CS 5/7320 Artificial Intelligence

Intelligent Agents
AIMA Chapter 2

Slides by Michael Hahsler based on slides by Svetlana Lazepnik

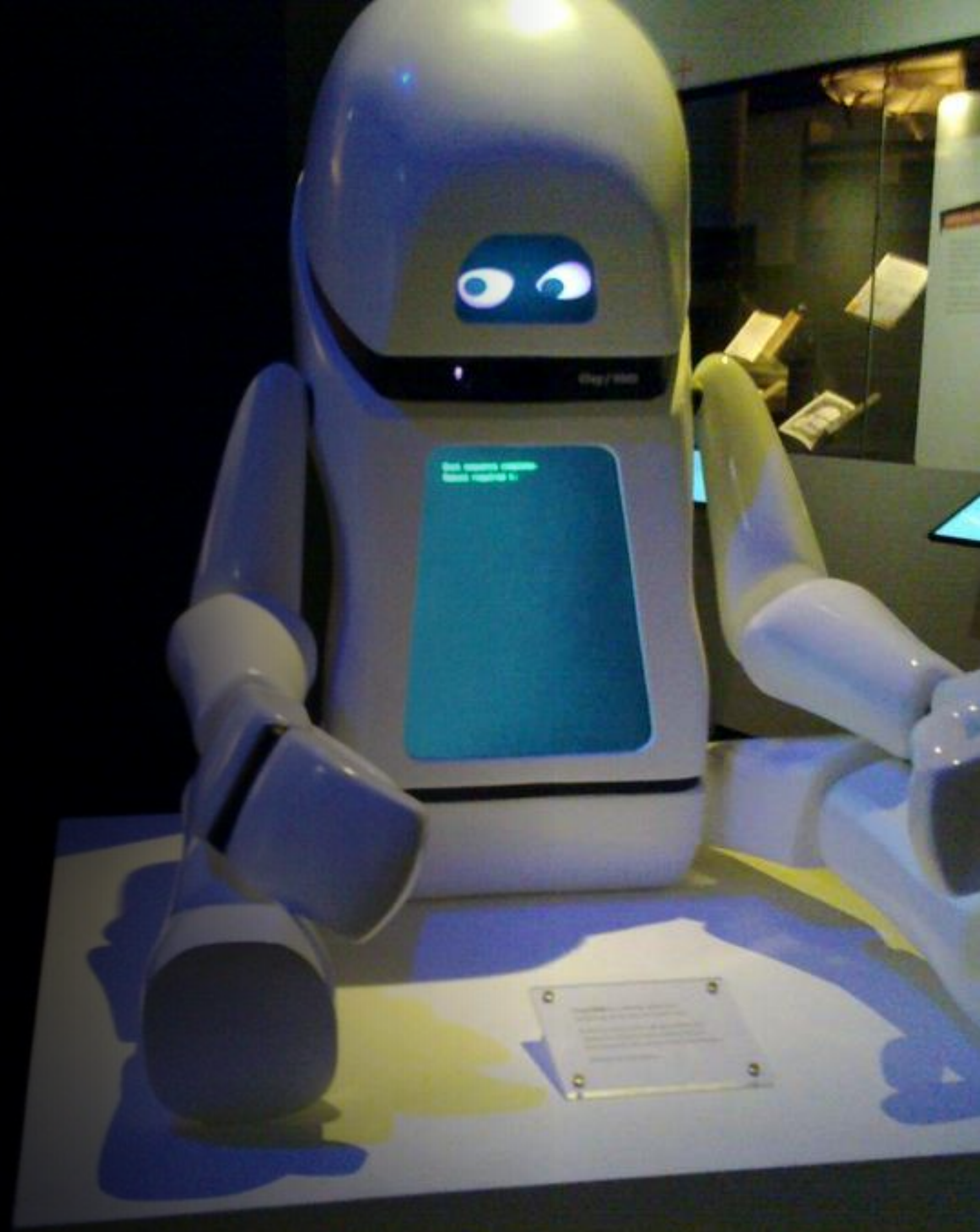


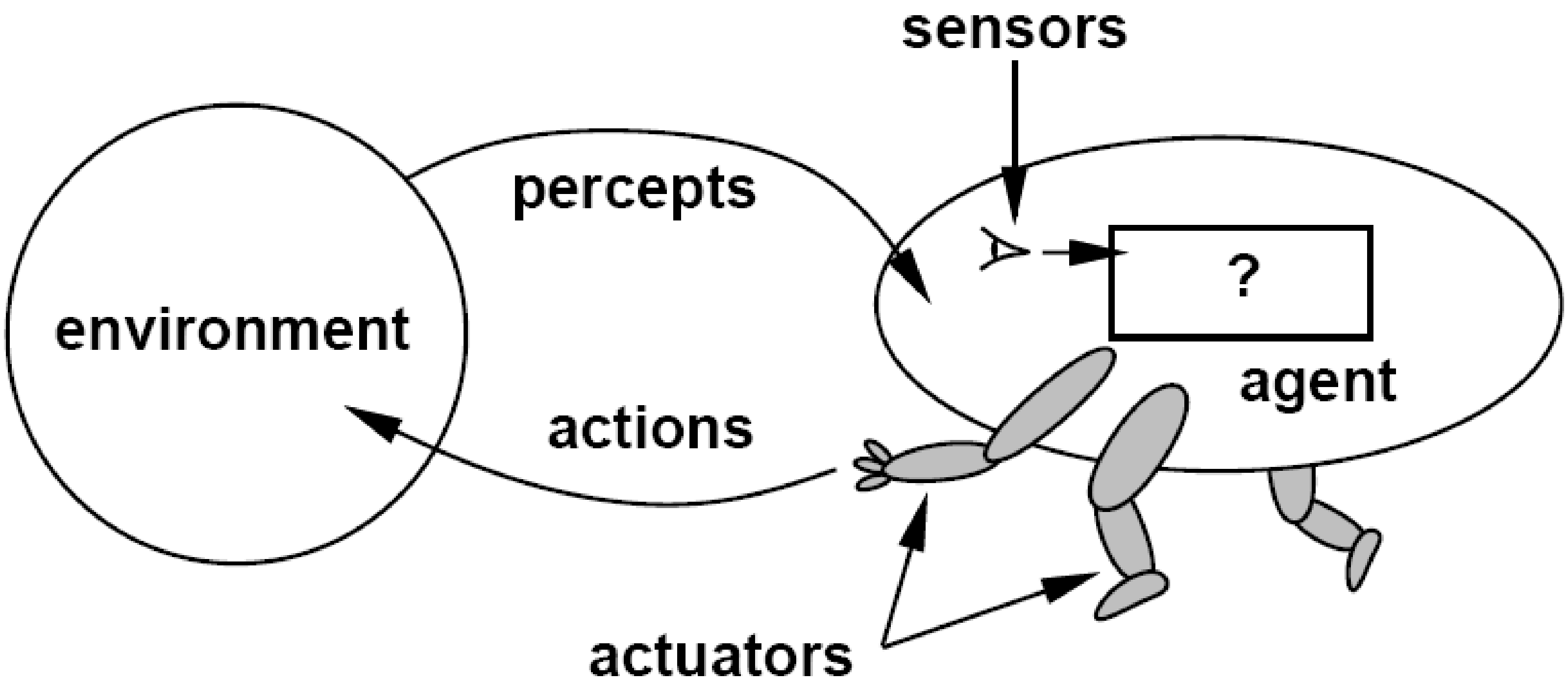
Image: "Robot at the British Library Science Fiction Exhibition" by BadgerGravling

Outline

- What is an intelligent agent?
- Rationality
- PEAS (Performance measure, Environment, Actuators, Sensors)
