

INTELLIGENT AGENTS

CHAPTER 2

Reminders

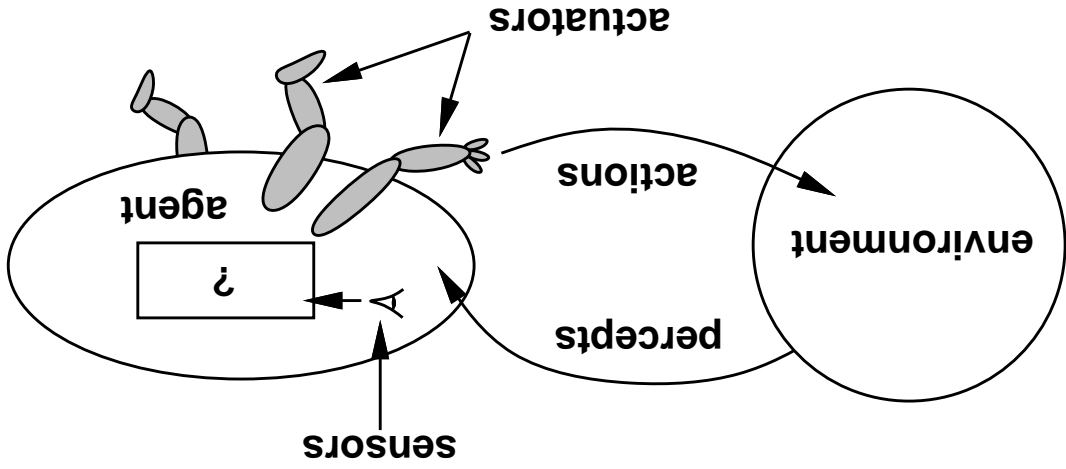
Assignment 0 (lisp refresher) due 1/28

Lisp/emacs/AIMA tutorial: 11-1 today and Monday, 271 Soda

- ◇ Agents and environments
- ◇ Rationality
- ◇ PEAS (Performance measure, Environment, Actuators, Sensors)
- ◇ Environment types
- ◇ Agent types

Outline

Agents and environments



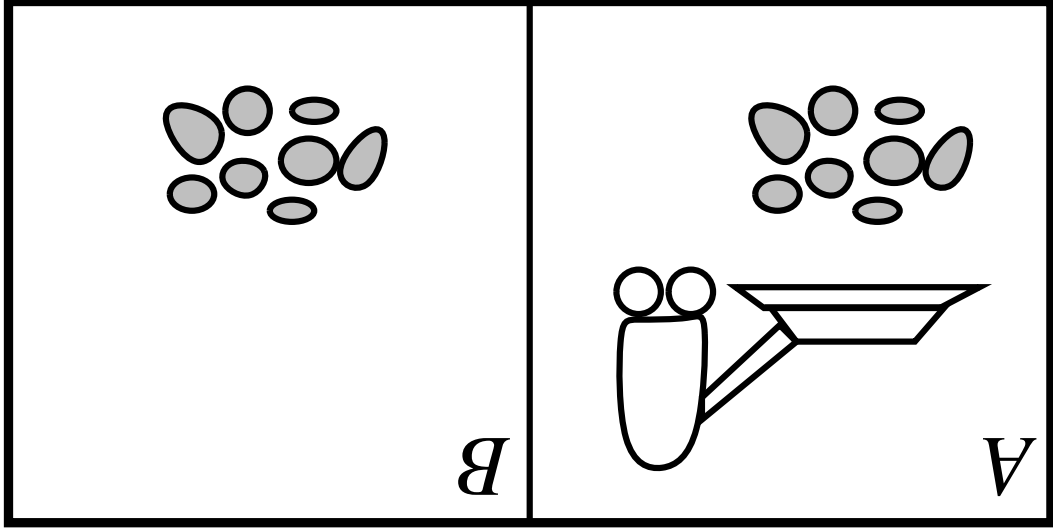
Agents include humans, robots, softbots, thermostats, etc.

