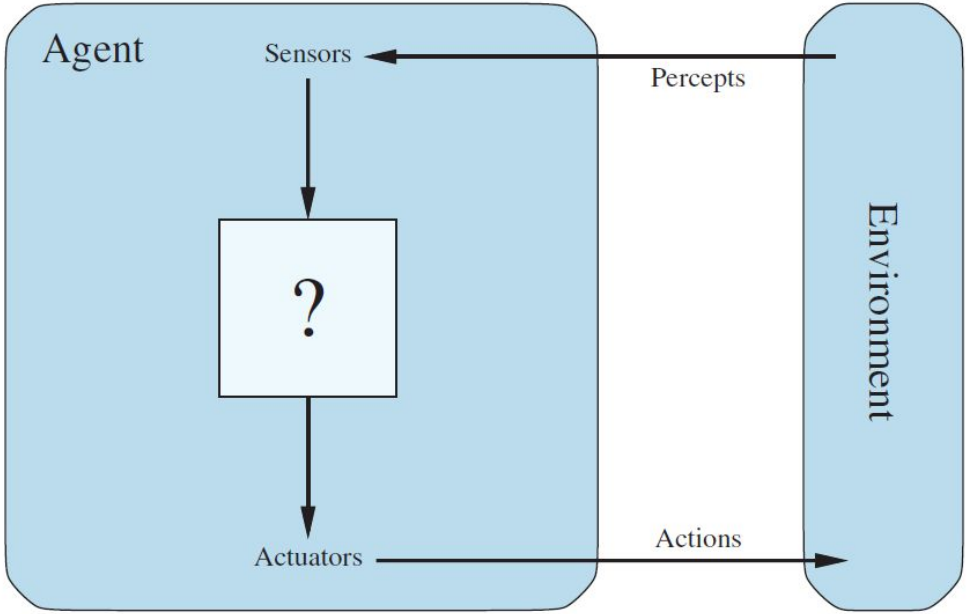
CS 471: Introduction to AI

Module 2: Intelligent Agents

Agents and Environments

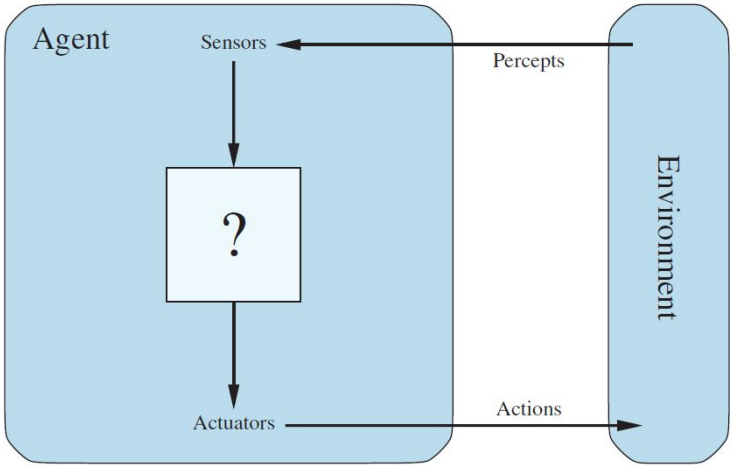
An agent perceives the environment through sensors and acts upon the environment through actuators.



Agents interact with environment through sensors and actuators.

Sensors and Actuators

Agent	Sensors	Actuators
Human agent	eyes, ears, and other organs	hands, legs, vocal tract, and so on
Robotic agent	cameras and infrared range finders	various motors
Software agent	file contents and human input (keyboard/mouse)	writing files and displaying information or generating sounds

