

Artificial Intelligence and Decision Systems

Inteligência Artificial e Sistemas de Decisão – MEEC, MEAer,

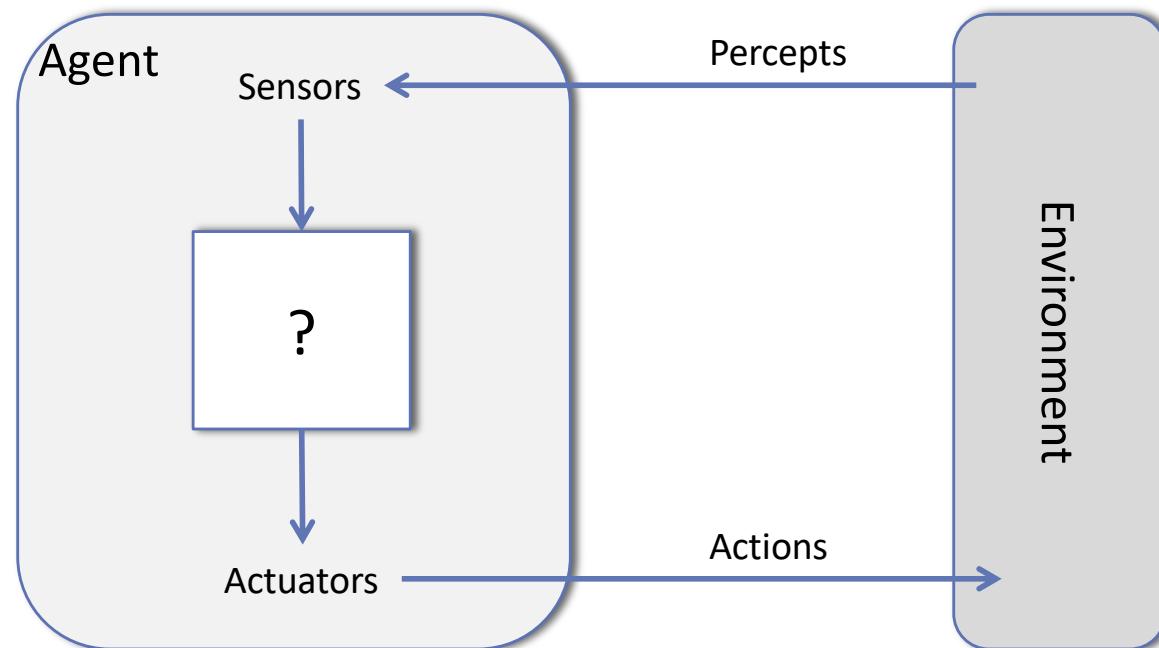
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Intelligent Agents

Agent is anything that can be viewed as perceiving its **environment** through **sensors** and acting upon that environment through **actuators**



What is an intelligent agent?

(2)

it can be, for instance, a rational agent

Rational Agents

A Rational Agent is one that does the right thing

but what does it mean to do the right thing?

for instance, do what provides higher success to the agent

but how to assess the success of the agent?

a performance measure is needed

who defines the performance measure?

- The agent itself (subjective measure)
 - greater agent's satisfaction
 - difficult to explain
 - non comparable
- Outside the agent (objective measure)
 - difficult to define sufficiently broad measures
 - timing is crucial

how to choose the action that allows for a greater success?

For each action, use the performance measure to

- determine the success (if the agent is omniscient), or
- estimate the success

Rationality depends on:

- Performance measure (criterion of success)
- Agent's prior knowledge of the environment
- Actions that the agent can perform
- Agent's percept sequence

Rational Agent definition:

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

Does this definition prevents irrational behavior?

From an external point of view, no.

