Intelligent Agents

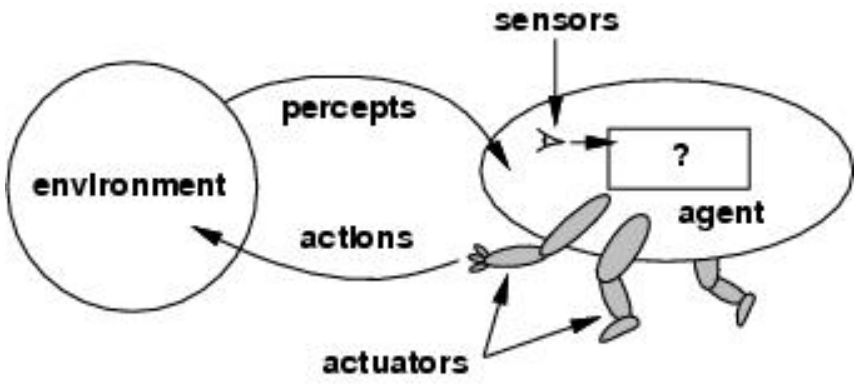
From Chapter 2,

Artificial Intelligence. A Modern Approach by S. Russell and P. Norvig

Outline

- Agents and environments.
  - **The vacuum-cleaner world**
- The concept of rational behavior.
- Environments.
- Agent structure.

Agents and environments

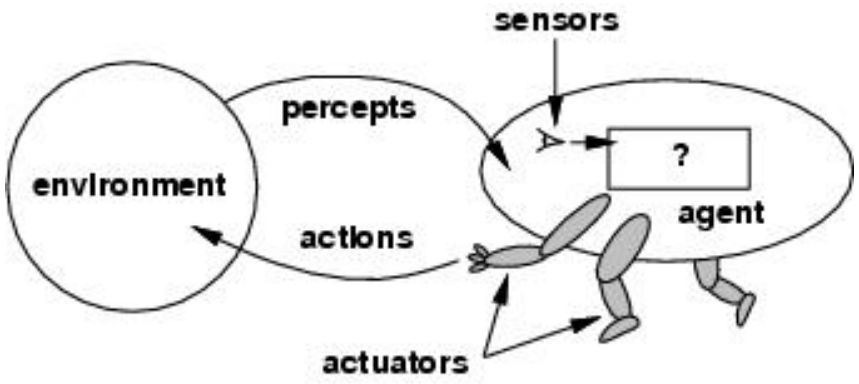


- Agents include human, robots, softbots, thermostats, etc.
- The *agent function* maps percept sequence to actions

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

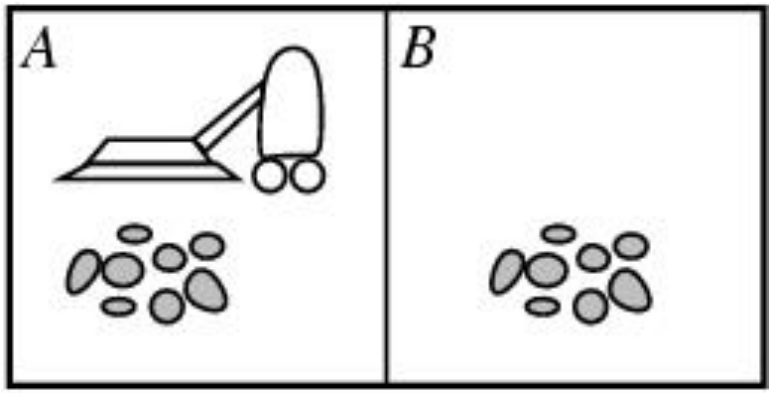
- An agent can perceive its own actions, but not always it effects.

