EDA132: Applied Artificial Intelligence
Agents (Chapter 2)

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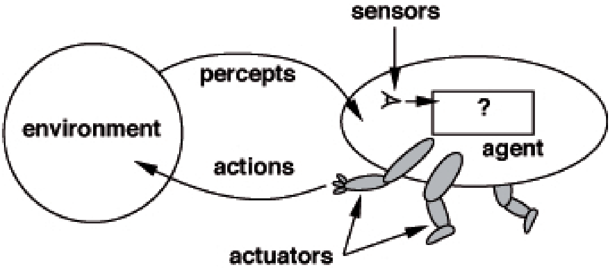
Plan for today

- What is an agent?
- PEAS (Performance measure, Environment, Actuators, Sensors)
- Agent architectures.
- Environments
- Multi-agent systems.

Agent



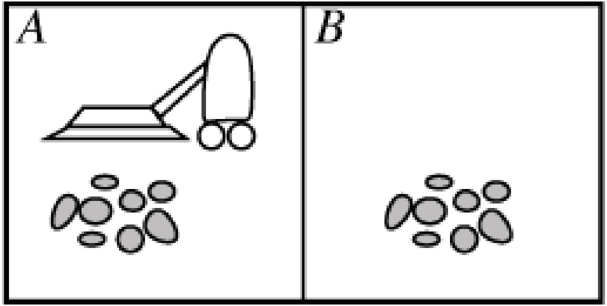
Agents include humans, robots, web-crawlers, thermostats, etc.

The *agent function* maps from percept histories to actions:

$$f : \mathcal{P}^* \rightarrow \mathcal{A}$$

The *agent program* runs on a physical *architecture* to produce f.

The vacuum-cleaning world



Percepts: location and contents, e.g. $< A, Dirty >$

Actions: *Left, Right, Suck, NoOp*

A vacuum-cleaning agent

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
$\dots$	$\dots$

A vacuum-cleaning agent

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...	...

```
function Reflex_Vacuum_Agent (location, status)
  if status == Dirty  then return Suck
  if location == A    then return Right
  if location == B    then return Left
```

A vacuum-cleaning agent

Percept sequence	Action
$< A, Clean >$	Right
$< A, Dirty >$	Suck
$< B, Clean >$	Left
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...	...

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function Reflex_Vacuum_Agent (location, status)
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What is the *RIGHT* function?

Rationality

Fixed performance measure evaluates the environment sequence:

- one point per square cleaned up in time T?
- one point per clean square per time step, minus one per move?
- penalize for $> k$ dirty squares?

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Rational is not omniscient
as percepts may not supply all relevant information
Rational is not clairvoyant
as action outcomes may not be as expected
Hence, rational is not necessarily successful

A rational agent

[Wooldridge, 2000]

An agent is said to be *rational* if it chooses to perform actions that are in its own best interests, given the beliefs it has about the world.

Properties of rational agents:

- Autonomy (they decide);
- Proactiveness (they try to achieve their goals);
- Reactivity (they react to changes in the environment);
- Social ability (they negotiate and cooperate with other agents).

PEAS

- PEAS: Performance measure, Environment, Actuators, Sensors
- Must first specify the setting for intelligent agent design
- Consider, e.g., the task of designing an automated taxi driver:
  - Performance measure
  - Environment
  - Actuators
  - Sensors

PEAS, example

AUTOMATED TAXI DRIVER:

- Performance measure: Safe, fast, legal, comfortable trip, maximize profits
- Environment: Roads, other traffic, pedestrians, customers
- Actuators: Steering wheel, accelerator, brake, signal, horn
- Sensors: Cameras, radars, speedometer, GPS, odometer, engine sensors, car-human interface

Autonomous agents

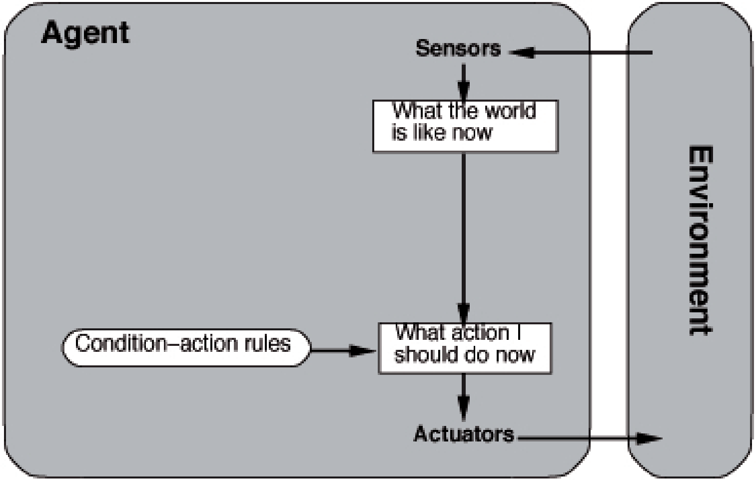
Can make decisions on their own.
Why do they need to? Because of the following properties of real environments (cf. Russell and Norvig):