Only if the agent is omniscient, fully autonomous and its performance measure is perfect

Examples:

- Crossing a street
- Bus driver

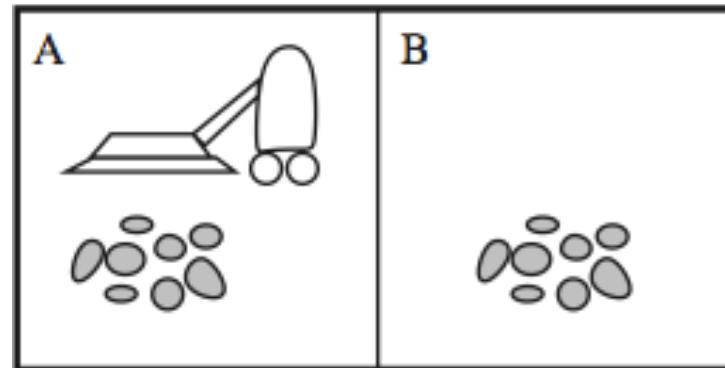
Autonomy – agent's degree of autonomy depends on the level of external intervention

If the agent depends only on *a priori* knowledge, it lacks autonomy

It should be able to learn what it can do to compensate for partial or incorrect *a priori* knowledge

Rational Agents - examples

Robotic vacuum cleaner



Percepts: $\langle r, d \rangle$

where $r \in \{A, B\}$ location of the robot

$d \in \{\text{true}, \text{false}\}$ if the agent's sensors detect dirt

Actions: {GoLeft, GoRight, SuckDirt, NoOp}

(6)

How to choose a performance measure for this vacuum cleaner agent?

Rational Agents - examples

	perceptions	actions	goal	environment
Medical diagnosis	symptoms test results	tests treatments	cure	hospital
Robotic arm	vision	Grasp or ungrasp objects	Task fulfill	industry
Internet softbot	User preferences	Search pages	Satisfy user	WWW
driver	cameras, GPS, sonars, IR	steering velocity	Reach destination, time, comfort	traffic

PEAS description of a task environment:

- **Performance**
- **Environment**
- **Actuators**
- **Sensors**

Properties:

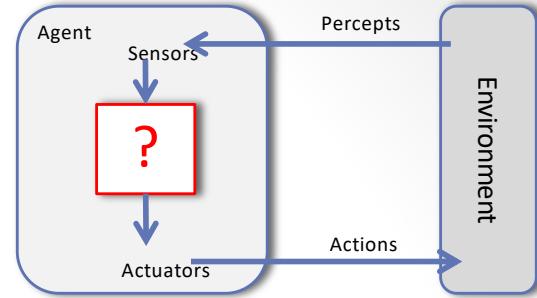
- Fully observable vs. partially observable
(partially observable because of noise, inaccurate or faulty sensors, or hidden parts)
- Single agent vs. multiagent (cooperative vs. competitive)
(in multiagent environments, communication may be a key issue)
- Deterministic vs. stochastic
(an environment is uncertain if it is not fully observable or not deterministic)
(nondeterministic environment is when actions have different possible outcomes but no probabilities associated)
- Episodic vs. sequential
- Static vs. dynamic
(if the environment doesn't change with the time but agent's performance does, it is **semidynamic**)
- Discrete vs. continuous (applies to states, time, percepts, and actions)
- Know vs. unknown
(depends on the agent's knowledge about how the world evolves – the “laws of physics” of the environment)

Environments

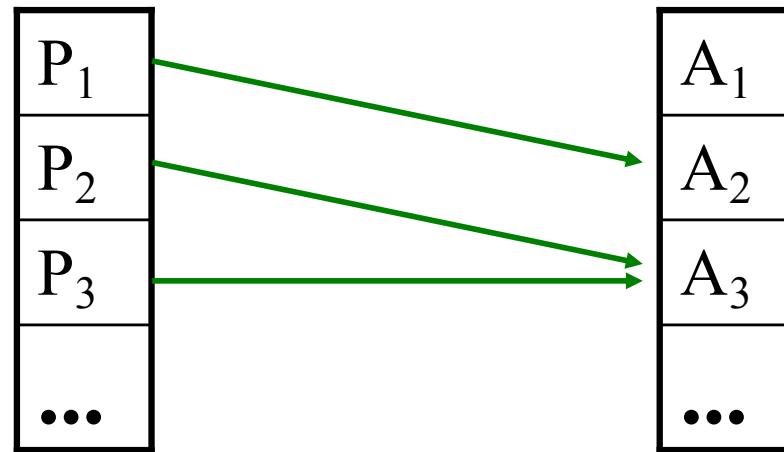
Examples:

	observable	deterministic	episodic	static	discrete
Chess	Y	Y	N	Y	Y
Poker	N	N	N	Y	Y
Taxi	N	N	N	N	N
Image analysis	Y	Y	Y	Semi	N