Agents and environments



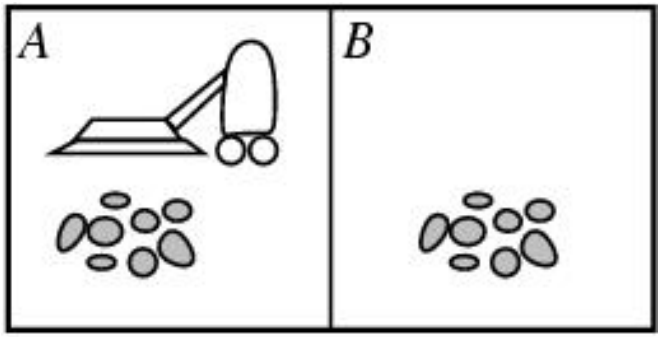
- The *agent function* will internally be represented by the *agent program*.
- The agent program runs on the physical *architecture* to produce *f*.

The vacuum-cleaner world



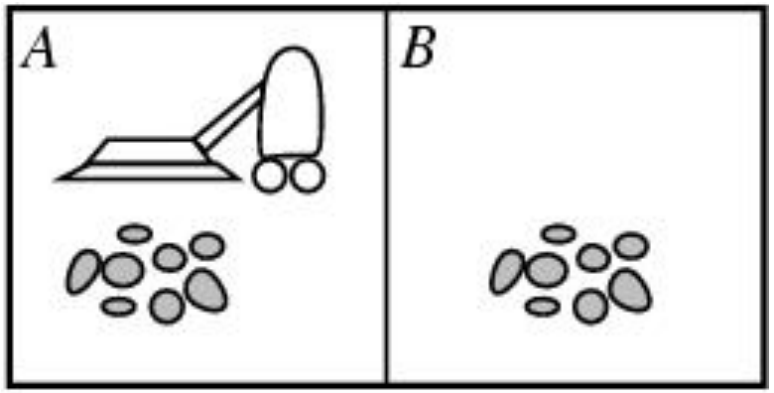
- Environment: square A and B
- Percepts: [location and content] e.g. *[A, Dirty]*
- Actions: left, right, suck, and no-op

The vacuum-cleaner world



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
…	…

The vacuum-cleaner world



function REFLEX-VACUUM-AGENT ([*location, status*]) return an action

if *status* == *Dirty* then return *Suck*

else if *location* == *A* then return *Right*

else if *location* == *B* then return *Left*

What is the right function? Can it be implemented in a small agent program?

The concept of rationality

- A **rational agent** is one that does the right thing.
  - **Every entry in the table is filled out correctly.**
- What is the right thing?
  - **Approximation: the most *succesfull* agent.**
  - ***Measure of success?***
- Performance measure should be objective
  - **E.g. the amount of dirt cleaned within a certain time.**
  - **E.g. how clean the floor is.**
  - **...**
- *Performance measure according to what is wanted in the environment instead of how the agents should behave.*

Rationality

- What is rational at a given time depends on four things:
  - **Performance measure,**
  - **Prior environment knowledge,**
  - **Actions,**
  - **Percept sequence to date (sensors).**
- DEF: *A rational agent chooses whichever action maximizes the expected value of the performance measure given the percept sequence to date and prior environment knowledge.*

Rationality

- Rationality ≠ omniscience
  - **An omniscient agent knows the actual outcome of its actions. Percepts may not supply all relevant information**
- Rationality ≠ clairvoyant
  - **action outcomes may not be as expected.**
- Rationality ≠ successful
  - **Rationality maximizes *expected* performance, while perfection maximizes *actual* performance.**

Rationality

- The proposed definition requires:
  - **Information gathering/exploration**
    - To maximize future rewards
  - **Learn from percepts**
    - Extending prior knowledge
  - **Agent autonomy**
    - Compensate for incorrect prior knowledge

Environments

- To design a rational agent we must specify its task environment.
- PEAS description of the environment:
  - **Performance**
  - **Environment**
  - **Actuators**
  - **Sensors**

Environments

- E.g. Fully automated taxi:
  - PEAS description of the environment:
    - **Performance**
      - Safety, destination, profits, legality, comfort
    - **Environment**
      - Streets/freeways, other traffic, pedestrians, weather,, …
    - **Actuators**
      - Steering, accelerating, brake, horn, speaker/display,…
    - **Sensors**
      - Video, sonar, speedometer, engine sensors, keyboard, GPS, …

Environment types

	Solitaire	Backgammom	Intenet shopping	Taxi
Observable??				
Deterministic??				
Episodic??				
Static??				
Discrete??				
Single-agent??				