- the real world is inaccessible (partially observable);
- the real world is nondeterministic (stochastic, sometimes strategic);
- the real world is nonepisodic (sequential);
- the real world is dynamic (non-static);
- the real world is continuous (non-discrete).

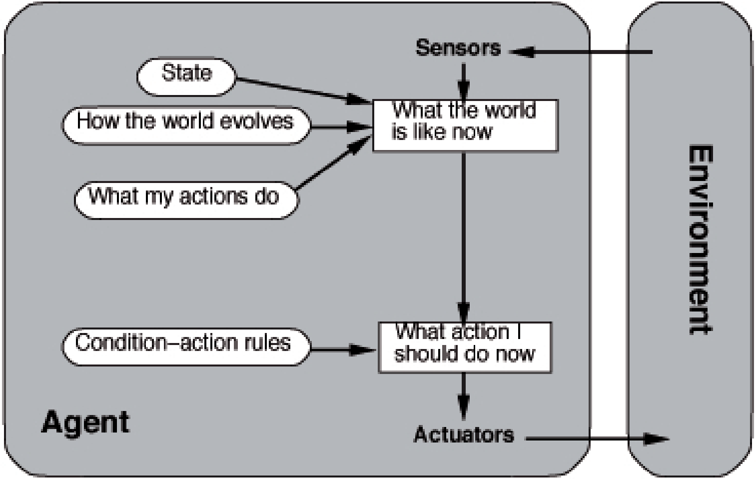
Agent taxonomy

- simple reflex agents
- reflex agents with state
- goal-based agents
- utility-based agents
-
- learning agents - independent property from the list above

