ARTIFICIAL INTELLIGENCE

Russell & Norvig
Chapter 2: Intelligent Agents
Agents

• “An **agent** is anything that can be viewed as perceiving its environment through sensors and acting upon that environment through actuators.”
Percepts

- **Percepts** are the agent’s “perceptual inputs” at any instance.
- The **Percept History** is the complete sequence of everything the agent has perceived.
- An agent’s choice of action at any given instant can depend on the entire percept sequence observed to date, but not anything it hasn’t perceived.
- Agent function maps from percept history to actions
Vacuum cleaner world example

- 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>
Rationality

• A **rational agent** is one that does the right thing.
  • Every entry in the table is filled out correctly.

• What is the right thing?
  • Approximation: the most **successful** agent.
  • *Measure of success?*

• Performance measure should be objective
  • E.g. the amount of dirt cleaned within a certain time.
  • E.g. how clean the floor is.
  • …

• *Performance measure according to what is wanted in the environment instead of how the agents should behave.*
Rational Agent

- What is rational depends on:
  - The performance measure that defines the criterion of success
  - The agent’s prior knowledge of the environment
  - The actions that the agent can perform
  - The agent’s percept sequence to date

- Definition of a 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.
More rationality!

- **Rationality ≠ omniscience**
  - An omniscient agent knows the actual outcome of its actions.

- **Rationality ≠ perfection**
  - Rationality maximizes *expected* performance, while perfection maximizes *actual* performance.

- **Components required for rationality**
  - Exploration (information gathering)
  - Learning (go beyond *apriori* knowledge)
  - Autonomy (independent of prior knowledge)
Environments

• To design a rational agent we must specify its task environment

• PEAS description of the environment:
  • Performance
  • Environment
  • Actuators
  • Sensors
Automated Taxi Driver Example

• PEAS Environment:
  
  • *Performance measure*: Safe, fast, legal, comfortable trip, maximize profits
  
  • *Environment*: Roads, other traffic, pedestrians, customers
  
  • *Actuators*: Steering wheel, accelerator, brake, signal, horn, display
  
  • *Sensors*: Cameras, sonar, speedometer, GPS, odometer, engine sensors, keyboard
### Agent: Medical diagnosis system

<table>
<thead>
<tr>
<th>Performance Measure</th>
<th>Healthy patient, reduced cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environment</td>
<td>Patient, hospital staff</td>
</tr>
<tr>
<td>Actuators</td>
<td>Display of questions, tests, diagnoses, treatments, referrals</td>
</tr>
<tr>
<td>Sensors</td>
<td>Keyboard entry of symptoms, findings, patient’s answers</td>
</tr>
</tbody>
</table>
Agent: Part-picking robot

<table>
<thead>
<tr>
<th>Performance Measure</th>
<th>Percentage of parts in correct bins</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environment</td>
<td>Conveyor belt with parts, bins</td>
</tr>
<tr>
<td>Actuators</td>
<td>Jointed arm and hand</td>
</tr>
<tr>
<td>Sensors</td>
<td>Camera, joint angle sensors</td>
</tr>
</tbody>
</table>
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, continued

- **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.
## Example task environments

<table>
<thead>
<tr>
<th></th>
<th>Crossword puzzle</th>
<th>Chess w/ clock</th>
<th>Poker</th>
<th>Backgammon</th>
<th>Taxi driving</th>
<th>Medical Diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Observable</strong></td>
<td>Fully</td>
<td>Fully</td>
<td>Partial</td>
<td>Fully</td>
<td>Partial</td>
<td>Partial</td>
</tr>
<tr>
<td><strong>Agents</strong></td>
<td>Single</td>
<td>Multi</td>
<td>Multi</td>
<td>Multi</td>
<td>Multi</td>
<td>Single</td>
</tr>
<tr>
<td><strong>Deterministic</strong></td>
<td>Determ</td>
<td>Determ</td>
<td>Stoch</td>
<td>Stoch</td>
<td>Stoch</td>
<td>Stoch</td>
</tr>
<tr>
<td><strong>Episodic</strong></td>
<td>Seq</td>
<td>Seq</td>
<td>Seq</td>
<td>Seq</td>
<td>Seq</td>
<td>Seq</td>
</tr>
<tr>
<td><strong>Static</strong></td>
<td>Static</td>
<td>Semi</td>
<td>Static</td>
<td>Static</td>
<td>Dyn</td>
<td>Dyn</td>
</tr>
<tr>
<td><strong>Discrete</strong></td>
<td>Disc</td>
<td>Disc</td>
<td>Disc</td>
<td>Disc</td>
<td>Cont</td>
<td>Cont</td>
</tr>
</tbody>
</table>
Simple vs. Real Environments

• The simplest environment is
  • Fully observable, deterministic, episodic, static, discrete and single-agent

• Most real situations are:
  • Partially observable, stochastic, sequential, dynamic, continuous and multi-agent