Structure of agents I



A perception sequence-action table



where P_i is a sequence of percepts and A_i is an action

Disadvantages

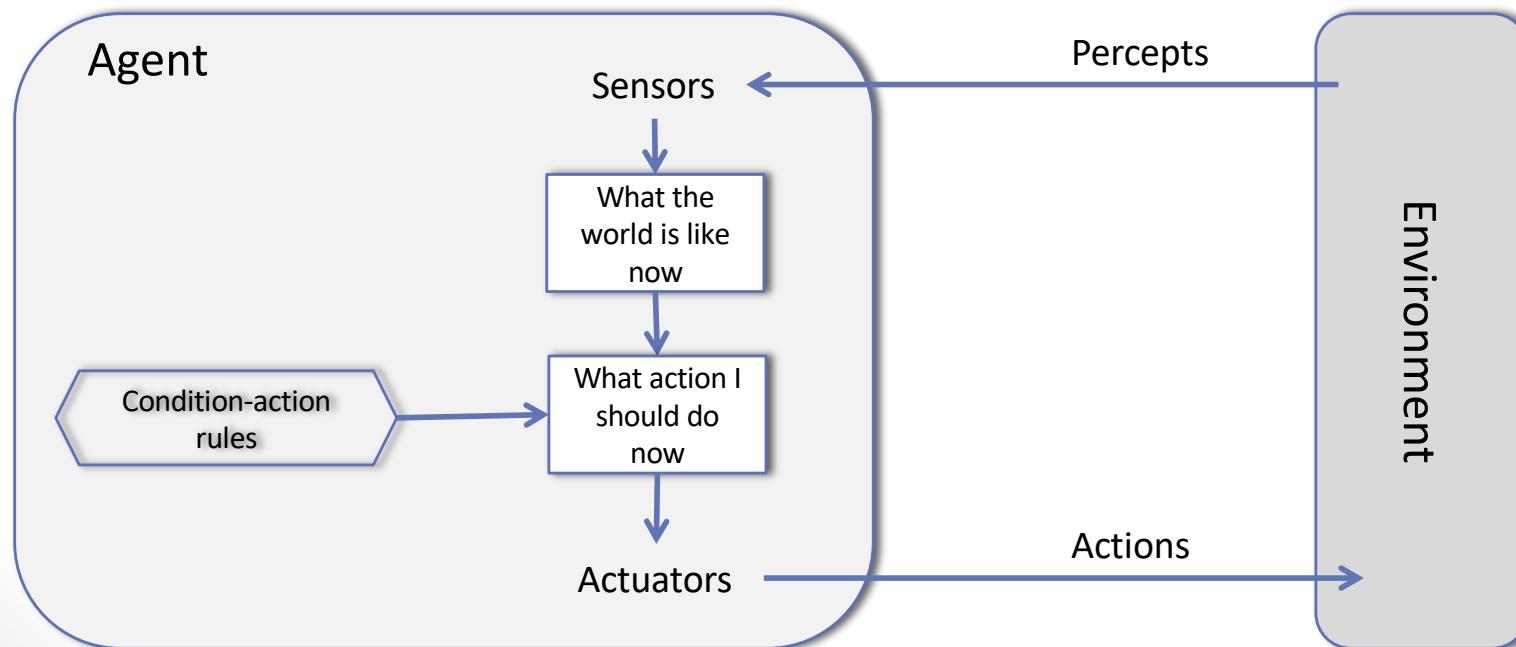
- table size (for instance, for chess it would be 10^{150})
- agent lacks autonomy

Simple reflex agent (reactive agent)

based on condition-action rules

Example:

```
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
```



Simple reflex agent (reactive agent)

based on condition-action rules

```
function SIMPLE-REFLEX-AGENT(percept) returns an action
  persistent: rules, a set of condition-action rules

  state  $\leftarrow$  INTERPRET-INPUT(percept)
  rule  $\leftarrow$  RULE-MATCH(state, rules)
  action  $\leftarrow$  rule.ACTION
  return action
```

Limitation

works only if the correct decision can be made on the basis of only the current percept