- Environment types
- Agent types

What is an Agents?

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



Agent function and agent program

The agent function maps from *percept sequences* P^* to *actions* A formulated as an abstract mathematical function $f : P^* \rightarrow A$ (e.g., a table).

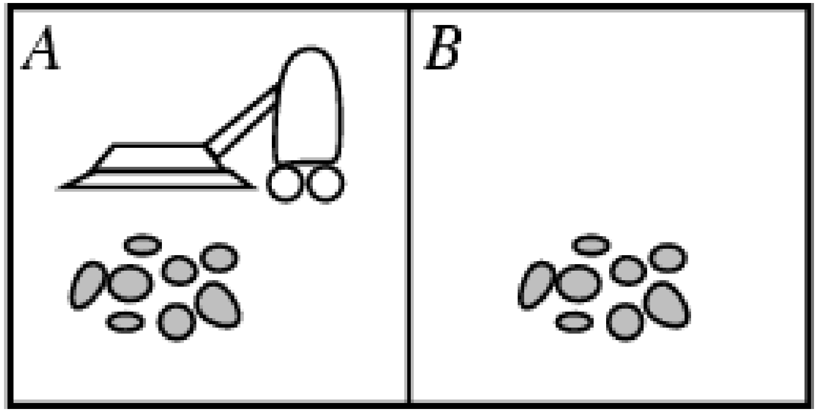
The agent program is the concrete implementation running in a physical system.

