Intelligent Agents

AIMA Chapter 2, 2nd Ed. (after Russell and Norvig)

Outline

- ◊ Administration
- ◊ Review and Discussion
- ◊ Agents and Environments
- ◊ Rationality
- ◊ Environment Specification and Types
- ◊ Agent Functions, Programs, and Types

Administration

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Review and Discussion

◇ Last time: What is AI, Foundations, History, State of the Art

◇ Discussion Point: Loebner Prize

Research and come prepared to report on the latest (or other recent) winner of the Loebner prize. What techniques does it use? How does it advance the state of the art in AI?

More Discussion Points

◇ There are well-known classes of problems that are intractably difficult or provably undecidable for computers. Does this mean that AI is impossible?

◇ Suppose we extend a classic ANALOGY program so that it can score 200 on a standard IQ test? Would we have a program more intelligent than a human?

◇ Why might the use of introspection (reporting on one's inner thoughts) be a bad methodology?

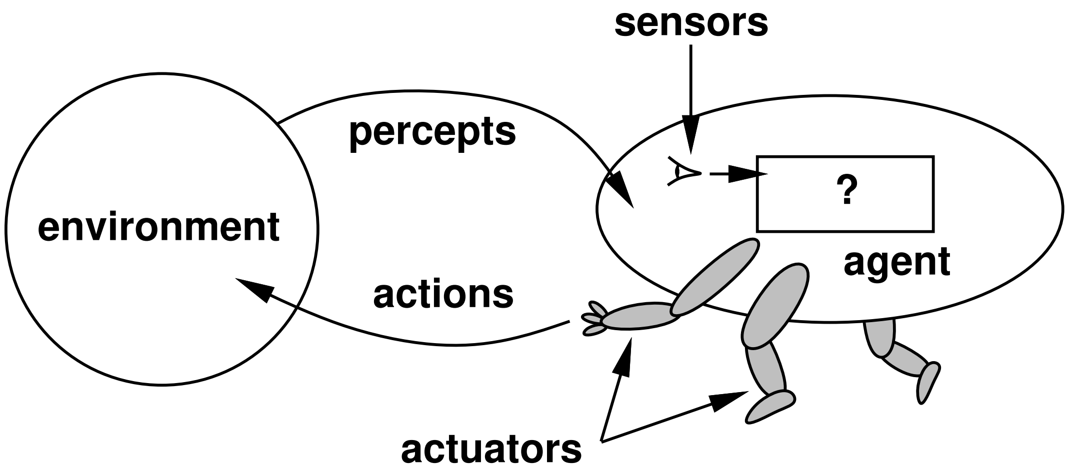
◇ "Surely computers cannot be intelligent - they can do only what their programmers tell them." Is the latter statement true, and does it imply the former?

◇ What about "Surely animals, humans and computers cannot be intelligent - they can do only what their constituent atoms are told to do by the laws of physics."?

Agents Interact with Environments

Must first specify the setting for intelligent agent design

An *agent* perceives its *environment* through *sensors* and acts upon it through *actuators*



Example Sensors and Actuators

Humans??

Robots??

Softbots??

Example Sensors and Actuators

Humans?? eyes and ears / hands and legs

Robot?? cameras / motors

Softbot?? keystrokes /displays

Agents and Environments (cont.)

Mathematically, an *agent function* maps any percept sequence to an action (and thus describes behavior)

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

Problematic from an implementation perspective (why?), so need *agent programs*

Examples (cont.)

Consider the task of designing an automated taxi:

Percepts??

Actions??

Environment??

Examples (cont.)