Environment types

Fully vs. partially observable: an environment is full observable when the sensors can detect all aspects that are *relevant* to the choice of action.

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Environment types

Deterministic vs. stochastic: if the next environment state is completely determined by the current state the executed action then the environment is deterministic.

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Environment types

Episodic vs. sequential: In an episodic environment the agent's experience can be divided into atomic steps where the agents perceives and then performs A single action. The choice of action depends only on the episode itself

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Static vs. dynamic: If the environment can change while the agent is choosing an action, the environment is dynamic. Semi-dynamic if the agent's performance changes even when the environment remains the same.

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Discrete??				
Single-agent??				

Environment types

Discrete vs. continuous: This distinction can be applied to the state of the environment, the way time is handled and to the percepts/actions of the agent.

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Single-agent??				

Environment types

Single vs. multi-agent: Does the environment contain other agents who are also maximizing some performance measure that depends on the current agent's actions?

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Single-agent??	YES	NO	NO	NO

Environment types

- The simplest environment is
  - **Fully observable, deterministic, episodic, static, discrete and single-agent.**
- Most real situations are:
  - **Partially observable, stochastic, sequential, dynamic, continuous and multi-agent.**

Agent types

- How does the inside of the agent work?
  - **Agent = architecture + program**
- All agents have the same skeleton:
  - **Input = current percepts**
  - **Output = action**
  - **Program= manipulates input to produce output**
- Note difference with agent function:

  which takes the entire percept history

Agent types

Function TABLE-DRIVEN_AGENT(*percept*) **returns** an action

static: *percepts*, a sequence initially empty
table, a table of actions, indexed by percept sequence

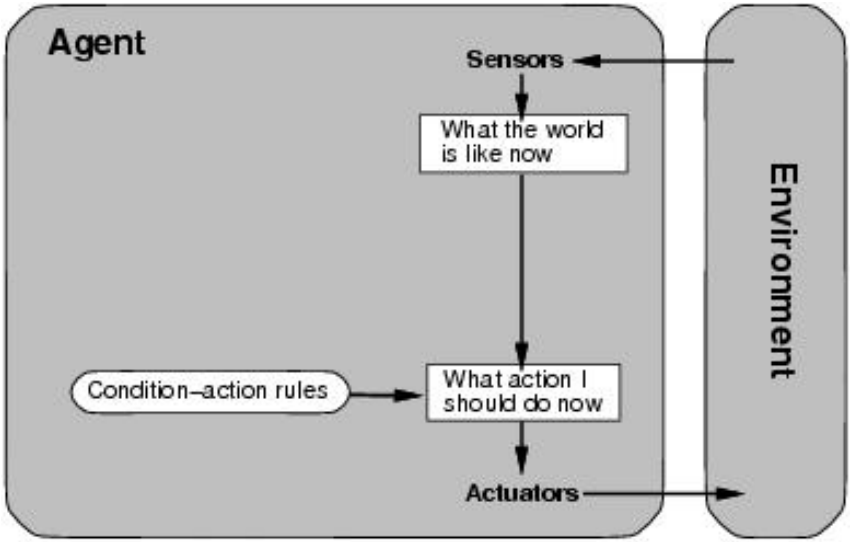
append *percept* to the end of *percepts*
action ← LOOKUP(*percepts*, *table*)
return *action*