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

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

The **agent program** runs on the physical **architecture** to produce f

Vacuum-cleaner world



Percepts: location and contents, e.g., $[A, Dirty]$

Actions: *Left, Right, Suck, NoOp*

A vacuum-cleaner agent

Percept sequence	<div> <div>[A, Clean]</div> <div>[A, Dirty]</div> <div>[B, Clean]</div> <div>[B, Dirty]</div> <div>[A, Clean]</div> <div>[A, Dirty]</div> <div>⋮</div> </div>
Action	<div> <div>Right</div> <div>Suck</div> <div>Left</div> <div>Suck</div> <div>Right</div> <div>Suck</div> <div>⋮</div> </div>

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*

What is the **right** function?

Can it be implemented in a small agent program?

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?

A **rational agent** chooses whichever action maximizes the **expected** value of the performance measure **given the percept sequence to date**

Rational \neq omniscient

- percepts may not supply all relevant information
- Rational \neq clairvoyant

- action outcomes may not be as expected
- Hence, rational \neq successful

Rational \Rightarrow exploration, learning, autonomy

PEAS

To design a rational agent, we must specify the **task environment**

Consider, e.g., the task of designing an automated taxi:

Performance measure??

Environment??

Actuators??

Sensors??

PEAS

To design a rational agent, we must specify the **task environment**

Consider, e.g., the task of designing an automated taxi:

Performance measure?? safety, destination, profits, legality, comfort, ...

Environment?? US streets/freeways, traffic, pedestrians, weather, ...

Actuators?? steering, accelerator, brake, horn, speaker/display, ...

Sensors?? video, accelerometers, gauges, engine sensors, keyboard, GPS, ...

Internet shopping agent

Performance measure??

Environment??

Actuators??

Sensors??

Internet shopping agent

Performance measure?? price, quality, appropriateness, efficiency

Environment?? current and future WWW sites, vendors, shippers

Actuators?? display to user, follow URL, fill in form

Sensors?? HTML pages (text, graphics, scripts)

Environment types

	<div> <div>Observable??</div> <div>Deterministic??</div> <div>Episodic??</div> <div>Static??</div> <div>Discrete??</div> <div>Single-agent??</div> </div>
<div> <div>Solitaire</div> <div>Backgammon</div> <div>Internet shopping</div> <div>Taxi</div> </div>	

Environment types

	<u>Observable??</u> <u>Deterministic??</u> <u>Episodic??</u> <u>Static??</u> <u>Discrete??</u> <u>Single-agent??</u>
Solitaire Backgammon Internet shopping Taxi Yes Yes No No	

Environment types

	Observable??	Deterministic??	Episodic??	Static??	Discrete??	Single-agent??
Solitaire	Yes	Yes				
Backgammon	Yes	No				
Internet shopping	No	Partly				
Taxi	No	No				

Environment types

	Observable??	Deterministic??	Episodic??	Static??	Discrete??	Single-agent??
Solitaire	Yes	Yes	No	No	No	No
Backgammon	Yes	No	No	No	No	No
Internet shopping	No	Partly	No	No	No	No
Taxi	No	No	No	No	No	No

Environment types

		Observable??	Deterministic??	Episodic??	Static??	Discrete??	Single-agent??
Solitaire	Yes	Yes	Yes	No	Yes		
Backgammon	Yes	No	No	No	Semi!		
Internet shopping	No	Partly	No	No	Semi!		
Taxi	No	No	No	No	No		

Environment types

	Observable??	Yes	Yes	Yes	No	No	No	No	No
	Deterministic??	Yes	No	No	No	Partly	No	Semi	Yes
	Episodic??	No	No	No	No	No	No	Semi	Yes
	Static??	Yes	Yes	Yes	No	No	No	Semi	Yes
	Discrete??	Yes	Yes	Yes	No	No	No	Semi	Yes
	Single-agent??	Yes	Yes	Yes	No	No	No	Semi	Yes
Solitaire		Yes	Yes	Yes	No	No	No	Semi	Yes
Backgammon		Yes	No	No	No	Partly	No	Semi	Yes
Internet shopping		No	No	No	No	No	No	Semi	Yes
Taxi		No	No	No	No	No	No	Semi	Yes

The environment type largely determines the agent design

The real world is (of course) partially observable, stochastic, sequential, dynamic, continuous, multi-agent

	Observable??	Yes	Yes	No
	Deterministic??	Yes	No	No
	Episodic??	No	No	No
	Static??	Yes	Semi!	No
	Discrete??	Yes	Yes	No
	Single-agent??	Yes	No	Yes (except auctions)
Solitaire		Yes	Yes	No
Backgammon		Yes	Semi!	No
Internet shopping		No	Partly	No
Taxi		No	No	No

