AIMA CHAPTER 2, 2ND ED. (AFTER RUSSELL AND NORVIG)
Outline

- Agent Functions, Programs, and Types
- Environment Specification and Types
- Rationality
- Agents and Environments
- Review and Discussion
- Administration
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- Homework questions: class alias: cs1573@cs.pitt.edu

Administration
Review and Discussion

it advance the state of the art in AI?
Winner of the Loebner Prize: What techniques does it use? How does research and come prepared to report on the latest (or other recent)

Discussion: Loebner Prize

Last time: What is AI, Fundamentals, History, State of the Art
What about "Surely animals, humans and computers cannot be intelligent forms."

- they can do only what their constituent atoms are told to do by the laws

Former programmer's tell them, "Is the latter statement true, and does it imply the

"Surely computers cannot be intelligent - they can do only what their

be a bad methodology?

Why might the use of introspection (reporting on one's inner thoughts)

human

on a standard IQ test? Would we have a program more intelligent than a

Suppose we extend a classic ANALOGY program so that it can score 200

probably undecidable for computers. Does this mean that AIs is impossible?

There are well-known classes of problems that are intrinsically difficult or

More Discussion Points
An agent perceives its environment through sensors and acts upon it through actuators. Agents interact with environments.
Example Sensors and Actuators
Example Sensors and Actuators

- Softbot
- Keystrokes / displays
- Robot
- Cameras / motors
- Humans
- Eyes and ears / hands and legs
Problematic from an Implementation perspective (why?), so need agent pro-

- percept sequence
  - action: an agent's action choice at any instant can depend on the entire
    - percept sequence: complete history
    - percepts: agent's perceptual inputs at any instance
  (and thus describes behavior)

Mathematically, an agent function maps any percept sequence to an action

Agnets and Environments (cont.)
Consider the task of designing an automated taxi:

- Environment
- Action
- Perception

Examples (cont.)
customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers', ... customers'
Another Example: Vacuum World
Another Example: Vacuum World
What is the obvious question for AI?

How can we define different vacuum world agents?

<table>
<thead>
<tr>
<th>Agent Action</th>
<th>Percept sequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right</td>
<td>(A, Clean)</td>
</tr>
<tr>
<td>Suck</td>
<td>(B, Dirty)</td>
</tr>
<tr>
<td>Left</td>
<td>(B, Clean)</td>
</tr>
<tr>
<td>Suck</td>
<td>(A, Dirty)</td>
</tr>
<tr>
<td>Right</td>
<td>(A, Clean)</td>
</tr>
</tbody>
</table>

Partial tabulation of this simple agent function:

Agent function: if the current square is dirty, then suck dirt; otherwise, move to the other square.

Simple Agent Function for Vacuum World
behavior

a performance measure embodies the criterion for success of an agent’s

therefore, we need to be able to measure success

the right action is the one that will cause the agent to be most successful

action function table is filled out correctly

A rational agent is one that does „the right thing“ e.g., every entry in the

Good Behavior: Rationality
What are reasonable performance measures for the vacuum world?

History

Performance Measure: an objective, numerical value for any environment

Performance Measures
(laws)

It's difficult to come up with measures (sustained mediocrity vs. highs and lows)

then how you think the agent should behave

better to measure what you want in the environment, rather

having a clean floor

the amount of dirt cleaned up in an hour

What are reasonable performance measures for the vacuum world?

Performance measure: an objective, numerical value for any environment

Performance Measures
Does our vacuum agent define a rational agent?

**Rational agent**: for each possible percept sequence, selects an action that is expected to maximize its performance measure.

**Rational action**: whichever action maximizes the expected value of the performance measure given the percept sequence to date and built-in knowledge.

- the agent's percept sequence to date
- the actions that the agent can perform
- the agent's prior knowledge of the environment
- the performance measure defining the success criterion

Rationality depends on...
and/or incorrect - knowledge)
learn to be autonomous (rely on percepts rather than prior – often partial)

learn from percepts (to augment or modify prior knowledge)

Rational agents should also

exploration of actions to modify future percepts, exploration

crossing without looking is not rational because lacks information

date! perception maximizes actual performance

rationality maximizes expected performance, depending on knowledge to

airplane flatters person crossing street example

Rational ≠ omniscient

Omniscience, Learning, and Autonomy
• Sensors: camera, sonar, speedometer, GPS
• Actuators: steering, accelerator, brake, horn
• Environment: roads, traffic, pedestrians, customers
• Profitable

Performance Measures: correct destination, safe, fast, legal, comfortable

Example: PEAS Specification for an Automated Taxi Driver Agent

We thus need to specify the problem before we develop the solution

Task Environments: "problems" to which "agents" are solutions
NOTE: toy ≠ artificial environment

See Figure 2.5 for more examples

What about a Speech-based Conversational Tutor?

