Intelligent Agents

Chapter 2
Outline

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

- An *agent* is anything that can be viewed as *perceiving* its *environment* through *sensors* and *acting* upon that environment through *actuators*.
- Human agent: eyes, ears, and other organs for sensors; hands, legs, mouth, and other body parts for actuators.
- Robotic agent: cameras and infrared range finders for sensors;
- various motors for actuators.
Agents and environments

- 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 \( f \)
- agent = architecture + program
Vacuum-cleaner world

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>
Rational agents

- An agent should strive to "do the right thing", based on what it can perceive and the actions it can perform. The right action is the one that will cause the agent to be most successful.

- Performance measure: An objective criterion for success of an agent's behavior.

- E.g., performance measure of a vacuum-cleaner agent could be amount of dirt cleaned up, amount of time taken, amount of electricity consumed, amount of noise generated, etc.
Rational Agent: 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.
Rational agents

- Rationality is distinct from omniscience (all-knowing with infinite knowledge)
- Agents can perform actions in order to modify future percepts so as to obtain useful information (information gathering, exploration)
- An agent is autonomous if its behavior is determined by its own experience (with ability to learn and adapt)
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
Must first specify the setting for intelligent agent design

Consider, e.g., the task of designing an 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, sonar, speedometer, GPS, odometer, engine sensors, keyboard
Agent: Medical diagnosis system

- Performance measure: Healthy patient, minimize costs, lawsuits
- Environment: Patient, hospital, staff
- Actuators: Screen display (questions, tests, diagnoses, treatments, referrals)
- Sensors: Keyboard (entry of symptoms, findings, patient's answers)
Agent: Part-picking robot

- Performance measure: Percentage of parts in correct bins
- Environment: Conveyor belt with parts, bins
- Actuators: Jointed arm and hand
- Sensors: Camera, joint angle sensors
PEAS

Agent: Interactive English tutor

- Performance measure: Maximize student's score on test
- Environment: Set of students
- Actuators: Screen display (exercises, suggestions, corrections)
- Sensors: Keyboard
Environment types

- **Fully observable** (vs. partially observable): An agent's sensors give it access to the complete state of the environment at each point in time.

- **Deterministic** (vs. stochastic): The next state of the environment is completely determined by the current state and the action executed by the agent. (If the environment is deterministic except for the actions of other agents, then the environment is **strategic**)

- **Episodic** (vs. sequential): The agent's experience is divided into atomic "episodes" (each episode consists of the agent perceiving and then performing a single action), and the choice of action in each episode depends only on the episode itself.
Environment types

- **Static** (vs. dynamic): The environment is unchanged while an agent is deliberating. (The environment is *semidynamic* if the environment itself does not change with the passage of time but the agent's performance score does)

- **Discrete** (vs. continuous): A limited number of distinct, clearly defined percepts and actions.

- **Single agent** (vs. multiagent): An agent operating by itself in an environment.
### Environment Types

<table>
<thead>
<tr>
<th></th>
<th>Chess with a clock</th>
<th>Chess without a clock</th>
<th>Taxi driving</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fully observable</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Deterministic</td>
<td>Strategic</td>
<td>Strategic</td>
<td>No</td>
</tr>
<tr>
<td>Episodic</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Static</td>
<td>Semi</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Discrete</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Single agent</td>
<td>No</td>
<td>No</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 functions and programs

- An agent is completely specified by the agent function mapping percept sequences to actions.
- One agent function (or a small equivalence class) is rational.
- Aim: find a way to implement the rational agent function concisely.
Table-lookup agent

\[
\text{function \ TABLE-DRIVEN-AGENT( percept) returns action} \\
\text{static: \ percepts, a sequence, initially empty} \\
\text{table, a table of actions, indexed by percept sequences, fully specified} \\
\text{append \ percept \ to \ the \ end \ of \ percepts} \\
\text{action} \leftarrow \text{LOOKUP( percepts, table)} \\
\text{return \ action}
\]

- **Drawbacks:**
  - Huge table
  - Take a long time to build the table
  - No autonomy
  - Even with learning, need a long time to learn the table entries
Agent program for a vacuum-cleaner agent

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
Agent types

- Four basic types in order of increasing generality:
  - Simple reflex agents
  - Model-based reflex agents
  - Goal-based agents
  - Utility-based agents
Simple reflex agents

Diagram:

- Agent
  - Sensors
    - What the world is like now
      - Condition-action rules
        - What action I should do now
          - Actuators
    - Environment
Simple reflex agents

function SIMPLE-REFLEX-AGENT( percept) returns action
    static: rules, a set of condition-action rules
    state ← INTERPRET-INPUT( percept)
    rule ← RULE-MATCH(state, rules)
    action ← RULE-ACTION[rule]
    return action
Model-based reflex agents
Model-based reflex agents

```plaintext
function REFLEX-AGENT-WITH-STATE( percept ) returns action
    static: state, a description of the current world state
            rules, a set of condition-action rules
            action, the most recent action, initially none
    state ← UPDATE-STATE(state, action, percept)
    rule ← RULE-MATCH(state, rules)
    action ← RULE-ACTION[rule]
    return action
```
Goal-based agents

- State
- What the world is like now
- What it will be like if I do action A
- Goals
- What action I should do now
- Actuators

How the world evolves
What my actions do
Utility-based agents
Learning agents

Performance standard

Critic

feedback

Learning element

changes

learning goals

Problem generator

knowledge

Environment

Sensors

Performance element

Actuators

Agent