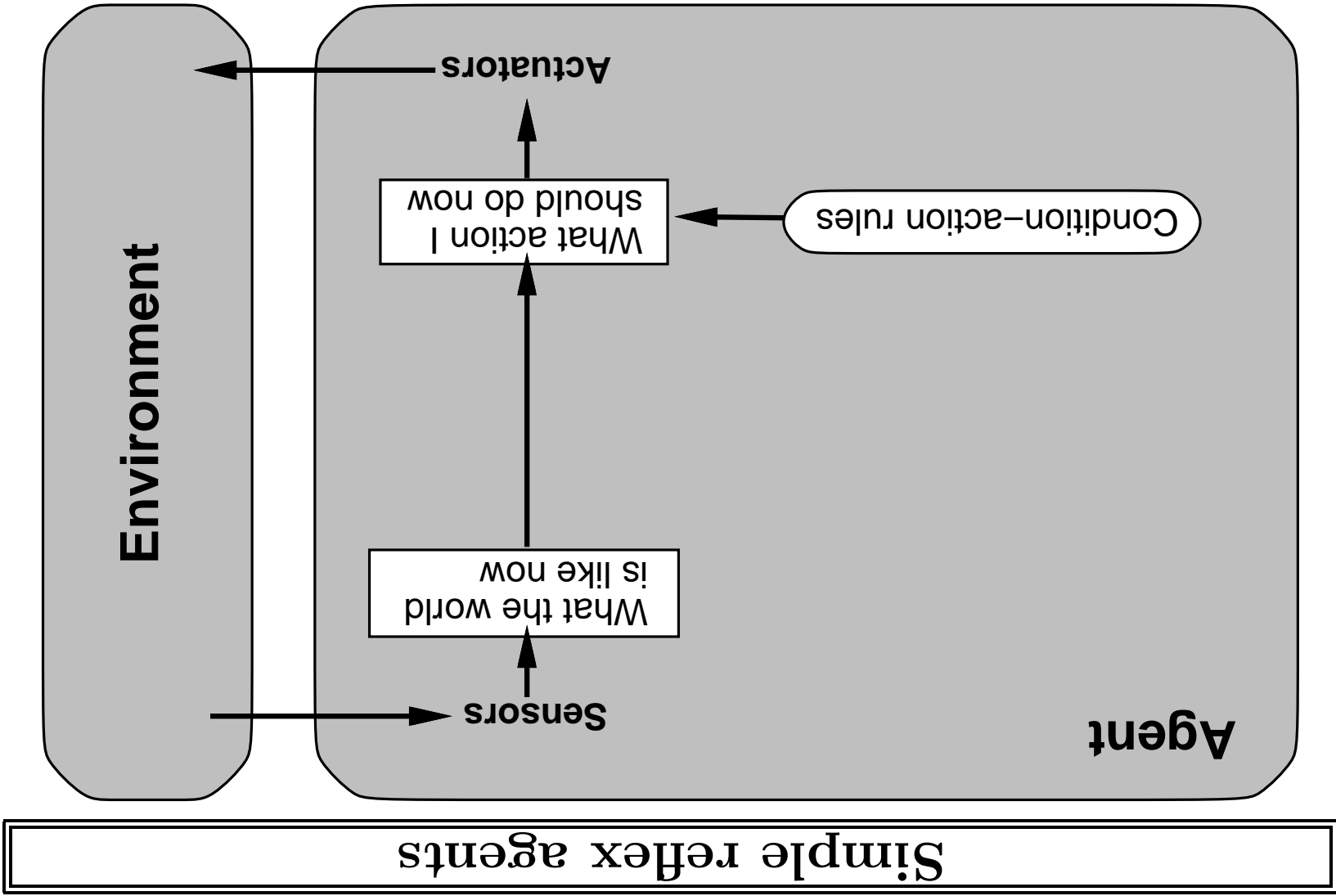
Environment types

Agent types

Four basic types in order of increasing generality:

- simple reflex agents
- reflex agents with state
- goal-based agents
- utility-based agents