This approach usually is considered too simple in classical AI

Agent types

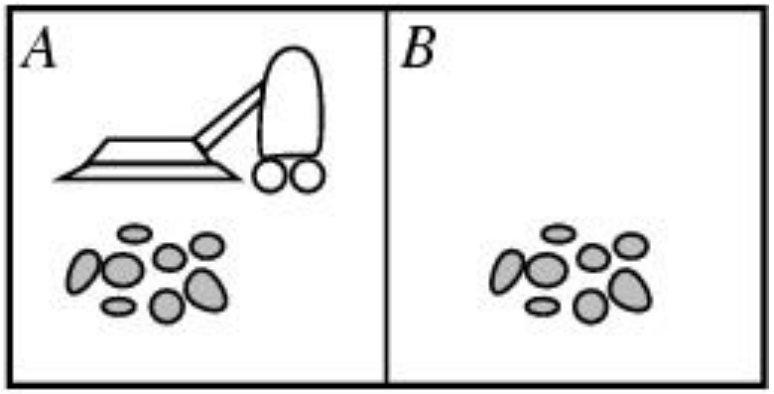
- Four basic kinds of agent programs will be discussed:
  - **Simple reflex agents**
  - **Model-based reflex agents**
  - **Goal-based agents**
  - **Utility-based agents**
- All these can be turned into learning agents.

Agent types; simple reflex



- Select action on the basis of *only the current* percept.
  - **E.g. the vacuum-agent**
- Large reduction in possible percept/action situations(next page).
- Implemented through *condition-action rules*
  - **If dirty then suck**

The vacuum-cleaner world



function REFLEX-VACUUM-AGENT ([*location, status*]) return an action

if *status* == *Dirty* then return *Suck*

else if *location* == *A* then return *Right*

else if *location* == *B* then return *Left*

Reduction from 4^T to 4 entries (ignores the percept history)

Agent types; simple reflex

function SIMPLE-REFLEX-AGENT(*percept*) **returns** an action

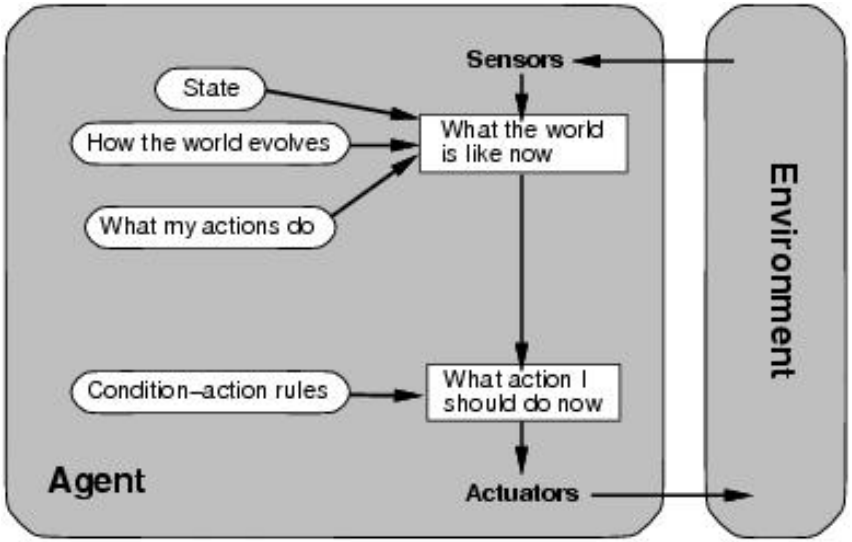
static: *rules*, a set of condition-action rules

state ← INTERPRET-INPUT(*percept*)
rule ← RULE-MATCH(*state*, *rules*)
action ← RULE-ACTION[*rule*]

return *action*

Will only work if the environment is *fully observable* otherwise infinite loops may occur.