Agent = architecture (hardware) + agent program

- Sensors
- Memory
- Computational power

Example: Vacuum-cleaner world

- **Percepts:**
  Location and status,
  e.g., [A, Dirty]
- **Actions:**
  Left, Right, Suck, NoOp



Last Percept

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

Percept Sequence	Action
[A, Clean]	Right
[A, Dirty]	Suck
…	
[A, Clean], [B, Clean]	Left
…	
[A, Clean], [B, Clean], [A, Dirty]	Suck
…	

Implemented agent program:

function 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
```

This table can become infinitively large!

Rational agents: What is good behavior?

Foundation

- **Consequentialism**: Evaluate behavior by its consequences.
- **Utilitarianism**: maximize happiness and well-being

Definition of a rational agent:

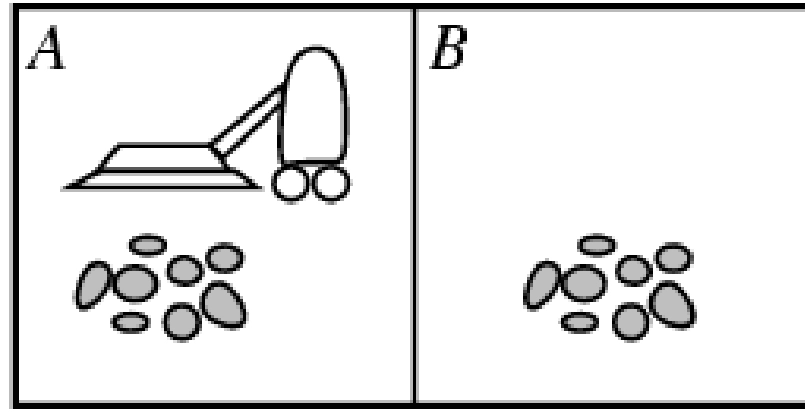
"For each possible percept sequence, a rational agent should select an ***action*** *that is* ***expected to maximize its performance measure****, given the evidence provided by the* ***percept sequence*** *and the* ***agent's built-in knowledge****."*

- Performance measure: An *objective* criterion for success of an agent's behavior (often called utility function).
- Expectation: Outcome averaged over all possible situations that may arise.

This means:

- **Rationality ≠ Omniscience** (rational agents can make mistakes if percepts and knowledge do not suffice to make a good decision)