All these can be turned into learning agents

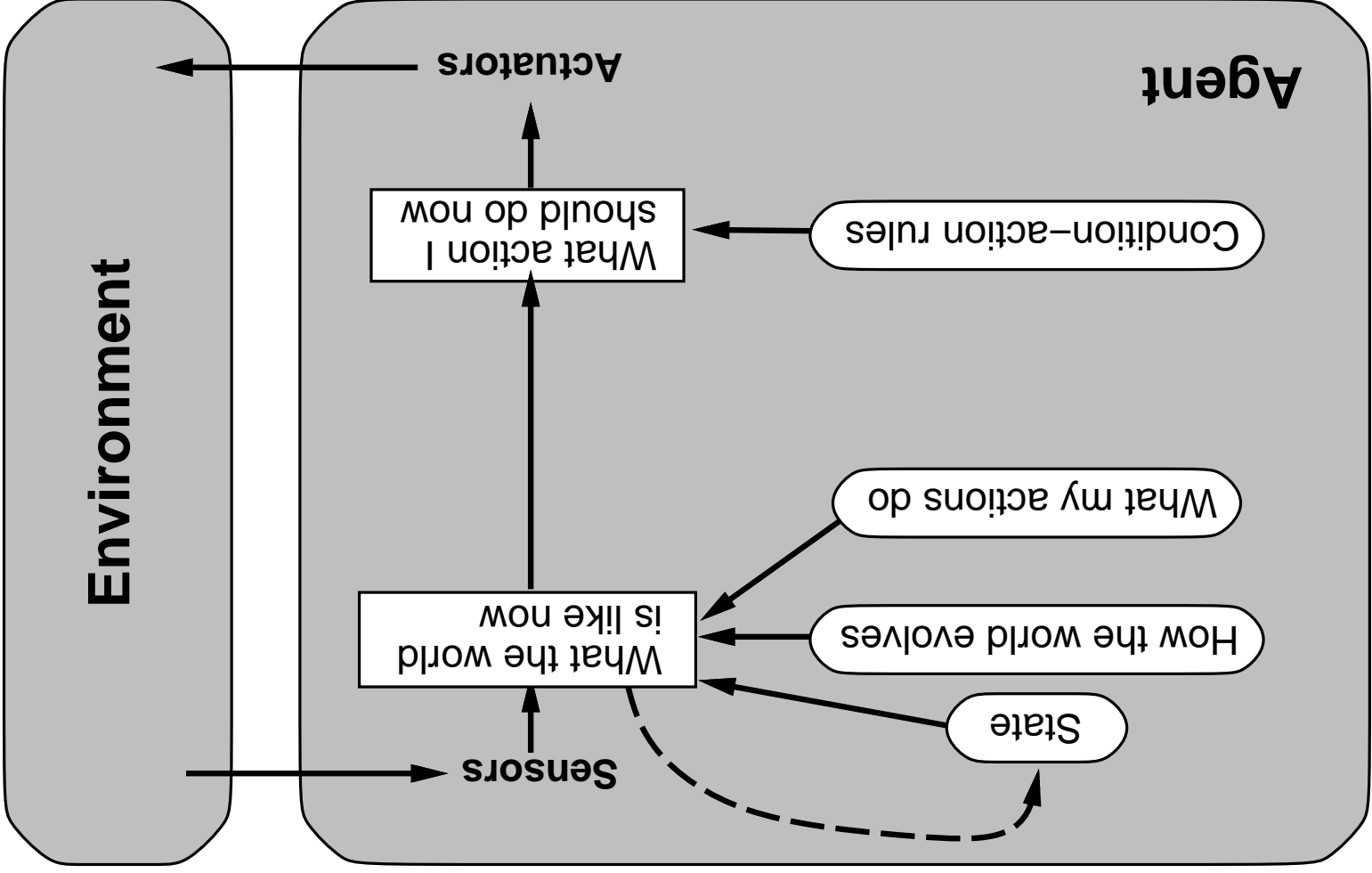


Example

```
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
```

```
(setq joe (make-agent :name 'joe :body (make-agent-body
:program (make-reflex-vacuum-agent-program)))
(defun make-reflex-vacuum-agent-program ()
  #'(lambda (percept)
    (let ((location (first percept)) (status (second percept)))
      (cond ((eq status 'dirty) 'Suck)
            ((eq location 'A) 'Right)
            ((eq location 'B) 'Left))))))
```