Agent types; reflex and state



- To tackle *partially observable* environments.
  - **Maintain internal state**
- Over time update state using world knowledge
  - **How does the world change.**
  - **How do actions affect world.**

  ⇒ ***Model of World***

The world is its best own model (Rodney Brooks, "Elephants Don't Play Chess, 1990)

Agent types; reflex and state

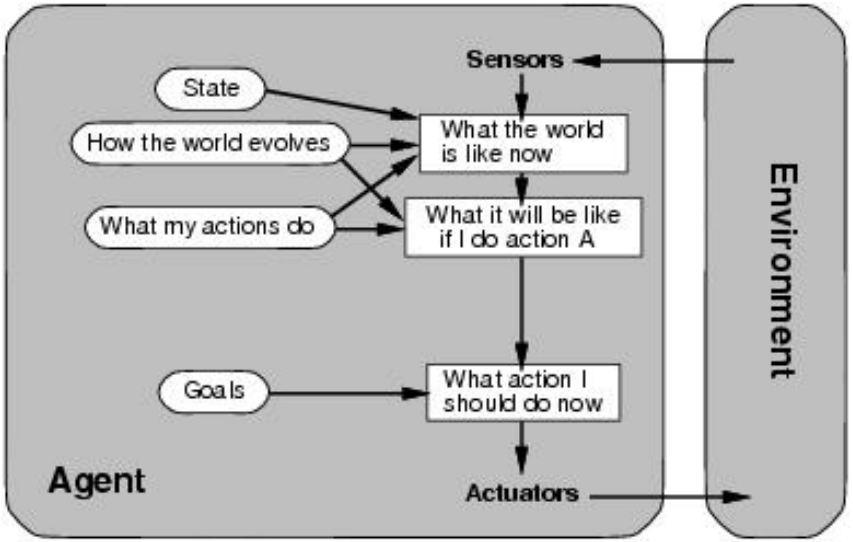
function REFLEX-AGENT-WITH-STATE(*percept*) **returns** an action

static: *rules*, a set of condition-action rules
state, a description of the current world state
action, the most recent action.

state ← UPDATE-STATE(*state*, *action*, *percept*)
rule ← RULE-MATCH(*state*, *rule*)
action ← RULE-ACTION[*rule*]