- **Rationality ≠ Perfection** (rational agents maximize **expected** outcomes not actual outcomes)
- **It is rational to explore and learn** (i.e., **use percepts** to supplement prior knowledge and become autonomous)

Example: Vacuum-cleaner world



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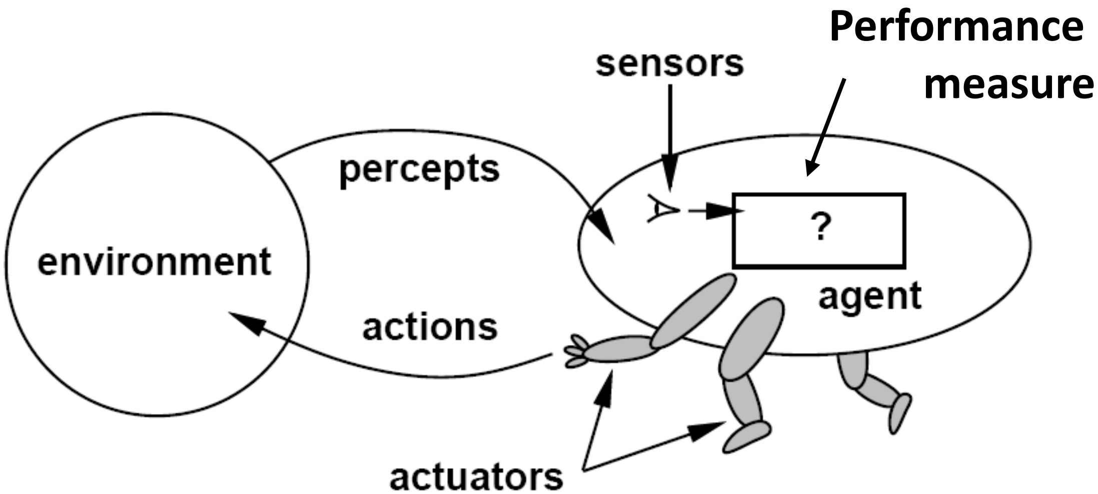
What could be a performance measure?
Is this agent rational?

Problem specification: PEAS



Performance measure	Environment	Actuators	Sensors

Example: Automated taxi driver

Performance measure	Environment	Actuators	Sensors
• Safe • fast • legal • comfortable trip • maximize profits	• Roads • other traffic • pedestrians • customers	• Steering wheel • accelerator • brake • signal • horn	• Cameras • sonar • speedometer • GPS • Odometer • engine sensors • keyboard

Example: Spam filter

Performance measure	Environment	Actuators	Sensors
• Minimizing false positives, false negatives	• A user’s email account • email server	• Mark as spam • delete • etc.	• Incoming messages • other information about user’s account

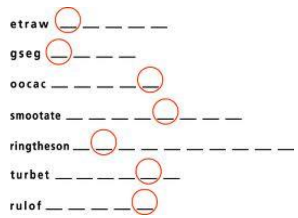
Environment types

- **Fully observable (vs. partially observable):** The agent's sensors give it access to the complete state of the environment at each point in time.
- **Deterministic (vs. stochastic):** The next state of the environment is completely determined by the current state and the agent’s action.