Example

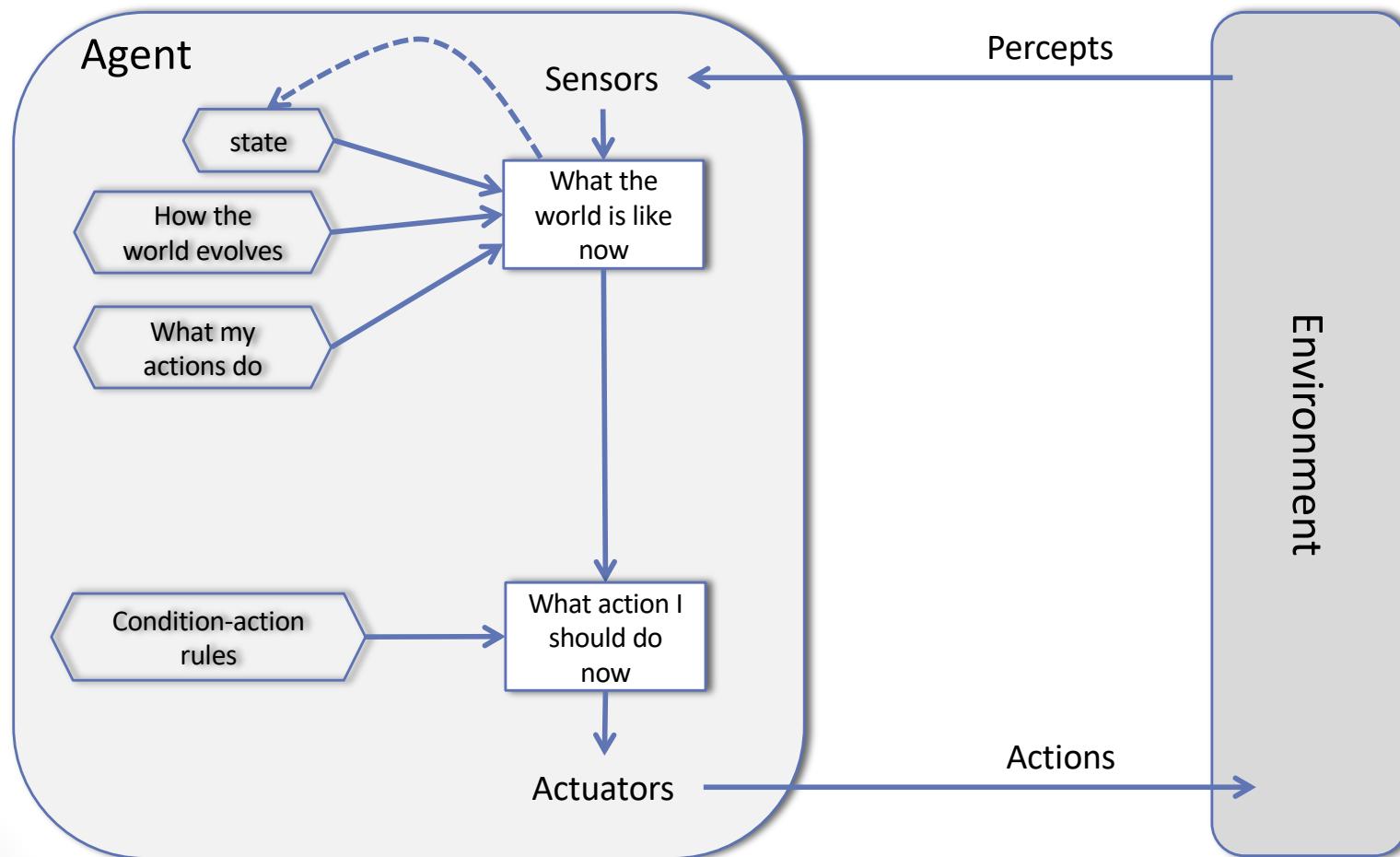
if car-in-front-is-braking then initiate-braking

what if the car in front doesn't have a brake light?

