CSEP 573: Artificial Intelligence

Agents and environments

slides adapted from
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Agents and environments
Rationality
PEAS (Performance measure, Environment, Actuators, Sensors)
Environment types
Agent types
An agent **perceives** its environment through **sensors** and **acts** upon it through **actuators** (or **effectors**, depending on whom you ask)
Are humans agents?
Yes!
- Sensors = vision, audio, touch, smell, taste, proprioception
- Actuators = muscles, secretions, changing brain state
Are pocket calculators agents?

Yes!

- Sensors = key state sensors
- Actuators = digit display
AI is more interested in agents with large computational resources and environments that require nontrivial decision making.
The **agent function** maps from percept histories to actions:

- \( f : \mathcal{P}^* \rightarrow \mathcal{A} \)
- I.e., the agent’s actual response to any sequence of percepts
Example: Vacuum world

- Percepts: [location, status], e.g., [A, Dirty]
- Actions: Left, Right, Suck, NoOp
## Vacuum cleaner agent

### Agent function

<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],[B,Clean]</td>
<td>Left</td>
</tr>
<tr>
<td>[A,Clean],[B,Dirty]</td>
<td>Suck</td>
</tr>
<tr>
<td>etc</td>
<td>etc</td>
</tr>
</tbody>
</table>

### Agent program

```java
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** agent function?

Can it be implemented by a small agent program?
Rationality

- A fixed *performance measure* evaluates the environment sequence
  - one point per square cleaned up?
    - Basically, but details matter: agent can dump dirt then clean, repeatedly
  - Add large penalty for dumping dirt? Add small penalty for moving?
- A *rational agent* chooses whichever action maximizes the *expected* value of the performance measure
  - given the percept sequence to date and prior knowledge of environment

Does Reflex-Vacuum-Agent implement a rational agent function?
  
  Yes, if movement is free, or new dirt arrives frequently
Rationality, contd.

- Are rational agents **omniscient**?
  - No – they are limited by the available percepts

- Are rational agents **clairvoyant**?
  - No – they may lack knowledge of the environment dynamics

- Do rational agents **explore and learn**?
  - Yes – in unknown environments these are essential

- Do rational agents **make mistakes**?
  - No – but their actions may be unsuccessful / suboptimal

- Are rational agents **autonomous** (i.e., transcend initial program)?
  - Yes – as they learn, their behavior depends more on their own experience
A human agent in Pacman
The task environment - PEAS

- **Performance measure**
  - -1 per step; +10 food; +500 win; -500 die; ghost
- **Environment**
  - Pacman dynamics (incl ghost behavior)
- **Actuators**
  - Left Right Up Down
- **Sensors**
  - Entire state is visible / observable (except power pellet duration)
Can we (in principle) extend this reflex agent to behave well in all standard Pacman environments?

- No – Pacman is not quite fully observable (power pellet duration)
- Otherwise, yes – we can \textit{(in principle)} make a lookup table.....
PEAS: Automated taxi

- **Performance measure**
  - Income, happy customer, vehicle costs, fines, insurance premiums

- **Environment**
  - US streets, other drivers, customers, weather, police...

- **Actuators**
  - Steering, brake, gas, display/speaker

- **Sensors**
  - Camera, radar, accelerometer, engine sensors, microphone, GPS

PEAS: Backgammon

- **Performance measure**
  - Move all checkers home first
- **Environment**
  - Game board, other player?
- **Actuators**
  - Roll dice, decide how to move pieces
- **Sensors**
  - See the full board
PEAS: Medical diagnosis system

- **Performance measure**
  - Patient health, cost, reputation
- **Environment**
  - Patients, medical staff, insurers, courts
- **Actuators**
  - Screen display, email
- **Sensors**
  - Keyboard/mouse, test results
## Environment types

<table>
<thead>
<tr>
<th></th>
<th>Pacman</th>
<th>Backgammon</th>
<th>Diagnosis</th>
<th>Taxi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fully or partially observable</td>
<td>F*</td>
<td>F</td>
<td>P</td>
<td>P</td>
</tr>
<tr>
<td>Single-agent or multiagent</td>
<td>M</td>
<td>M</td>
<td>S</td>
<td>M</td>
</tr>
<tr>
<td>Deterministic or stochastic</td>
<td>D</td>
<td>S</td>
<td>D*</td>
<td>S</td>
</tr>
<tr>
<td>Static or dynamic</td>
<td>D</td>
<td>D</td>
<td>S</td>
<td>D</td>
</tr>
<tr>
<td>Discrete or continuous</td>
<td>D</td>
<td>D</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>Known physics?</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>Known perf. measure?</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>Y*</td>
</tr>
</tbody>
</table>
Agent design

- The environment type largely determines the agent design
  - *Partially observable* => agent requires *memory* (internal state)
  - *Stochastic* => agent may have to prepare for *contingencies*
  - *Multi-agent* => agent may need to behave *randomly*
  - *Static* => agent has time to compute a rational decision
  - *Continuous time* => continuously operating *controller*
  - *Unknown physics* => need for *exploration*
  - *Unknown perf. measure* => observe/interact with *human principal*
Summary

- An **agent** interacts with an **environment** through **sensors** and **actuators**
- The **agent function** describes what the agent does in all circumstances
- Rational agents choose actions that maximize their expected utility
- PEAS descriptions define task environments; precise PEAS specifications are essential and strongly influence agent designs
- More difficult environments require more complex agent designs and more sophisticated representations