  - **Strategic:** the environment is deterministic except for the actions of other agents are stochastic, but follow a strategy.
- **Episodic (vs. sequential):** The agent's experience is divided into atomic “episodes,” and the choice of action in each episode depends only on the episode itself (i.e., the agent does not learn).

Environment types

- **Static (vs. dynamic):** The environment is unchanged while an agent is deliberating
  - **Semidynamic:** the environment does not change with the passage of time, but the agent's performance score does
- **Discrete (vs. continuous):** The environment provides a fixed number of distinct percepts, actions, and environment states
  - Time can also evolve in a discrete or continuous fashion
- **Single agent (vs. multi-agent):** An agent operating by itself in an environment
- **Known (vs. unknown):** The agent knows the rules of the environment

Examples of different environments



Word jumble solver

Chess with a clock

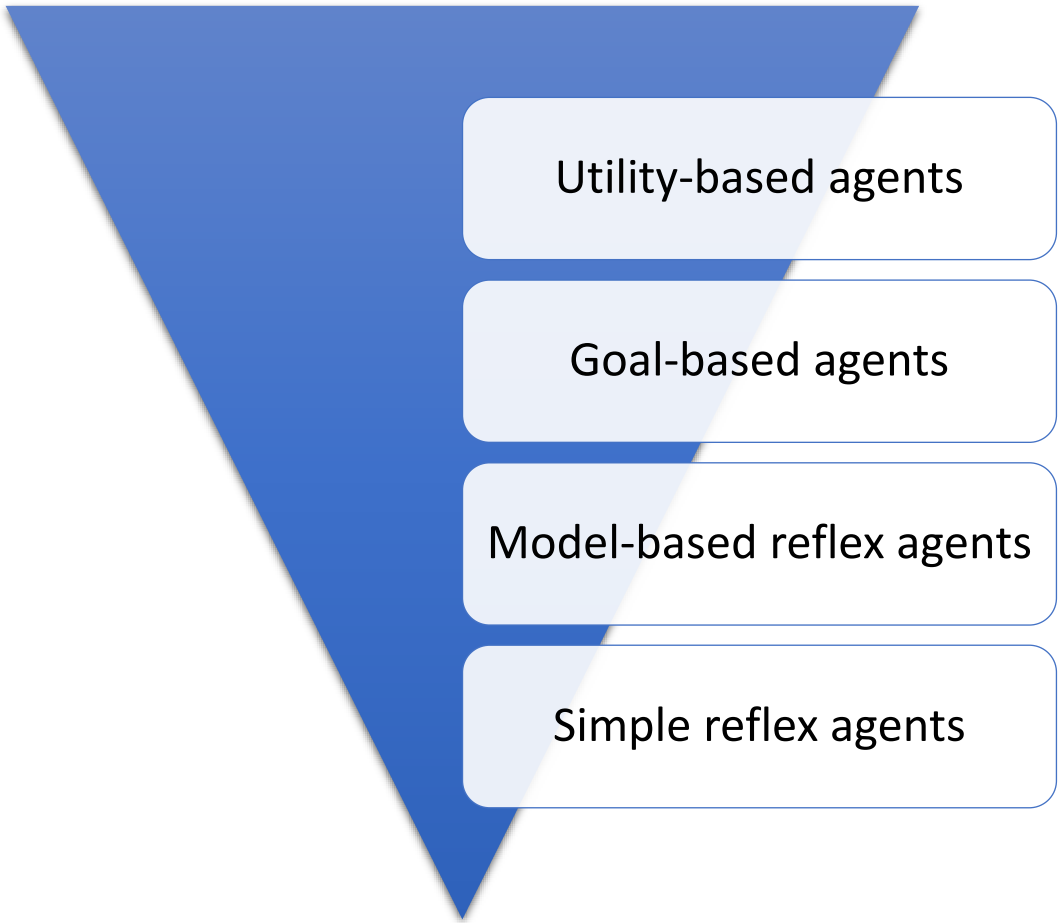
Scrabble

Taxi driving

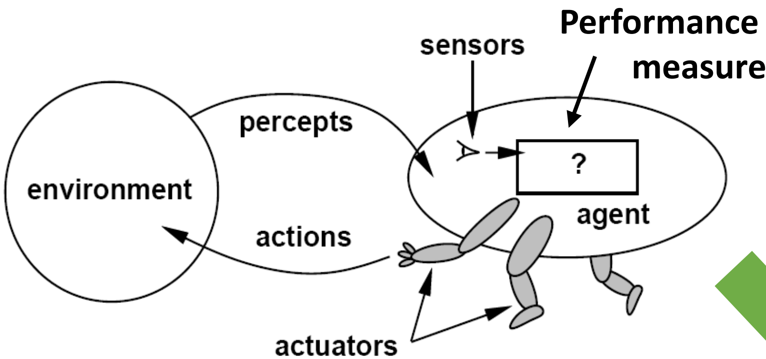
	Word jumble solver	Chess with a clock	Scrabble	Taxi driving
Observable	Fully	Fully	Partially	Partially
Deterministic	Deterministic	Strategic	Stochastic (+Strategic)	Stochastic
Episodic	Episodic	Sequential	Sequential	Sequential
Static	Static	Semidynamic	Static	Dynamic
Discrete	Discrete	Discrete	Discrete	Continuous
