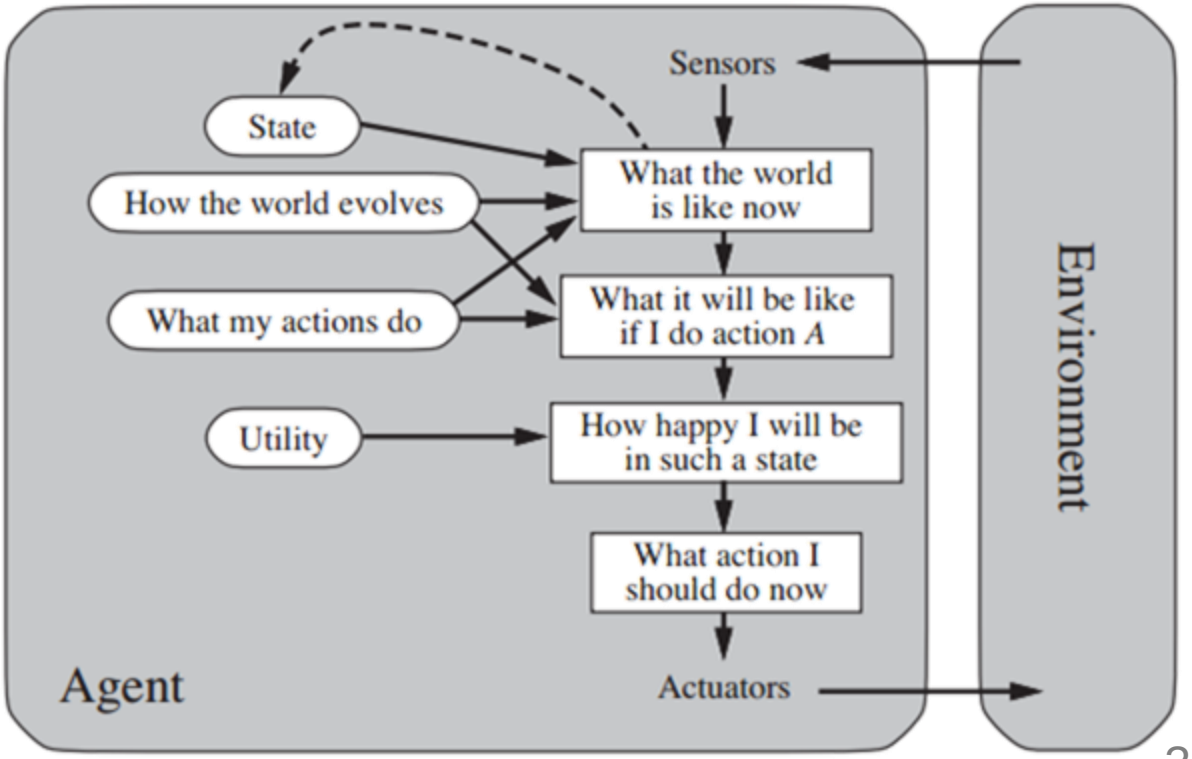


e.g., a GPS system finding a path to certain destination.

Utility-based Agents

The agent decides its action(s) based on utilities/ preferences.

Utility function to decide which world state (Optimality) is better for an agent.



e.g., A GPS system finding a shortest/fastest/safer path to certain destination.

Learning Agents

The agent adapts its action(s) based on feedback (not only sensors).

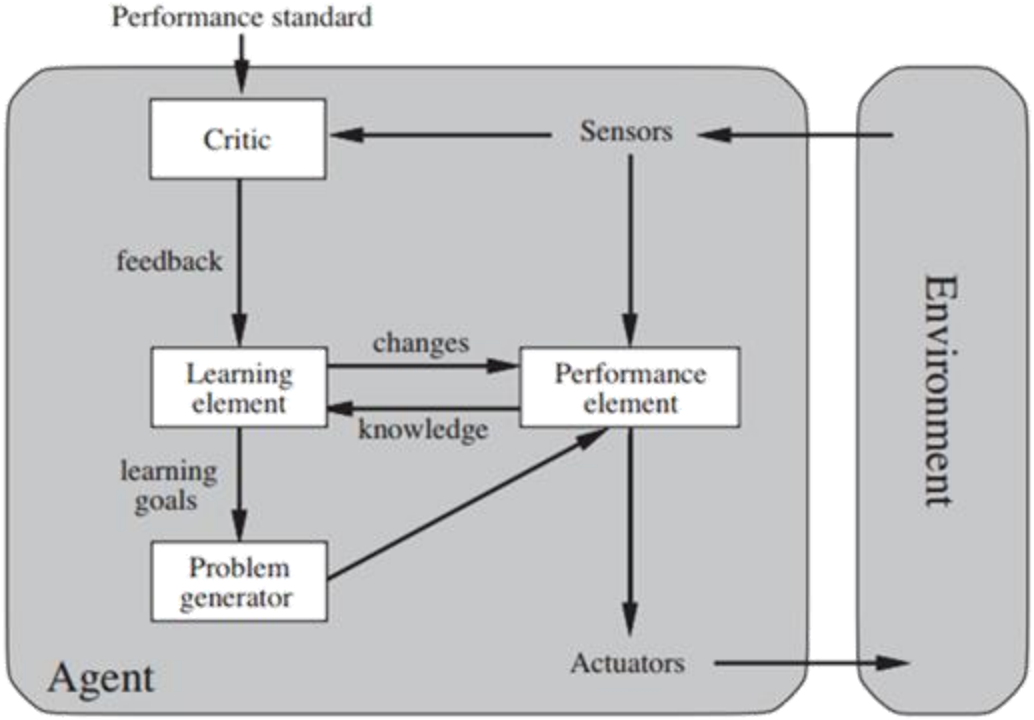
Learning element - responsible for making improvements from past events.

Performance element - what we have up to now considered to be the entire agent. Takes percepts and then decides on actions.

Critic - gives the learning element feedback on how the performance element is doing and if it needs to be modified.

Problem generator - it suggests actions that lead to new and informative experiences.

e.g., human agent



Summary

- Agents interact with environments through actuators and sensors
- The agent function describes what the agent does in all circumstances.
- The performance measure evaluates the environment sequence.
- A perfectly rational agent maximizes expected performance.
- Agent programs implement (some) agent functions PEAS descriptions define task environments.
- Environments are categorized along several dimensions:
  - Observable? deterministic? episodic? static? discrete? single-agent?
- Several basic agent architectures exist:
  - Simple Reflex, Model based, goal-based, utility-based, Learning