- Sensors: keyboard entry
- Actuators: display exercise, suggestions, corrections
- Environment: students, testing agency
- Performance: maximize test score

Text-based Conversational Tutor

More PEAS Examples
Sequential: short term actions can have long term consequences.

Episode: independent episodes (current percept, then perform a single action, e.g., assembly line).

Episodic versus Sequential:

Current state and action choice is deterministic if next environment state is completely determined by the current state and action choice.

Deterministic versus Stochastic:

Often partial due to noise and incompleteness.

Fully is with respect to observation relevance for action choice (thus de-

Fully versus Partially Observable.
What is the harshest environment?

- Multi-agent can be cooperative, competitive (which can impact choice)
  - multi-agents can be cooperative, competitive

Single vs. Multi-Agent

- can be applied to environment state, time, percepts and actions

Discrete vs. Continuous

Score does

- semidynamic: environment doesn’t change with time but performance

Dynamic: environment can change during thought

Static vs. Dynamic
<table>
<thead>
<tr>
<th>Crossword</th>
<th>Backgammon</th>
<th>Tutor</th>
<th>Taxi</th>
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<tbody>
<tr>
<td>Environment Dimensions: Examples</td>
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<td></td>
<td></td>
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</tbody>
</table>

**Agents**

**Discrete**

**Static**

**Episodic**

**Deterministic**

**Observable**
See also Figure 2.6

continuous

The real world is (of course) inaccessible, stochastic, sequential, dynamic,

The environment type largely determines the agent design

<table>
<thead>
<tr>
<th>Multi</th>
<th>Multi</th>
<th>Multi</th>
<th>Single</th>
<th>Agent?</th>
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</thead>
<tbody>
<tr>
<td>No</td>
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<td>Yes</td>
<td>Yes</td>
<td>Discrete?</td>
</tr>
<tr>
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<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Static?</td>
</tr>
<tr>
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<td>No</td>
<td>No</td>
<td>No</td>
<td>Episodic?</td>
</tr>
<tr>
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<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Deterministic?</td>
</tr>
<tr>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Observable?</td>
</tr>
</tbody>
</table>

Examples: Environment Dimensions
One agent function (or a small equivalence class) is rational.

Obviously, a lookup table would usually be immense.

In principle, one can supply each possible sequence to see what it does.

An agent is completely specified by the agent function mapping percept sequences to actions (desirable behavior)

Agent Functions
An agent program takes a single percept as input, keeps internal state:

- agent = architecture + program

The job of AI is to design the agent program that implements the agent.
Agent Types

- utility-based agents
- goal-based agents
- model-based reflex agents with state
- simple reflex agents

Four basic types in order of increasing generality:
represent both innate and learned reflexes
Condition-action rules (e.g., if car-in-front-is-breaking then initiate-breaking)

Action selection is based on the current percept (assumes fully observable environment)
Note that the programs are smaller than the function they implement (Figure 2.3).

Figures 2.8 (specific to vacuum world) and 2.10 (generalization)
State is updated with the model (how the world evolves, agent's actions):
State handles partial observability

Agent

Environment

Actuators

What should I do now?

What my actions do

How the world evolves

State

Condition-action rules

What action I

What the world is like now

Model-Based Reflex Agents with State
These agents consider the future (e.g., break via reasoning, not just reflexes) and planning deal with tricky goal-based action (sequence) selection.
Useful for conflicting goals and goal choice

order

A utility function maps a state onto a real number representing a preference

Goals are just binary

Utility-Based Agents
Previously, learning is how programs come into being and improve. Learning is concerned with methods for action selection in the agent program. Performance element was previously the agent; problem generator is for ex-
Learning agents: improve performance via learning

Agent designs: best choice (e.g., simple reflex) depends on environment

Agent program: implements the agent function

dynamic

Task environment: specification via PEA$S$, many dimensions (e.g., static or

measure given the percept sequence to date

Rational agent: acts to maximize the expected value of the performance

Performance measure: evaluates the agent's behavior in an environment

guence

Agent function: specifies the action taken in response to any percept as-

Agent: something that perceives and acts in an environment

Summary
Continue Python Self-Study

Next reading from syllabus

Recognition errors, 2.12

Discussion points (2.2’, 2.5-2.6) for a spoken dialogue system with speech

HW1 DUE

Send emails (if needed)

For Next Time