Single agent	Single	Multi	Multi	Multi

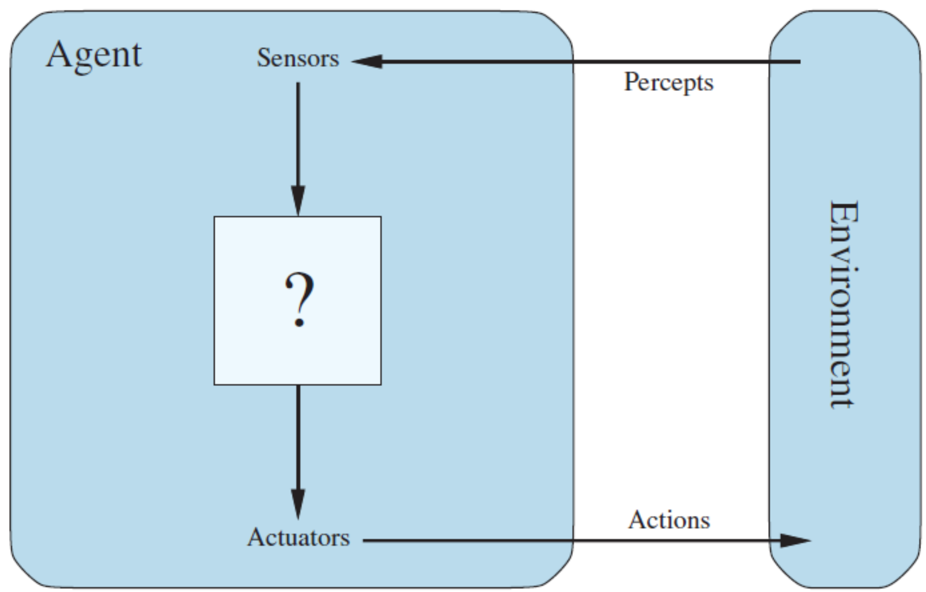
learning

Hierarchy of agent types



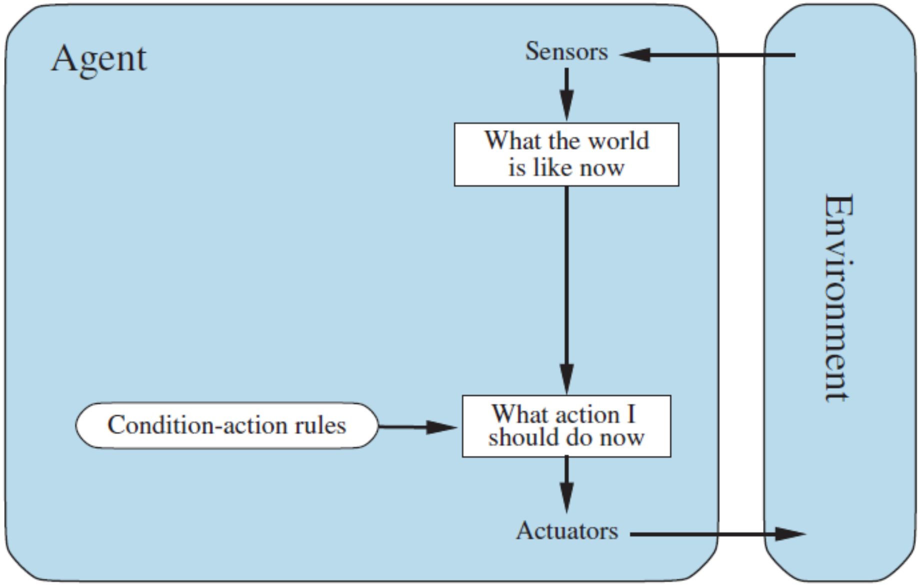
Structure of an Agent





Simple reflex agent

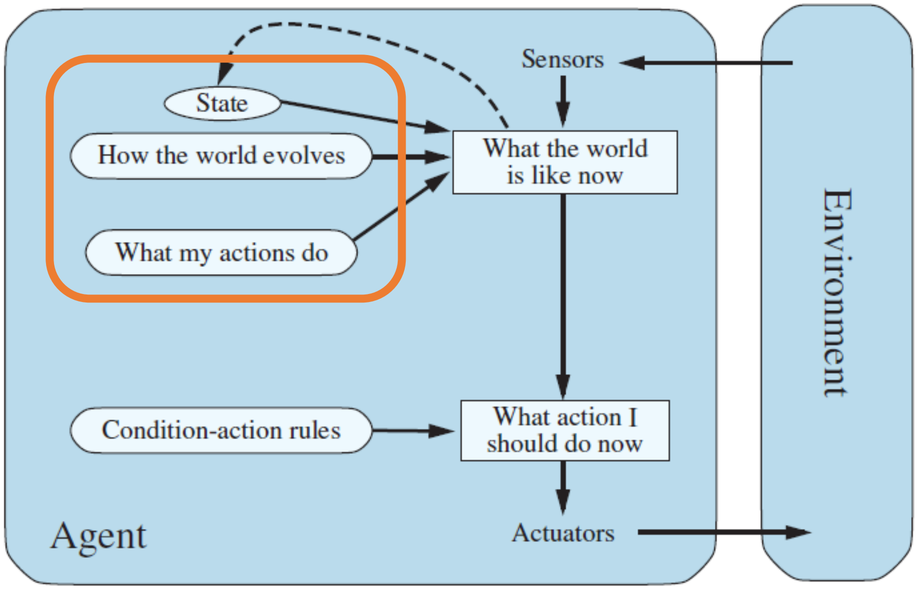
Rues select action only **based on current percept**, ignoring all past percepts (no memory). This is typically very fast!



Example: simple, rule-based vacuum cleaner from before.

Model-based reflex agent

Maintains **internal state** (memory) to keeps track of aspects of the environment that cannot be currently observed. There is now more information for the rules to making decisions.

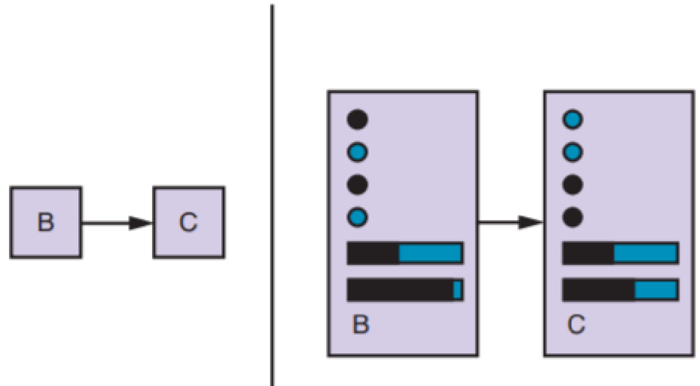


Example: simple, vacuum cleaner that remembers were it has already cleaned.

State representation

States help to keep track of the environment. The representation can be

- **Atomic**: Just a label for a black box. E.g., A, B
- **Factored**: A vector of attribute values. E.g., [location = left, status = clean, temperature = 75 deg. F]



(a) Atomic (b) Factored

State Space: The set of all possible states.

Old-school vs. Smart thermostat

Old-school thermostat

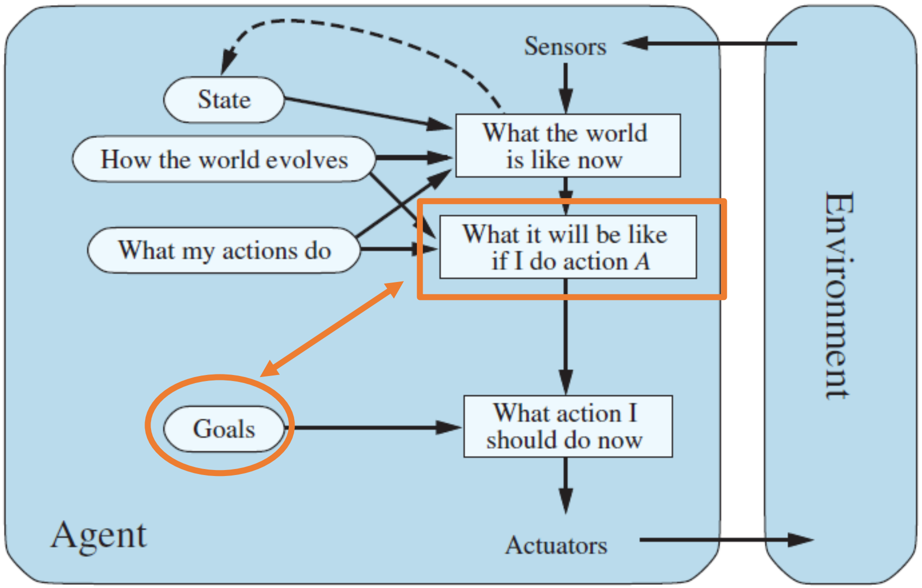
Percepts	**States**

Smart thermostat

Percepts	**States**

Goal-based agent

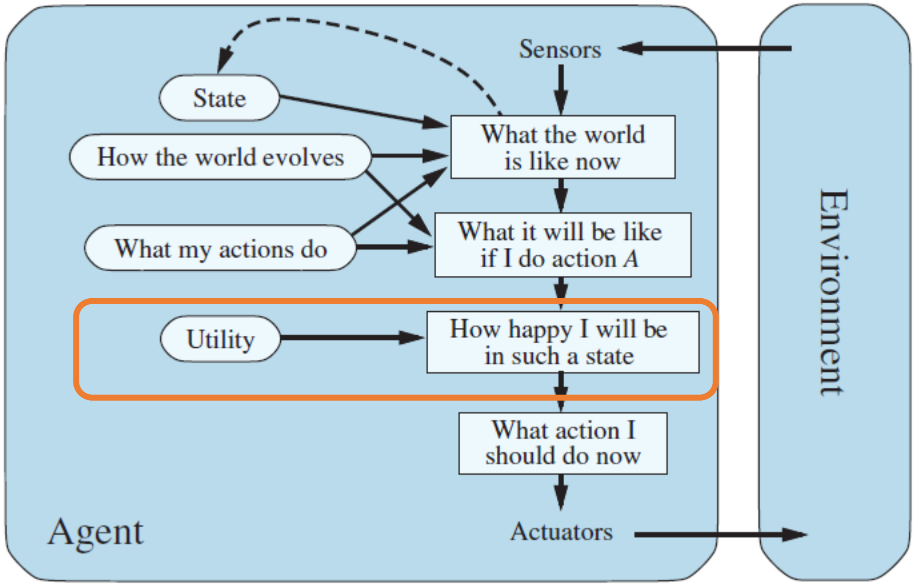
The agent chooses actions in the current state to reach a **goal state** as fast as possible. We need **search algorithms** to find action sequences that reach that goal.