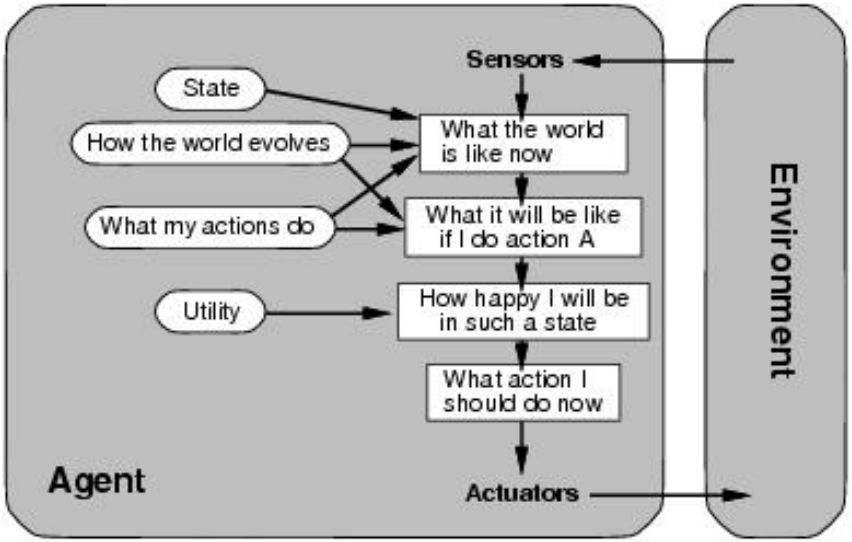
return *action*

Agent types; goal-based



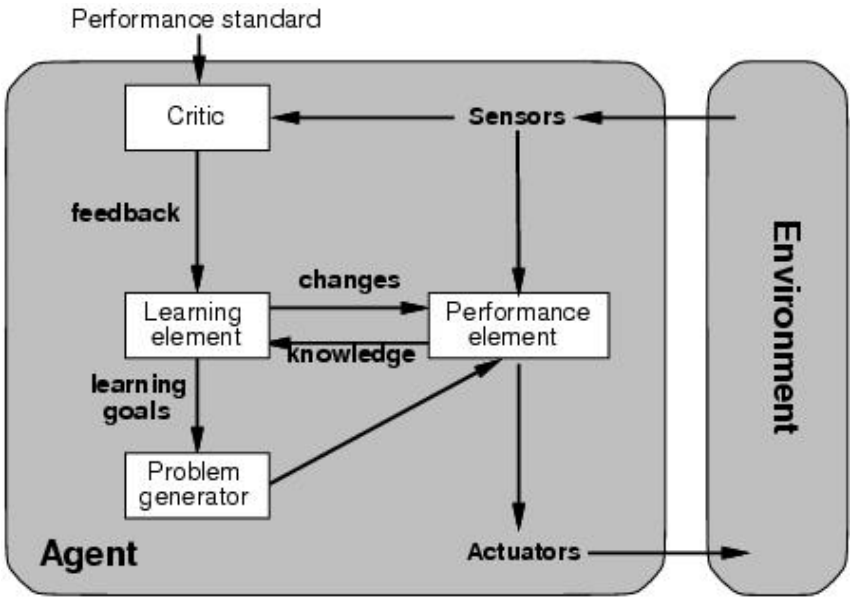
- The agent needs a goal to know which situations are *desirable*.
  - **Things become difficult when long sequences of actions are required to find the goal.**
- Typically investigated in **search** and **planning** research.
- Major difference: future is taken into account
- It's more flexible since knowledge is represented explicitly and can be manipulated.

Agent types; utility-based



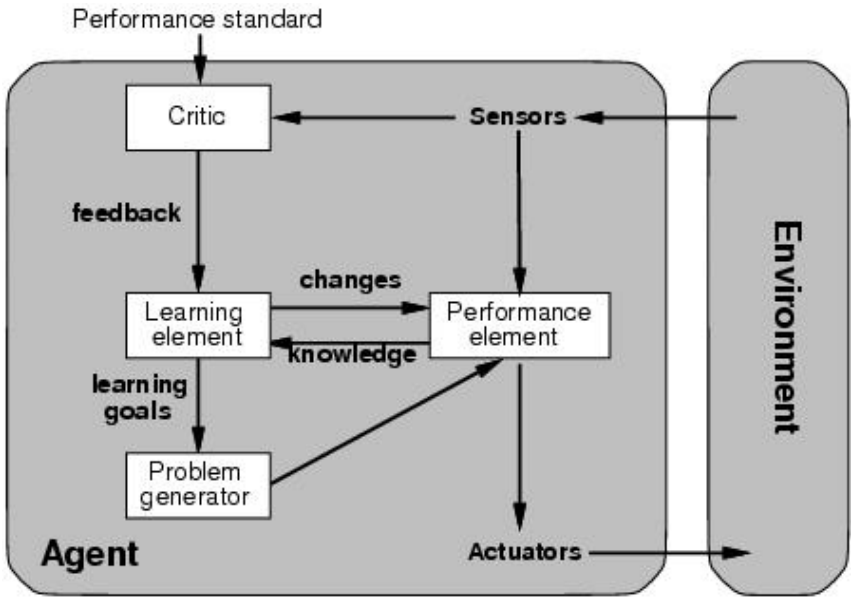
- Certain goals can be reached in different ways.
  - **Some are better, have a higher utility.**
- Utility function maps a (sequence of) state(s) onto a real number.
- Improves on goals:
  - **Selecting between conflicting goals (speed/safe)**
  - **Select appropriately between several goals based on likelihood of success.**

Agent types; learning



- All previous agent-programs describe methods for selecting *actions*.
  - **Yet it does not explain the origin of these programs.**
  - **Learning mechanisms can be used to perform this task.**
  - **Teach them instead of instructing them.**
  - **Advantage is the robustness of the program toward initially unknown environments.**

Agent types; learning



- *Learning element*: introduce improvements in performance element.
  - **Critic provides feedback on agents performance based on fixed performance standard.**
- *Performance element*: selecting actions based on percepts.
  - **Corresponds to the previous agent programs**
- *Problem generator*: suggests actions that will lead to new and informative experiences.
  - **Exploration vs. exploitation**