Structure of agents III

Model-based reflex agent (informed agent)

keeps track of environment evolution (internal state of the world)



Model-based reflex agent (informed agent)

keeps track of environment evolution (internal state of the world)

```
function MODEL-BASED-REFLEX-AGENT(percept) returns an action
    persistent: state, the agent's current conception of the world state
                model, a description of how the next state depends on current state and action
                rules, a set of condition-action rules
                action, the most recent action, initially none

    state  $\leftarrow$  UPDATE-STATE(state, action, percept, model)
    rule  $\leftarrow$  RULE-MATCH(state, rules)
    action  $\leftarrow$  rule.ACTION
    return action
```

Limitation

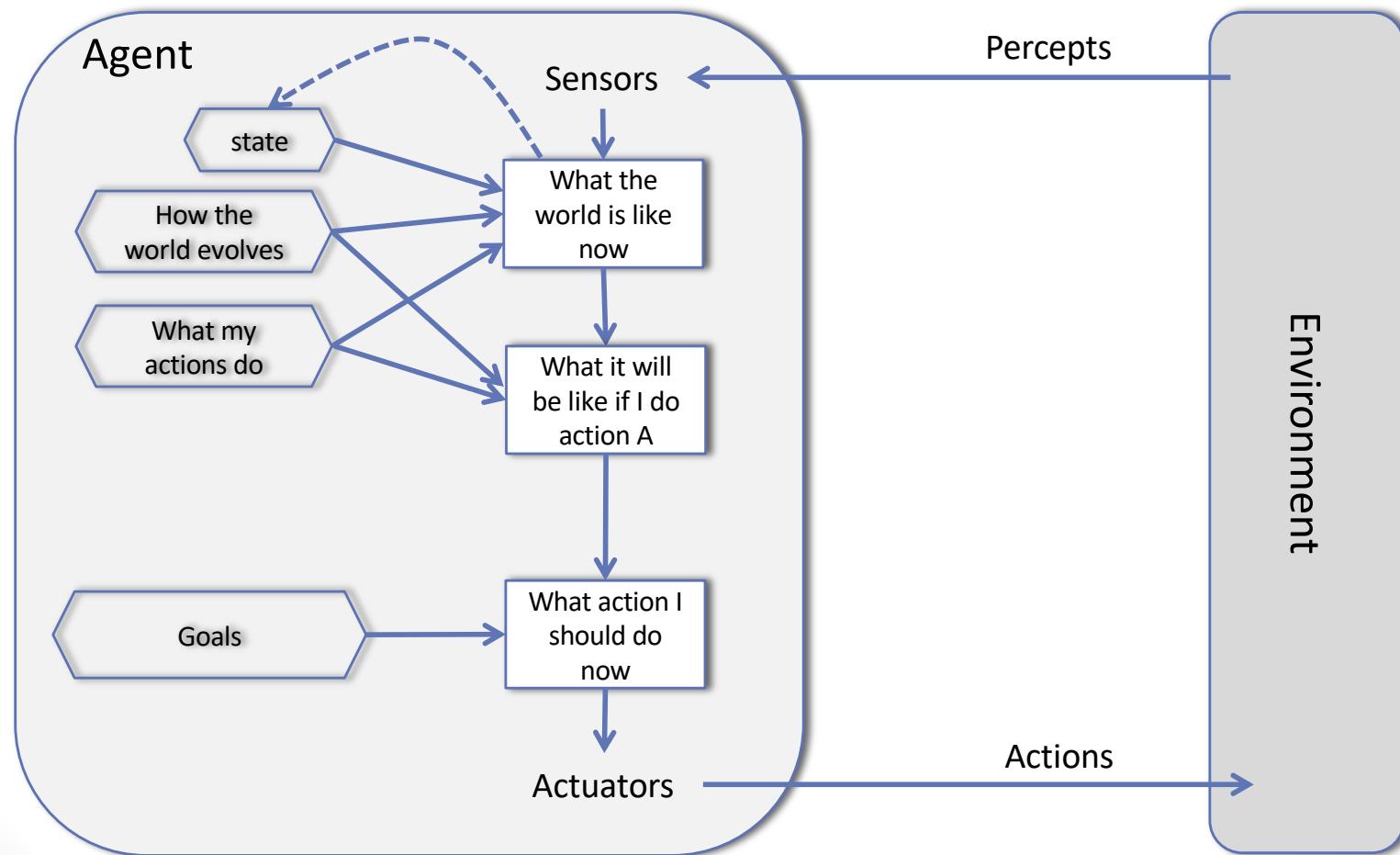
even knowing how world evolves is not always enough to decide what to do

Examples

- Crossroad (left, right or in front?)
- Car overtaking (yes or no?)