Example: Solving a puzzle. What action gets me closer to the solution?

Utility-based agent

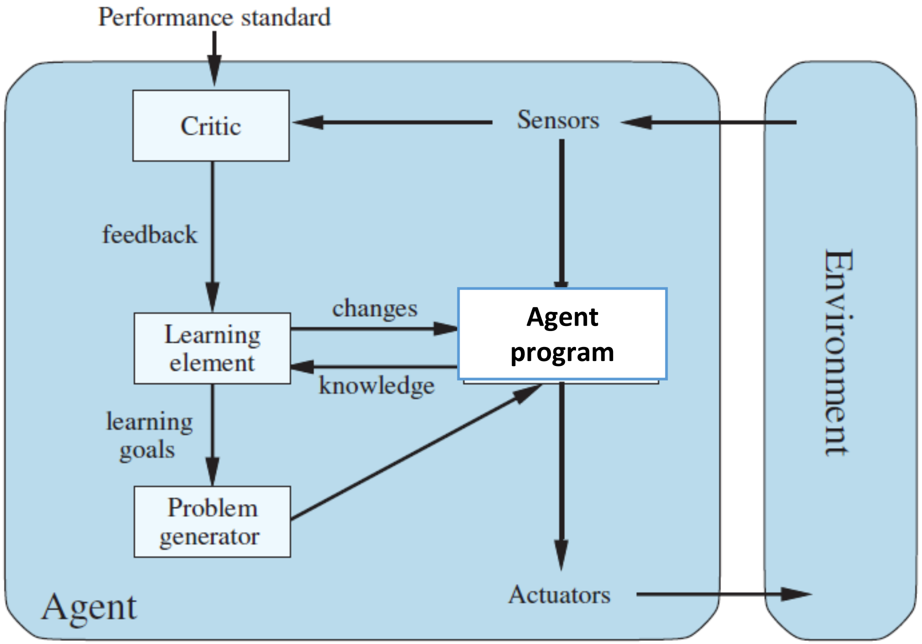
The agent uses a utility function to evaluate the **desirability of states** that could result from each possible action. Choose the action to maximize expected utility over time.



Example: An autonomous Mars rover prefers states where its battery is not critically low.

Learning agent

The **learning element** modifies the agent program (reflex-based, goal-based, or utility-based) to improve its performance.



Smart thermostat

Change temperature when you are too cold/warm.

Smart thermostat

Percepts

- Temp: deg. F
- Outside temp.
- Weather report
- Energy curtailment
- Someone walking by
- Someone changes temp.
- Day & time
- …

States

Factored states

- Estimated time to cool the house
- Someone home?
- How long till someone is coming home?
- A/C: on, off

Goal-based?

Utility-based?

What type of intelligent agent is this?

Features are:

- Control via App
- Cleaning Modes
- Navigation
- Mapping
- Boundary blockers

iRobot Roomba 960

Read TechHive's review

$247.17 See It

on Amazon (Prime Eligible)

The Roomba 960's flawless navigation, stellar cleaning, and advanced features set it apart from all other robot vacuums.

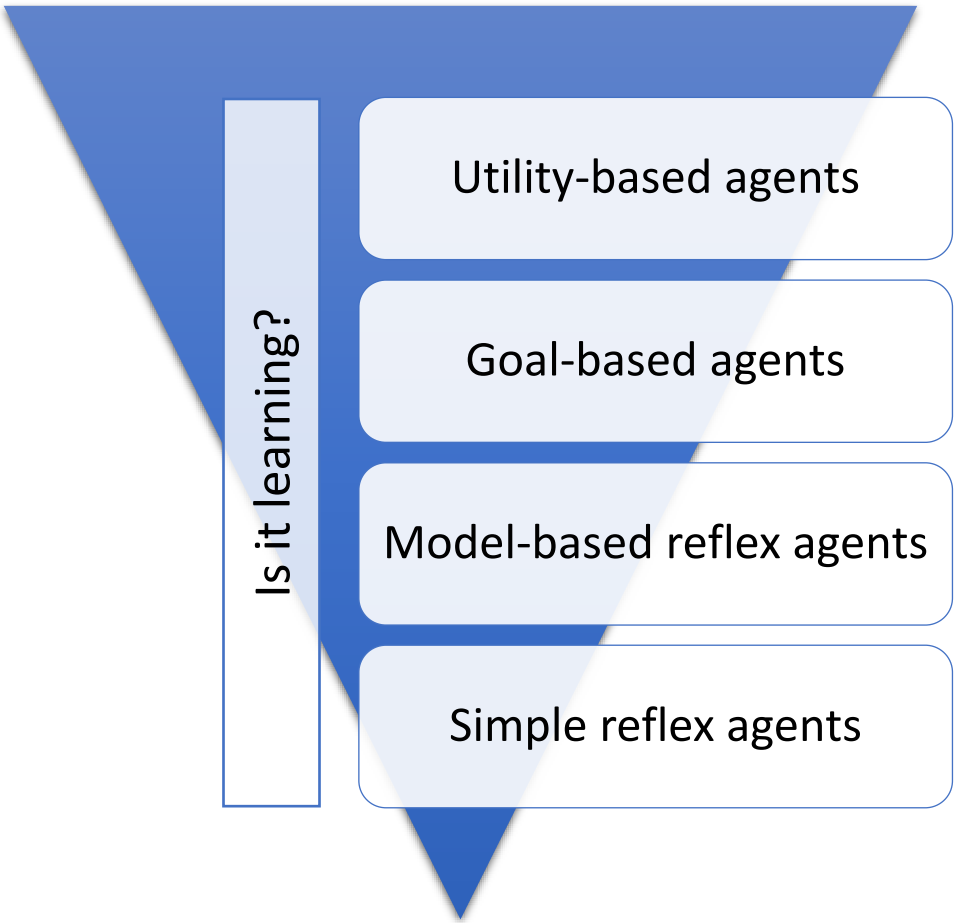
