Title: Intelligent Agents
AIMA: Chapter 2

Introduction to Artificial Intelligence
CSCE 476-876, Fall 2017 URL:
www.cse.unl.edu/~choueiry/F17-476-876

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Intelligent Agents

1. Agents and environments
2. Rationality
3. PEAS
   Specifying the task environment:
   Performance measure, Environment, Actuators, Sensors
4. Types of environments
5. Types of Intelligent Agents
Agent

Anything that

\[
\begin{cases}
\text{perceives its environment through sensors} \\
\text{acts upon its environment through actuators}
\end{cases}
\]

Agents include: Humans, robots, software, etc. Sensors? Actuators?

The agent function maps from percept sequences to actions:

\[ f : \mathcal{P}^* \rightarrow \mathcal{A} \]

The agent program runs on the physical architecture to produce \( f \)
Vacuum-cleaner world

Percepts: locations 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>
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<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>(\ldots)</td>
<td></td>
</tr>
<tr>
<td>([A, Clean],[A, Clean],[A, Clean])</td>
<td>Right</td>
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<tr>
<td>(\ldots)</td>
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**Function** Reflex-Vaccum-Agent \([\text{[location, status]}]\) returns an action

- if \(\text{status} = \text{Dirty}\) then return \(\text{Suck}\)
- else if \(\text{location} = A\) then return \(\text{Right}\)
- else if \(\text{location} = B\) then return \(\text{Left}\)
Goal of AI

Build rational agents.

Rational = ?

What is “rational” depends on:

1. Performance measures (how, when)
2. The agents’ prior knowledge of the environment
3. The actions the agent can perform
4. Percept sequence to date (history): everything agent has perceived so far
Performance measure

Fixed performance measure evaluates the environment sequence

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

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

Rational $\neq$ omniscient, clairvoyant
Rationality maximizes expected performance
Perfection maximizes actual performance

Rational $\implies$ exploration, learning, autonomy

After a sufficient experience of its environment, behavior of a rational agents becomes effectively independent of prior knowledge.
PEAS

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

Performance measure?
Environment?
Actuators?
Sensors?

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

**Performance measure**: safety, destination, profits, legality, comfort, ...

**Environment**: US urban streets, freeways, traffic, pedestrians, stray animals, weather, ...

**Actuators**: steering, accelerator, brake, horn, speaker/display, ...

**Sensors**: video, accelerometers, gauges, engine sensors, keyboard, GPS, ...
Environment (1)

1. Fully Observable vs. Partially Observable
2. Deterministic vs. stochastic
3. Episodic vs. sequential
4. Static vs. dynamic
5. Discrete vs. continuous
6. Single agent vs. multiagent
Environment (2)

Fully/Partially Observable: sensors can detect all aspects of the world
Effectively fully observable: relevant aspects

Deterministic vs. stochastic: from the agent’s view point
Next state determined by current state and agents’ actions
Partially observable + deterministic appears stochastic

Episodic vs. sequential: Agent’s experience divided into atomic episodes; subsequent episodes do not depend on actions in previous episodes
Environment (3)

Static vs. dynamic:
- Dynamic: Environment changes while agent is deliberating
- Semidynamic: environment static, performance scores dynamic

Discrete vs. continuous: Finite number of precepts, actions

Single agent vs. multiagent: $B$’s behavior maximizes a performance measure whose value depends on $A$’s behavior.
- Cooperative, competitive, communication.

Chess? Taxi driving? hardest case?
**Environment** \((4)\)

Hardest case: partially observable, stochastic, sequential, dynamic, continuous, and multiagent

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<th>Solitaire</th>
<th>Backgammon</th>
<th>Internet shopping</th>
<th>Taxi</th>
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<tbody>
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<td>Observable</td>
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Answers depend on how you define/interpret the case

Episodic: chess tournament
The environment type largely determines the agent design.

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

Four, in order of increasing generality:

1. Simple reflex agents
2. Simple reflex agents with state
3. Goal-based agents
4. Utility-based agents
5. Learning agents

All these can be turned into learning agents.
Simple reflex agents

- Simple look-up table, mapping percepts to actions, is out of question (too large, too expensive to build)

- Many situations can be summarized by condition-action rules (humans: learned responses, innate reflexes)

Rectangles: agent’s internal state  
Ovals: background information

Implementation: easy; Applicability: narrow
Simple reflex agents with state

- Sensory information alone is not sufficient
- Need to keep track of how the world evolves
  (evolution: independently of agent, or caused by agent’s actions)

How the world evolved: model-based agent
Goal-based agents

- State & actions don’t tell where to go
- Need goals to build sequences of actions (planning)

Goal-based: uses the same rules for different goals
Reflex: will need a complete set of rules for each goal
Utility-based agents

- Several action sequences to achieve some goal (binary process)
- Need to **select** among actions & sequences. Preferences.
- Utility: State $\rightarrow$ real number (express degree of satisfaction, specify trade-offs between conflicting goal)
Learning agents

Agent operates in an initially unknown environment, and becomes more competent than its initial knowledge alone might allow.

Learning: process of modification of each component of the agent to bring the components into closer agreement with the available feedback information, thus improving overall performance of the agent.