Artificial Intelligence

Intelligent Agents

Agent

- **Agent** is anything that *perceives* its environment through *sensors* and *acts* upon that environment through *effectors*.
  - Another definition later (by Minsky)
- **Humans**
  - Sensors: eyes, ears, etc.
  - Effectors: hands, legs, mouth, etc.
- **Robots**
  - Sensors: cameras, infrared range finders
  - Effectors: various motors
Agent Percepts

• Percept
  – Agent’s perceptual inputs at any given instant

• Percept “sequence”
  – Complete history of everything agent has perceived

• Agent’s choice of action can depend on entire percept sequence
Agent Function and Program

• Agent function
  – Specifies which action to take in response to any given percept sequence
    • Maps any given percept sequence to an action
  – Abstract mathematical description

• Agent program
  – Implements the agent function for an agent
    • Runs on the agent architecture

“Ideal Mapping” of Percepts to Actions

• Table of actions in response to each possible percept sequence
  – Simple table representation can be huge
    • For chess, the table would have $35^{100}$ entries!
  – Takes too long to build the table

• Define a specification of the mapping
  – Example: $\sqrt{}$ using Newton’s method rather than enumeration of all possible mappings
Good Behavior: The Rational Agent

- A **rational agent** is one that does the right thing (to be most successful)
  - e.g., *every* entry in the function table is filled out correctly
- What is the rational action for a particular circumstance?
  - Whichever action that will cause the agent to be most successful
    - Given what you have seen/know
    - **Need a way to measure success**

Performance Measure

- Performance measure
  - A way to evaluate the agent’s success
    - Embodies the criterion for success of an agent’s behavior
    - Specifies numerical value for any environment history toward the goals
- Performance measures for vacuum cleaner
  - Amount of dirt cleaned up in shift
    - BUG: Could maximize by cleaning-up, dumping, cleaning-up, etc!
  - Amount of electricity consumed
  - Amount of noise generated
- **When** to evaluate is also important
  - Timespan (shift, day, month, etc.)
Rationality Depends on…

• The **performance measure** that defines degree of success
• Everything the agent has perceived so far
  – The **percept sequence**
• What the agent **knows about the environment**
• The **actions** that the agent can perform

*This leads to...*

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Ideal Rational Agent

• For each possible percept sequence, do whatever action is **expected to maximize its performance measure**, using evidence provided by the **percept sequence** and any **built-in knowledge**
Rationality

• Rationality does not mean omniscience!
  – Omniscient agent knows actual outcome of its actions and can act accordingly
  – Impossible in reality (though available in simulation)
• Rationality is concerned with expected success given what has been perceived
  – Considered safe crossing street (left/right clear), but then hit from above…
  – Can “explore” to gather more information

Autonomy

• Autonomous behavior
  – Behavior is determined by its own experience
• Non-autonomous behavior
  – If no use of percepts (use only built-in knowledge), then system has no autonomy
    • A standard/generic clock has no autonomy
      – But consider a clock that detects and sets to atomic clock, or adjusts to different time zones, then it does!
  – All of its assumptions must hold
  – Certain animal behaviors
• A rational agent should be autonomous
Nature of Environments

- Must specify the setting for intelligent agent design
- Task environments
  - The “problems” to which rational agents are the “solutions”
- Multiple flavors of task environments
  - Directly affects the design of the agent
- PEAS description
  - (P)erformance Measure
  - (E)nvironment
  - (A)cutators
  - (S)ensors

PEAS Description

- Consider an “automated taxi driver” (Total Recall)
  - Performance Measure?
    - Safe, fast, obey laws, reach destination, comfortable trip, maximize profits
  - Environment?
    - Roads, other traffic, pedestrians, weather, customers
  - Actuators?
    - Steering, accelerator, brake, signal, horn, speak, display
  - Sensors?
    - Cameras, microphone, sonar, speedometer, GPS, odometer, accelerometer, engine sensors, keyboard
Other PEAS Examples

<table>
<thead>
<tr>
<th>Agent Type</th>
<th>Perf. Measure</th>
<th>Environment</th>
<th>Actuators</th>
<th>Sensors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medical diagnosis system</td>
<td>Healthy patient, minimize costs/lawsuits</td>
<td>Patient, hospital, staff</td>
<td>Display questions, tests, diagnoses, treatments, referrals</td>
<td>Keyboard entry of symptoms, findings, patient’s answers</td>
</tr>
<tr>
<td>Satellite image analysis system</td>
<td>Correct image classification</td>
<td>Downlink from orbiting satellite</td>
<td>Display classification of scene</td>
<td>Color pixel arrays (cameras)</td>
</tr>
<tr>
<td>Part-picking robot</td>
<td>Percentage of parts in correct bins</td>
<td>Conveyor belt with parts, bins</td>
<td>Jointed arm and hand</td>
<td>Camera, joint angle sensors</td>
</tr>
<tr>
<td>Refinery controller</td>
<td>Maximize purity, yield, safety</td>
<td>Refinery, operators</td>
<td>Valves, pumps, heaters, displays</td>
<td>Temperature, pressure, chemical sensors</td>
</tr>
<tr>
<td>Interactive English tutor</td>
<td>Maximize student’s score on test</td>
<td>Set of students, testing agency</td>
<td>Display exercises, suggestions, corrections</td>
<td>Keyboard entry</td>
</tr>
</tbody>
</table>

Properties of Environments

- Fully observable vs. partially observable
  - If sensors give access to complete state of environment
- Deterministic vs. stochastic
  - If next state of environment is completely determined by current state and the action executed by the agent (Can’t predict environment in stochastic)
- Episodic vs. sequential
  - Experience divided into atomic episodes (perceiving and acting)
  - Next episode does not depend on previous episodes
- Static vs. dynamic
  - Environment not change while agent is “thinking”
- Discrete vs. continuous
  - Distinct, clearly defined percepts and actions (chess)
- Single Agent vs. multi-agent
  - Solving a puzzle is single agent
  - Chess is competitive multi-agent environment
Environment Examples

<table>
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<tr>
<th></th>
<th>Crossword puzzle</th>
<th>Taxi Driving</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observability</td>
<td>Fully</td>
<td>Partially</td>
</tr>
<tr>
<td>Deterministic vs Stochastic</td>
<td>Deterministic</td>
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<td>Single vs Multi Agent</td>
<td>Single</td>
<td>Multi</td>
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Structure of Intelligent Agents

- **Agent = Architecture + Program**
  - Architecture is the computing device
    - Makes sensor percepts available to the program
    - Runs the program
    - Feeds action choices to effectors
  - Program
    - Implements agent function mapping of percepts to actions

- The main job of AI is to design successful **Agent Programs**
  - Though much current emphasis on **embodiment**
Basic Types of Agent Programs

- Simple reflex agents
  - Condition-action rules on current percept
    - Environment must be fully observable
- Model-based reflex agents
  - Maintain internal state about how world evolves and how actions effect world
- Goal-based agents and utility-based agents
  - Use goals and planning to help make decision
  - Do what makes the agent “happiest”
- Learning agents
  - Makes improvements to self

Summary

- Agent
  - Perceives and acts in an environment
- Ideal agent
  - Takes the action that is expected to maximize the performance measure, given its percepts
- Agent design: PEAS
  - (P)erformance measure, (E)nvironment, (A)ctuators, and (S)ensors
Summary (con’t)

- Agent environments
  - Environments that are partially observable, stochastic, sequential, dynamic, continuous, and multi-agent are hardest (real world)

- Agent types
  - Reflex, model-based, goal-based, utility-based, learning