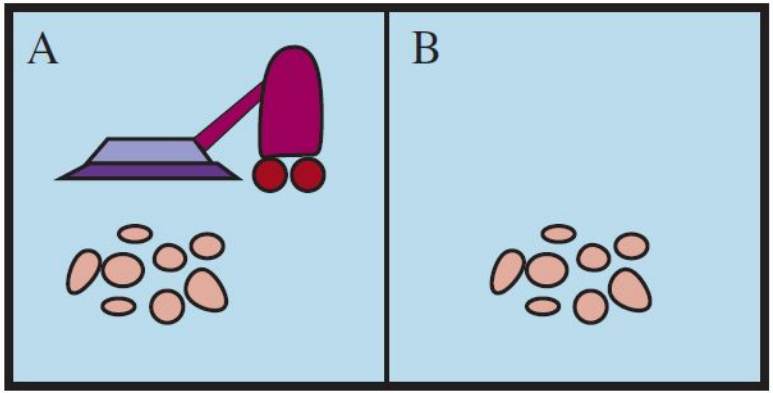


Environment

- Environment could be everything: the entire universe!
- In practice it is just that part of the universe that affects what the agent perceives and that is affected by the agent’s actions.

Example: Agents and Environments

Consider a robotic vacuum-cleaning agent in a world consisting of squares that can be either dirty or clean.



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
⋮	⋮
[A, Clean], [A, Clean], [A, Clean]	Right
[A, Clean], [A, Clean], [A, Dirty]	Suck
⋮	⋮

What is the right way to fill out the table?

What makes an agent good or bad, intelligent or stupid?

Performance Measures

A rational agent is one that does the right thing. What does it mean to do the right thing?

- It can be quite hard to formulate a performance measure correctly.
- For the vacuum-cleaner agent, performance measure can be the amount of dirt cleaned up in a single eight-hour shift.

  With a rational agent, what you ask for is what you get. A rational agent can maximize this performance measure by cleaning up the dirt, then dumping it all on the floor, then cleaning it up again, and so on.

- A more suitable performance measure would be for an agent to have a clean floor.
- In practice, choosing right objective is challenging and it is possible that we might put the wrong purpose into the machine

Rational Agent: Definition

Based on the agents prior knowledge, for each possible percept sequence, a rational agent should select an action that is expected to maximize its performance measure.

Specifying the Task Environment

- PEAS = Performance, Environment, Actuators, Sensors
- In designing an agent, the first step must always be to specify the task environment as fully as possible.

Specifying the Task Environment

Summary of the PEAS description for the taxi's task environment.

Agent Type	Performance Measure	Environment	Actuators	Sensors
Taxi driver	Safe, fast, legal, comfortable trip, maximize profits, minimize impact on other road users	Roads, other traffic, police, pedestrians, customers, weather	Steering, accelerator, brake, signal, horn, display, speech	Cameras, radar, speedometer, GPS, engine sensors, accelerometer, microphones, touchscreen

More restricted the environment, the easier the design problem.

Specifying the Task Environment

Agent Type	Performance Measure	Environment	Actuators	Sensors
Medical diagnosis system	Healthy patient, reduced costs	Patient, hospital, staff	Display of questions, tests, diagnoses, treatments	Touchscreen/voice entry of symptoms and findings
Satellite image analysis system	Correct categorization of objects, terrain	Orbiting satellite, downlink, weather	Display of scene categorization	High-resolution digital camera
Part-picking robot	Percentage of parts in correct bins	Conveyor belt with parts; bins	Jointed arm and hand	Camera, tactile and joint angle sensors
Refinery controller	Purity, yield, safety	Refinery, raw materials, operators	Valves, pumps, heaters, stirrers, displays	Temperature, pressure, flow, chemical sensors
Interactive English tutor	Student's score on test	Set of students, testing agency	Display of exercises, feedback, speech	Keyboard entry, voice

Examples of agent types and their PEAS descriptions

Properties of Task Environments

Fully observable vs. partially observable

- A task environment is fully observable if the sensors detect all aspects that are relevant to the choice of action.
- An environment might be partially observable because of noisy and inaccurate sensors or because parts of the state are simply missing from the sensor data

  Eg: A vacuum agent with only a local dirt sensor cannot tell whether there is dirt in other squares, and an automated taxi cannot see what other drivers are thinking.
- If the agent has no sensors at all then the environment is unobservable.

