INTELLIGENT AGENTS

CHAPTER 2
Outline

◊ Agents and environments
◊ Rationality
◊ PEAS (Performance measure, Environment, Actuators, Sensors)
◊ Environment types
◊ Agent types
Agents include humans, robots, softbots, thermostats, etc.

The agent function maps from percept histories to actions:

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

The agent program runs on the physical architecture to produce $f$
Percepts: location and contents, e.g., \([A, Dirty]\)

Actions: Left, Right, Suck, NoOp
## A vacuum-cleaner agent

<table>
<thead>
<tr>
<th>Percept sequence</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>[A, Clean]</td>
<td>Right</td>
</tr>
<tr>
<td>[A, Dirty]</td>
<td>Suck</td>
</tr>
<tr>
<td>[B, Clean]</td>
<td>Left</td>
</tr>
<tr>
<td>[B, Dirty]</td>
<td>Suck</td>
</tr>
<tr>
<td>[A, Clean], [A, Clean]</td>
<td>Right</td>
</tr>
<tr>
<td>[A, Clean], [A, Dirty]</td>
<td>Suck</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

**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
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??**
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

<table>
<thead>
<tr>
<th></th>
<th>Solitaire</th>
<th>Backgammon</th>
<th>Internet shopping</th>
<th>Taxi</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Observable??</strong></td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td><strong>Deterministic??</strong></td>
<td>Yes</td>
<td>No</td>
<td>Partly</td>
<td>No</td>
</tr>
<tr>
<td><strong>Episodic??</strong></td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td><strong>Static??</strong></td>
<td>Yes</td>
<td>Semi</td>
<td>Semi</td>
<td>No</td>
</tr>
<tr>
<td><strong>Discrete??</strong></td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td><strong>Single-agent??</strong></td>
<td>Yes</td>
<td>No</td>
<td>Yes (except auctions)</td>
<td>No</td>
</tr>
</tbody>
</table>

**The environment type largely determines the agent design**

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

Agent

Sensors

What the world is like now

Condition–action rules

What action I should do now

Actuators

Environment
Example

```
function Reflex-Vacuum-Agent([location, status]) returns an action
    if status = Dirty then return Suck
    elseif location = A then return Right
    elseif location = B then return Left
```

```lisp
(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

Agent

- State
- How the world evolves
- What my actions do
- Condition–action rules

What the world is like now

What action I should do now

Sensors

Actuators

Environment

Chapter 2
Example

**function** Reflex-Vacuum-Agent([location, status]) **returns** an action

**static:** last_A, last_B, numbers, initially \( \infty \)

\[
\text{if } status = \text{Dirty} \text{ then } \ldots
\]

(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)))
        )))

Chapter 2   16
Goal-based agents

Agent

State

What the world is like now

What it will be like if I do action A

What my actions do

How the world evolves

Goals

What action I should do now

Environment

Sensors

Actuators

Chapter 2  17
Utility-based agents

- Agent
  - State
  - How the world evolves
  - What my actions do
  - Utility
- Environment
  - Sensors
    - What the world is like now
    - What it will be like if I do action A
    - How happy I will be in such a state
    - What action I should do now
- Actuators
Learning agents

Performance standard

Agent

Environment

Critic

Sensors

feedback

changes

knowledge

learning goals

Problem generator

Performance element

Actuators

Learning element
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.