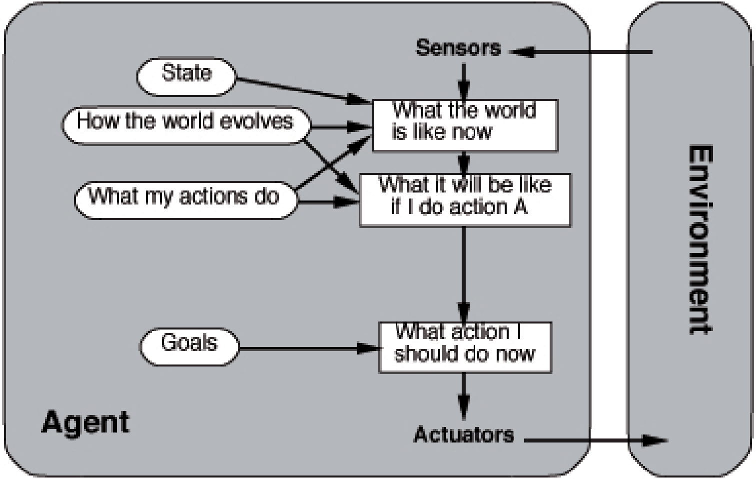
Simple reflex agent



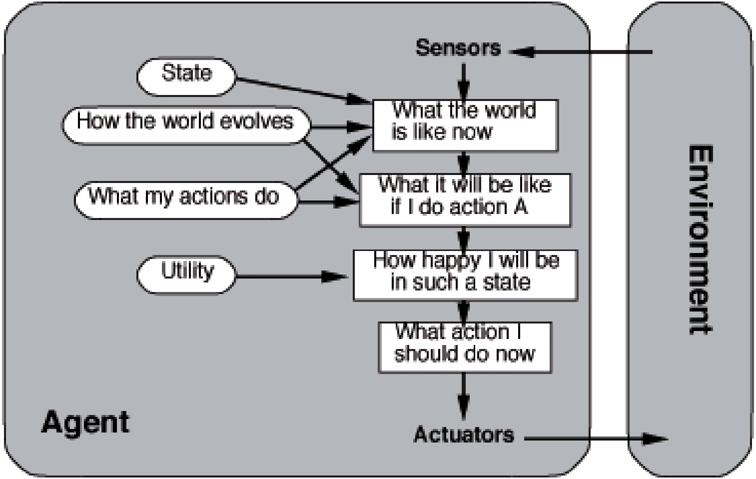
Reflex agent with state



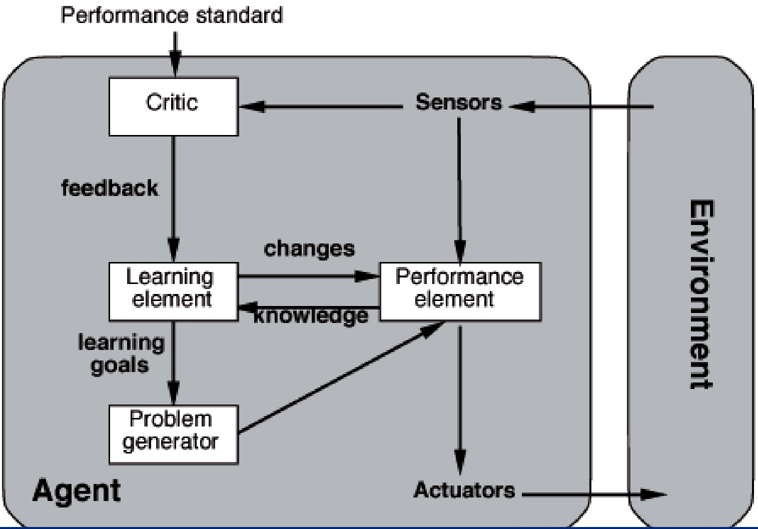
Goal-based agent



Utility-based agent



Learning agent



A bit more on rationality

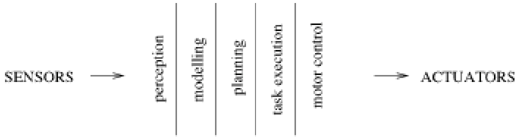
Rationality is a very powerful assumption.

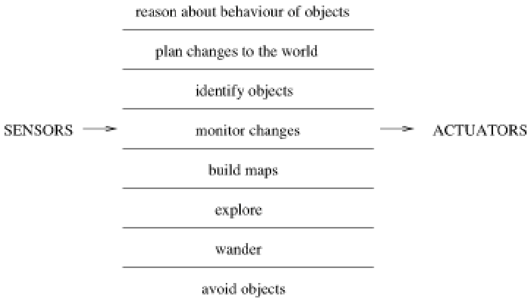
It allows us to compute things we wouldn't otherwise be able to dream of!

40 first years of AI were based solely on this assumption.

What do you think about?

Rodney Brooks, 1985





Subsumption

- horizontal vs. vertical decomposition
- a system is more than a sum of its parts (emergent intelligence)
- each behaviour can sense the environment and generate a physical action

Physical Grounding Hypothesis

- situatedness

  "the world is its own best model"

- embodiment
- intelligence

  "intelligence is determined by the dynamics of interaction with the world"

- emergence

  "intelligence is in the eye of the observer"

Principles of computation

- an asynchronous network of active computational elements with a fixed topology network of unidirectional connections
- messages sent over connections have no implicit semantics
- sensors and actuators are connected to this network

Agent architectures

- sense - think - act (serial decomposition, functional decomposition);
- parallel decomposition (e.g. subsumption, more general: behaviour-based control);
- hybrid, mixed, layered.

Multi-agent systems

Interesting for a number of reasons:

- performance: many agents may do the job faster, with less effort
  Sometimes only many agents can do the job (if they are heterogenous or if the deadline is hard)
- reliability, robustness: when one agent fails, the rest may do the job
- adaptivity: agents exposed to different environmental conditions can learn appropriately (and even communicate the results to others)

Note special case of faults: communication faults not occuring in a single-agent case

Interaction, Coordination, Cooperation

- *Interaction*: common resources
  - antagonistic (incompatibility of goals)
  - non-antagonistic
- *Coordination*: planning for use of common resources
- *Cooperation*: planning for maximisation of utility
  - *eusocial* behaviour (innate, McFarland)
  - cooperative behaviour (selfish agents maximising personal utility)

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Several basic agent architectures exist:
reflex, reflex with state, goal-based, utility-based