Properties of Task Environments

Single-agent vs. multiagent

- Agent solving a crossword puzzle by itself is a single-agent environment.
- Chess = trying to maximize its performance measure, which minimizes opponent's performance measure. Chess is a competitive multi-agent environment.

Properties of Task Environments

Deterministic vs. nondeterministic

- Next state is completely determined by the current state => deterministic;

  Agent's actions uniquely determine the outcome. Example, if we had a pawn while playing chess and we moved that piece from A2 to A3, that would always work. There is no uncertainty in the outcome of that move.

  otherwise, it is nondeterministic.

  Taxi driving is nondeterministic, because one can never predict the behavior of traffic exactly.

Properties of Task Environments

Episodic vs. sequential

- Episodic: Next action does not depend on the previous actions.

  Example: an agent that has to spot defective parts bases each decision on the current part, regardless of previous decisions;
- In sequential environments, current decision could affect all future decisions.
  - Chess is sequential: short-term actions can have long-term consequences.

Properties of Task Environments

Static vs. dynamic

- If the environment can change, then we say the environment is dynamic.
  - Taxi driving is dynamic: the other cars and the taxi itself keep moving while the driving algorithm decides about what to do next.
- Static environments are easy to deal with because the agent need not worry about the passage of time.
  - Crossword puzzles are static.

Properties of Task Environments

Discrete vs. continuous

- Discrete/continuous distinction applies to the percepts and actions of the agent.
- Example: Chess has a discrete set of percepts and actions.
- Taxi driving is a continuous: the speed and location of the taxi and of the other vehicles sweep through a range of continuous values.

Properties of Task Environments

Known vs. unknown

- Known environment => outcomes for all actions are given
- Unknown environment => the agent will have to learn how it works in order to make good decisions.

The hardest case is partially observable, multiagent, nondeterministic, sequential, dynamic, continuous, and unknown.

The Structure of Agents

The job of AI is to design an agent program that implements the agent function: the mapping from percepts to actions.

agent = architecture + program

Agent Programs

- To build a rational agent, designers must construct a table that contains the appropriate action for every possible percept sequence.
- Huge lookup tables: chess has at least 10^{150} entries. In comparison, the number of atoms in the observable universe is less than 10^{80}.
- The size of these tables means that
  - No physical agent in this universe will have space to store the table
  - The designer would not have time to create the table
  - No agent could ever learn all the right table entries from its experience

Agent Programs

The key challenge for AI is to find out how to write programs that produce rational behavior from a program rather than from a vast table.

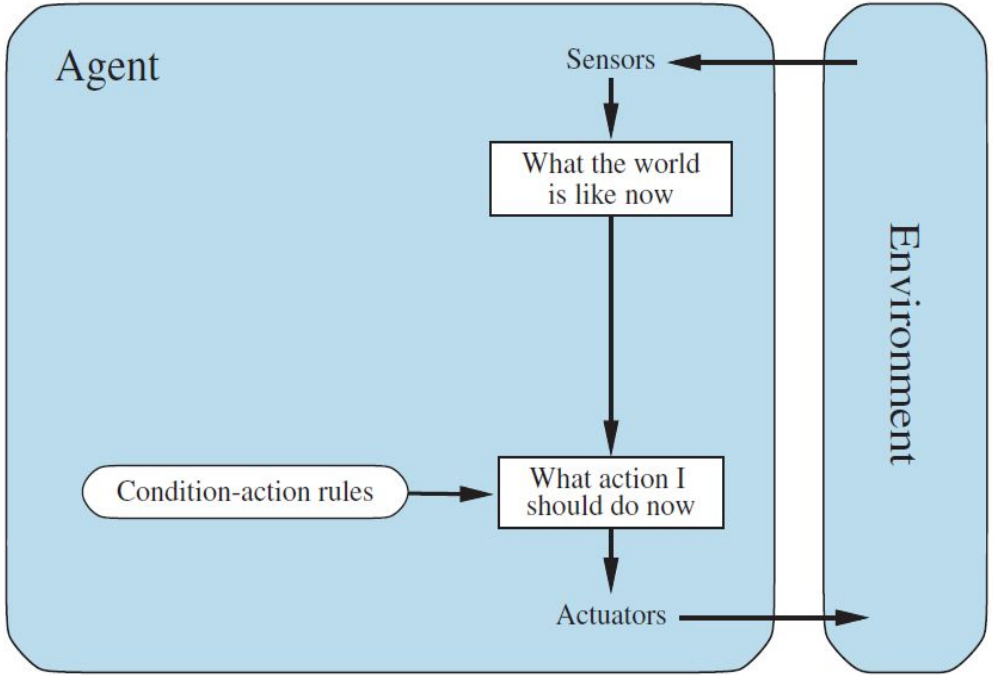
Four basic kinds of agent programs:

- Simple reflex agents
- Model-based reflex agents
- Goal-based agents; and
- Utility-based agents

Simple Reflex Agents

Simplest kind of agent: select actions on the basis of the current percept, ignoring the rest of the percept history.

Eg: the vacuum agent is a simple reflex agent, because its decision is based only on the current location and on whether that location contains dirt.



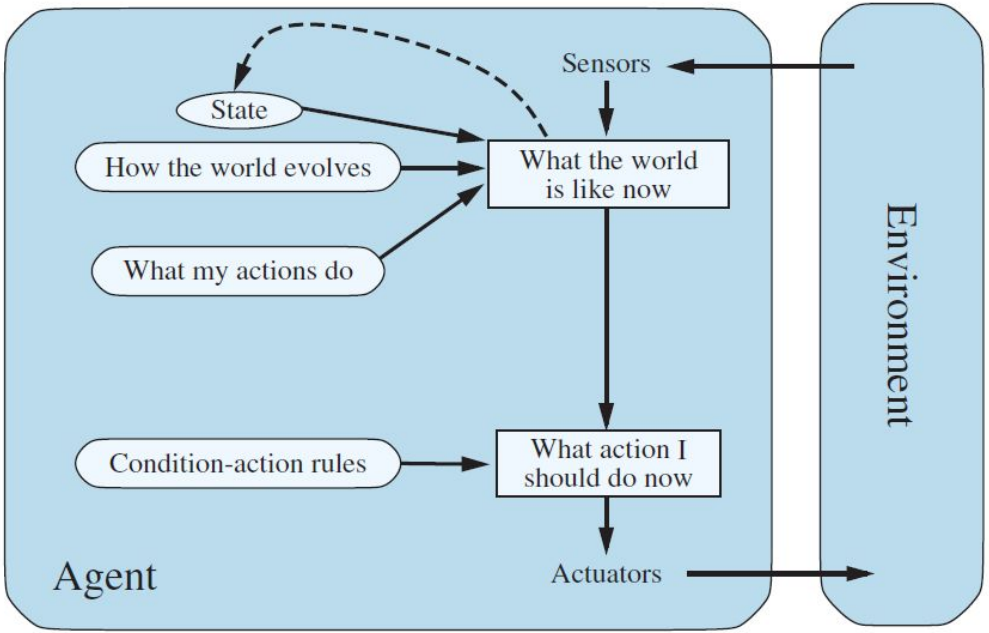
Condition-action rules allow the agent to make the connection from percept to action.

Model-based Reflex Agents

Keeps track of the part of the world it can't see.

Agent maintains some sort of internal state that depends on the percept history

Eg: when the agent turns the steering wheel clockwise, the car turns to the right, and when it's raining the car's cameras can get wet.