iRobot's Roomba brand has become as synonymous with robot vacuum as Q-tips is with cotton swabs. The Wi-Fi-enabled Roomba 960 is ample evidence why. It turns a tiresome chore into something you can almost look forward to. With three cleaning modes and dirt-detecting sensors, it kept all the floor surfaces in our testing immaculate, and its camera-driven navigation and mapping were superb. Its easy-to-use app provides alerts and detailed cleaning reports. The ability to control it with Amazon Alexa and Google Home voice commands are just the cherry on top.

Source: https://www.techhive.com/article/3269782/best-robot-vacuum-cleaners.html

PEAS Description of a modern robot vacuum

Performance measure	Environment	Actuators	Sensors

What type of intelligent agent is a modern robot vacuum?



How would the utility be defined?

Does it have a goal state?

Does it use states. How would they be defined (atomic/factored)?

Does it use simple reflexes?

Conclusion

Intelligent agents inspire the research areas of modern AI

Search for a goal (e.g., navigation).

Optimize functions (e.g., utility).

Stay within given **constraints**

(constraint satisfaction problem; e.g., reach the goal without running out of power)

Deal with **uncertainty** (e.g., current traffic on the road).

Learn a good agent program from data and improve over time (machine learning).

Sensing
(e.g, natural language processing, vision)