Goal-based agent

it has a goal



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it has a goal

Limitation

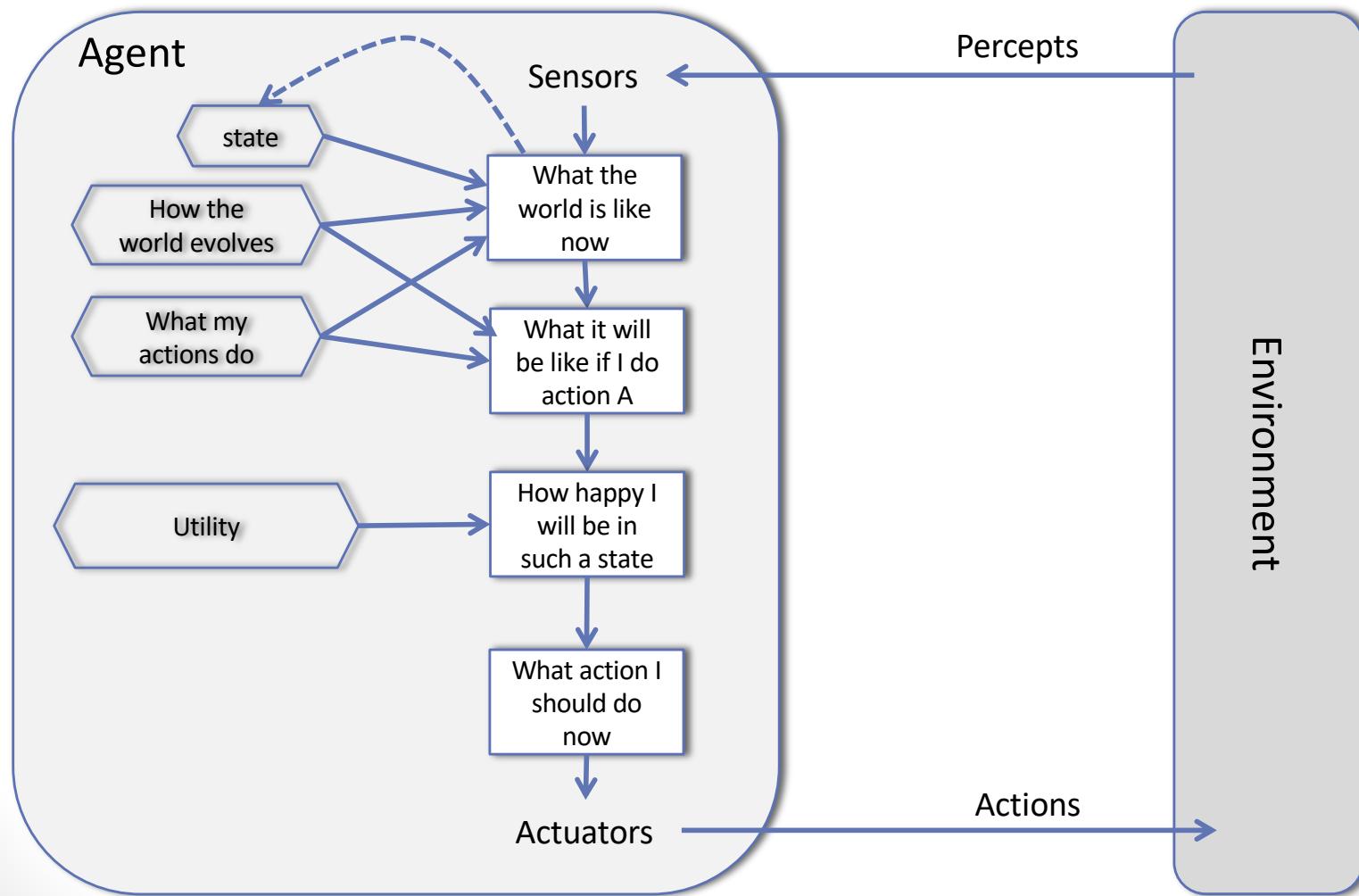
A goal-based agent may achieve the desired objective but not necessarily in the most efficient way

Example

Crossroad ("All roads lead to Rome")