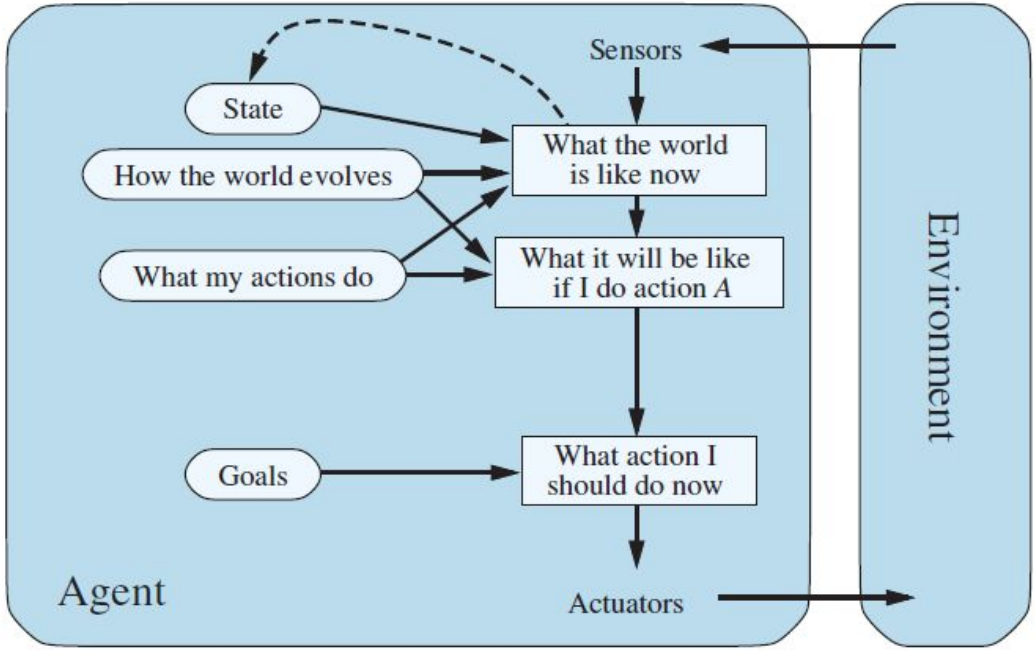


A model-based reflex agent showing how the current percept is combined with the old internal state to generate the updated description of the current state.

Goal-based Agents

- Knowing something about the current state of the environment is not always enough to decide what to do.

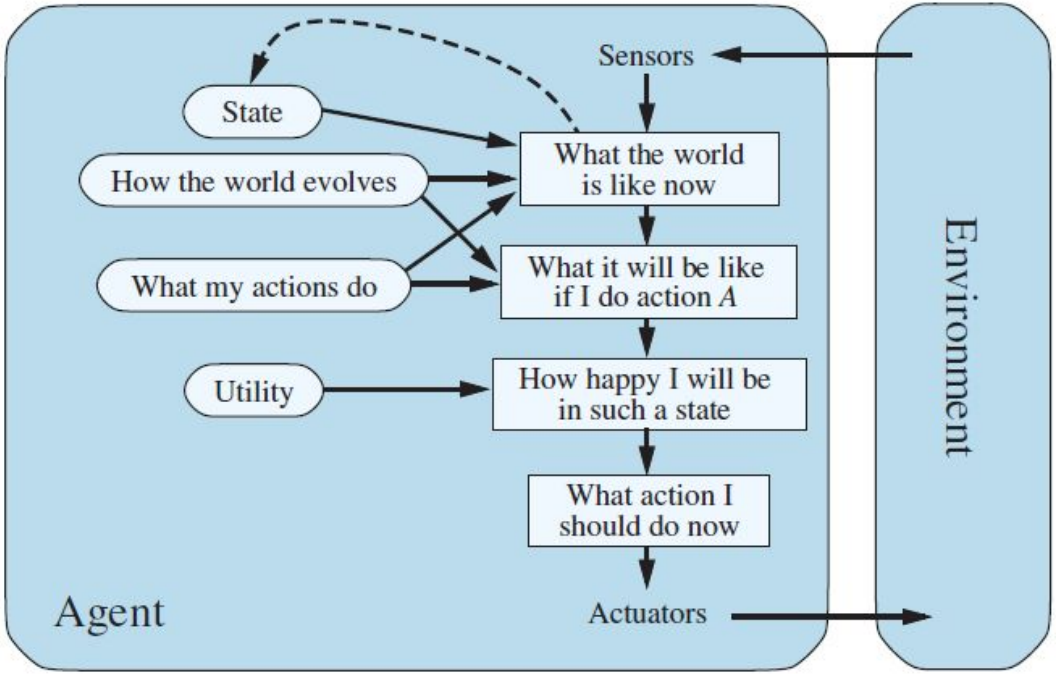
  Eg: at a road junction, the taxi can turn left, turn right, or go straight on. The correct decision depends on where the taxi is trying to get to.
- Agent needs goal information that describes situations that are desirable;



keeps track of the world as well as a set of goals it is trying to achieve, and chooses an action that will (eventually) lead to the achievement of its goals.