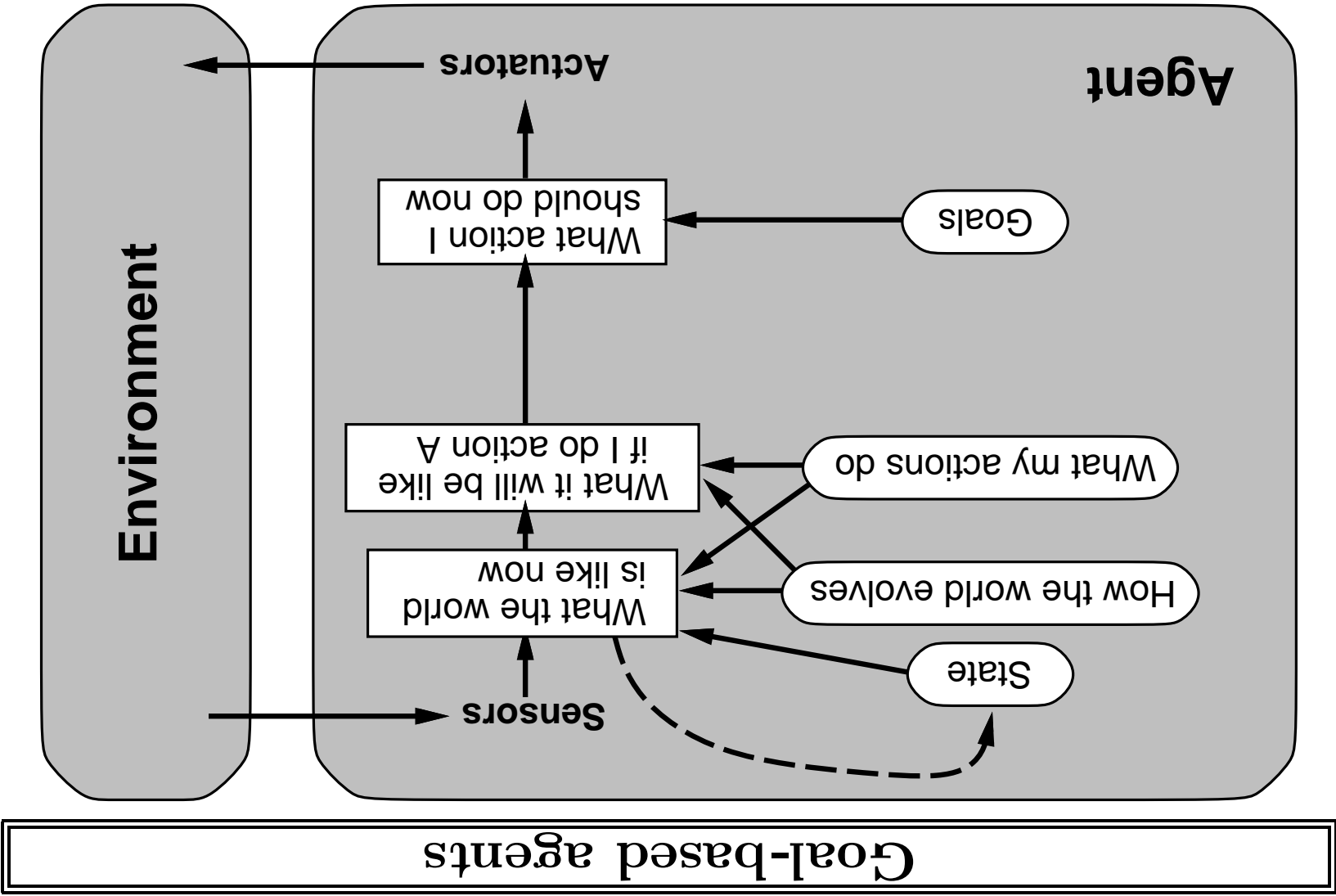
Reflex agents with state

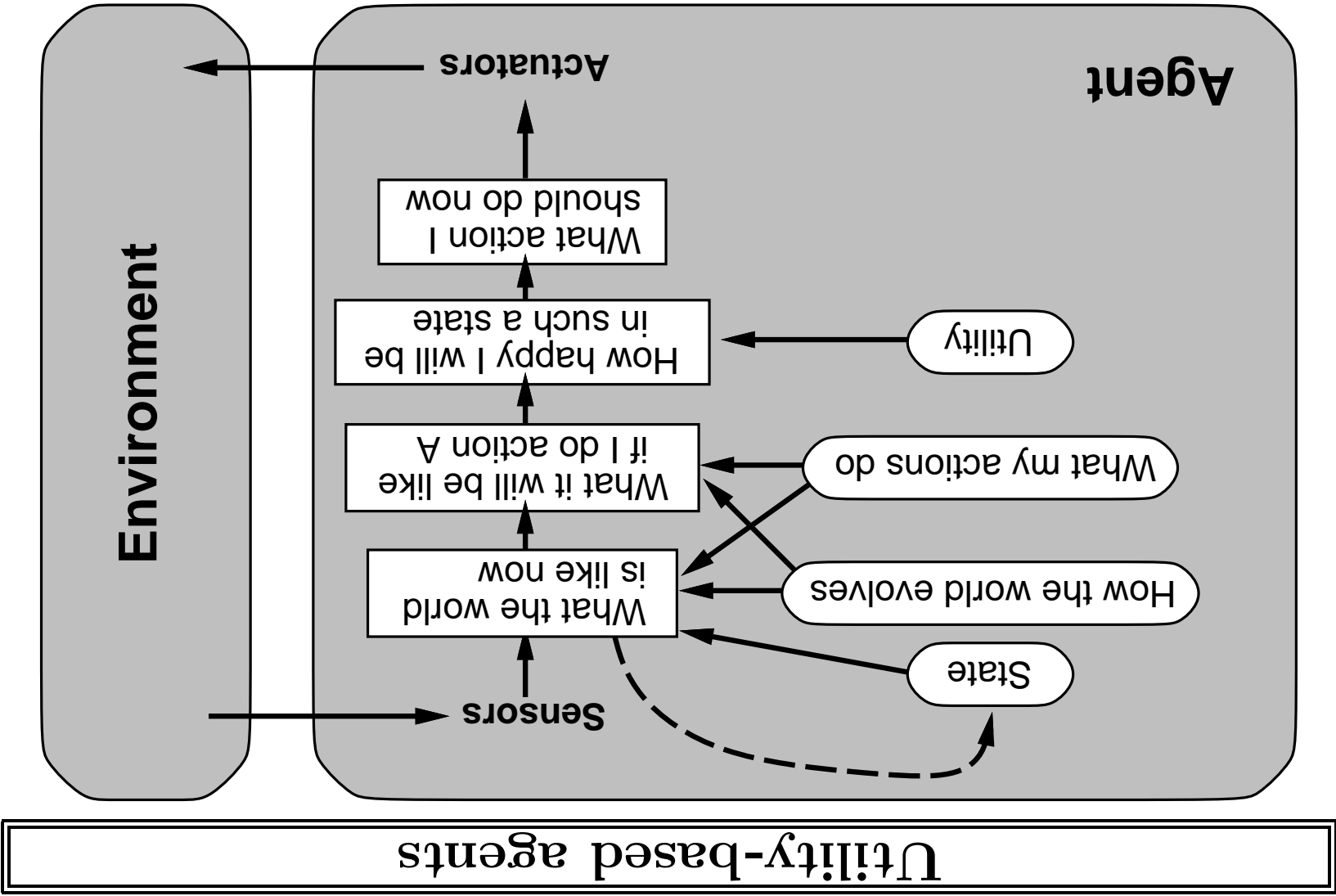


Example

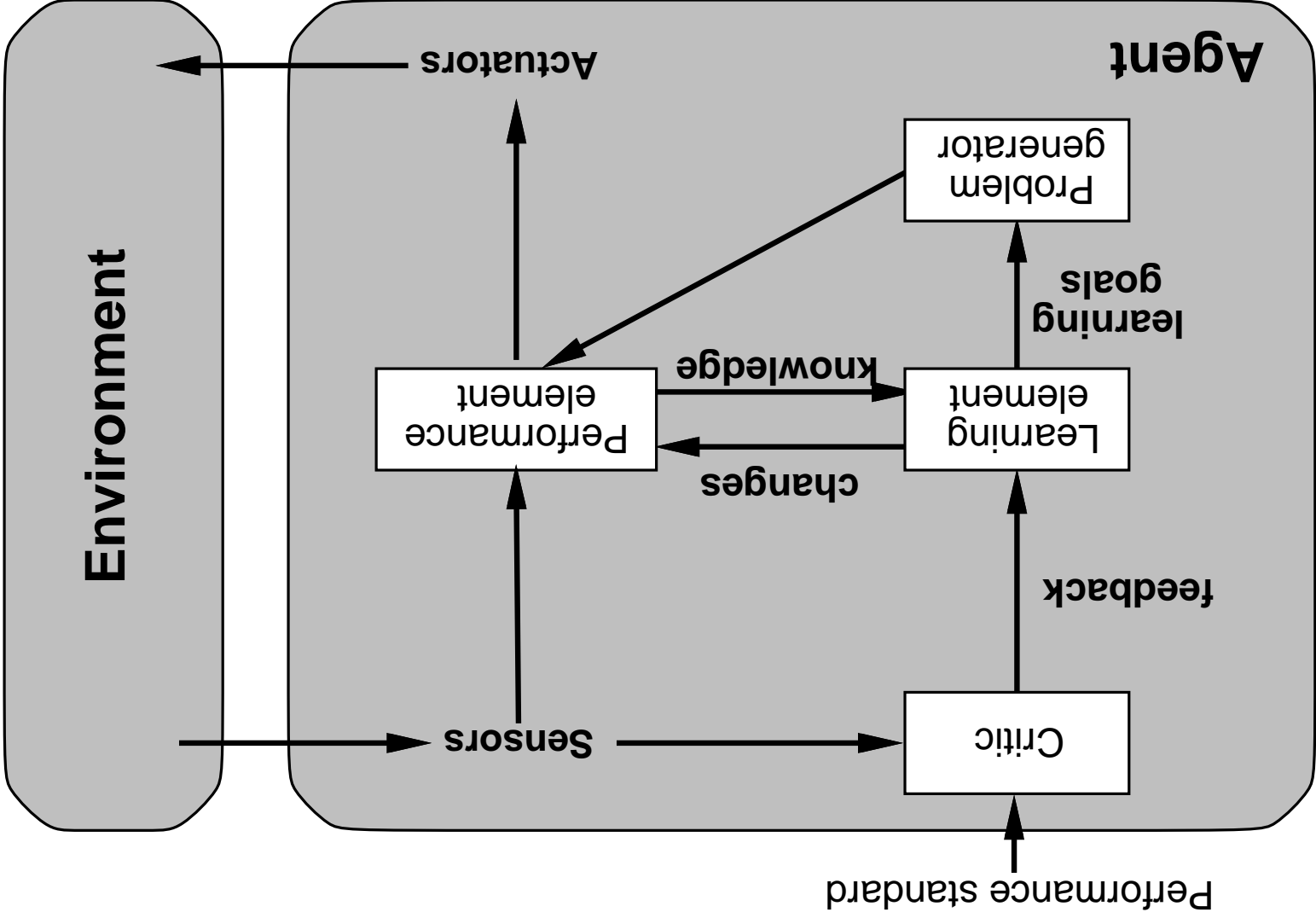
```
function REFLEX-VACUUM-AGENT([location,status]) returns an action
static: last-A, last-B, numbers, initially ∞
if status = Dirty then ...
```

```
(defun make-reflex-vacuum-agent-with-state-program ()
  (let ((last-A infinity) (last-B infinity))
    #'(lambda (percept)
      (let ((location (first percept)) (status (second percept)))
        (incf last-A) (incf last-B)
        (cond
          ((eq status 'dirty)
            (if (eq location 'A) (setq last-A 0) (setq last-B 0))
            'Suck)
          ((eq location 'A) (if (> last-B 3) 'Right 'NoOp))
          ((eq location 'B) (if (> last-A 3) 'Left 'NoOp)))))))
```





Learning agents



Summary

Agents interact with **environments** through **actuators** and **sensors**

The **agent function** describes what the agent does in all circumstances

The **performance measure** evaluates the environment sequence

A **perfectly rational** agent maximizes expected performance

Agent programs implement (some) agent functions

PEAS descriptions define task environments

Environments are categorized along several dimensions:

observable? deterministic? episodic? static? discrete? single-agent?

Several basic agent architectures exist:

reflex, reflex with state, goal-based, utility-based