Utility-based agent

it has a utility function to evaluate states

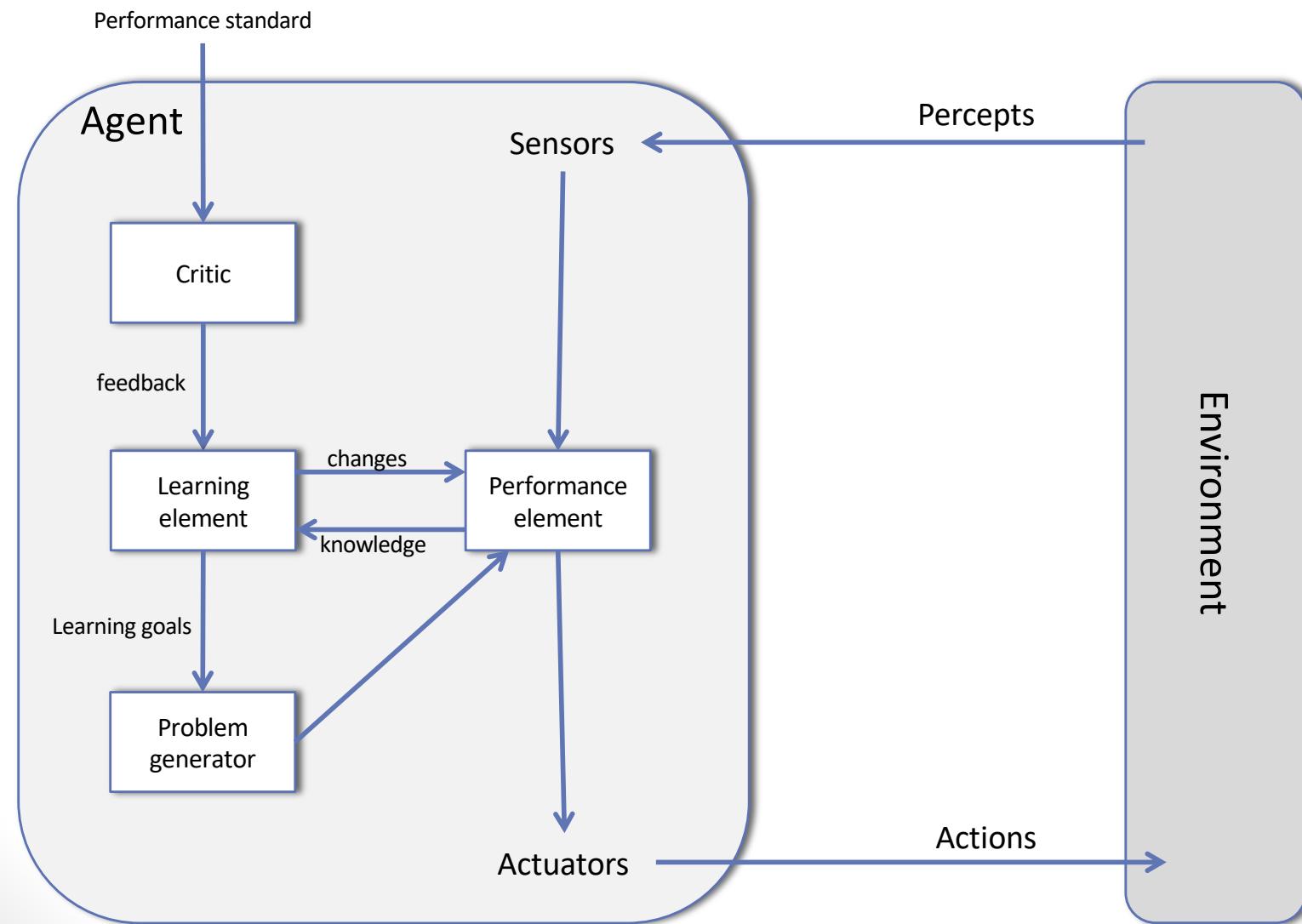


Utility-based agent

it has a utility function to evaluate states

- Utility: internalization of the performance measure
- Expected utility to cope with stochastic environments

Learning agent



Learning agent

- Performance element can be any of the previous structures
- Learning element is responsible for making improvements
- Critic establishes how well the agent is doing with respect to a fixed performance measure
- Problem generator is responsible for suggesting actions that will lead to new experiences (perhaps better)

Exploration vs. exploitation