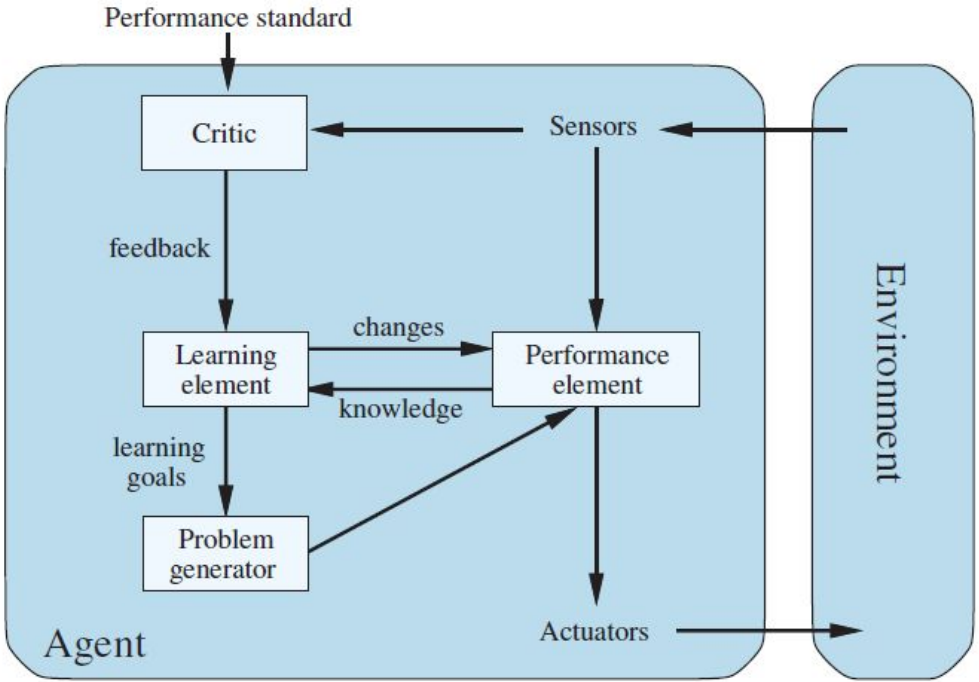
Utility-based Agents

Goals alone are not enough to generate high-quality behavior in most environments. Ex: many action sequences will get the taxi to its destination (thereby achieving the goal), but some are quicker, safer, more reliable, or cheaper than others => maximize its utility based on the performance measure.



Learning Agents

Allows the agent to operate in initially unknown environments and to become more competent than its initial knowledge.



Four components:

- Learning element: Responsible for making improvements
- Performance element: It takes in percepts and decides on actions.
- Critic: Provides feedback to the learning element on how the agent is doing and determines how the performance element should be modified to do better in the future.
- Problem generator: Responsible for suggesting actions that will lead to new and informative experiences.

Summary

- An agent is something that perceives and acts in an environment.
- Task environment = performance measure + external environment + actuators + sensors.
- Task environments can be:

  fully or partially observable, single-agent or multi-agent,

  deterministic or nondeterministic, episodic or sequential,

  static or dynamic, discrete or continuous, and known or unknown.
- **Simple reflex agents** respond directly to percepts

  Model-based reflex agents maintain internal state to track aspects of the world that are not evident in the current percept.

  Goal-based agents act to achieve their goals, and

  Utility-based agents try to maximize their own expected “happiness.”

All agents can improve their performance through learning.

THANK YOU!