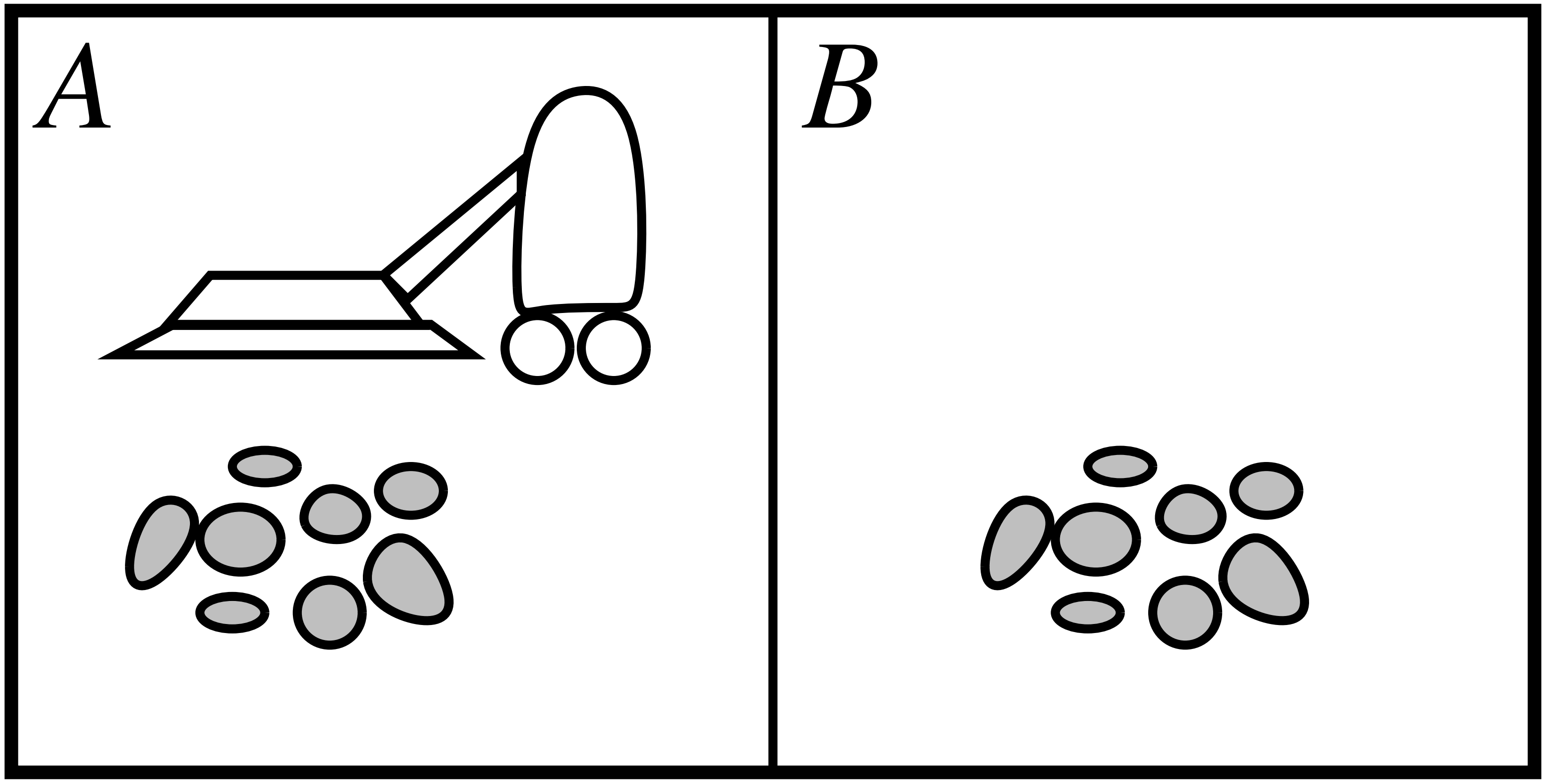
Consider the task of designing an automated taxi:

Percepts?? video, accelerometers, gauges, engine sensors, keyboard, GPS, . . .

Actions?? steer, accelerate, brake, horn, speak/display, . . .

Environment?? US urban streets, freeways, traffic, pedestrians, weather, customers, . . .

Another Example: Vacuum World



Percepts??

Actions??

Environment??

Another Example: Vacuum World

Percepts?? location, dirtiness

Actions?? suck, left, right, no-op

Environment?? grid, walls/obstacles, dirt distribution and creation, agent body (movement actions work unless bump into wall, suck actions put dirt into agent body (or not))

Simple Agent Function for Vacuum World

Partial tabulation of this simple agent function

Percept sequence	Action
(A, Clean)	Right
(A, Dirty)	Suck
(B, Clean)	Left
(B, Dirty)	Suck
(A, Clean) (A, Clean)	Right
...	...

How can we define different vacuum world agents?

What is the obvious question for AI?

Agent Program

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

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*

Good Behavior: Rationality

A *rational agent* is one that does "the right thing", e.g., every entry in the action function table is filled out correctly

- the right action is the one that will cause the agent to be most successful
- therefore, we need to be able to measure success
- a *performance measure* embodies the criterion for success of an agent's behavior

Performance Measures

Performance measure: an objective, numerical value for any environment history

What are reasonable performance measures for the vacuum world?

Performance Measures

Performance measure: an objective, numerical value for any environment history

What are reasonable performance measures for the vacuum world?

- the amount of dirt cleaned up in an hour
  - one point per square cleaned up in time T?
  - one point per clean square per time step, minus one per move?
  - penalize for $> k$ dirty squares?
- having a clean floor
- generally better to measure what you want in the environment, rather than how you think the agent should behave
- difficult to come up with measures (sustained mediocrity vs. highs and lows)

Rationality

Rationality depends on

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

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

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

Rational $\neq$ omniscient
Rational $\neq$ clairvoyant
Rational $\neq$ successful

Omniscience, Learning, and Autonomy

Rational $\neq$ omniscient

- airplane flattens person crossing street example
- rationality maximizes *expected* performance, depending on knowledge *to date*; perfection maximizes *actual performance*
- crossing without looking is not rational because lacks information gathering (doing actions to modify future percepts, exploration)

Rational agents should also

- *learn* from percepts (to augment or modify prior knowledge)
- learn to be *autonomous* (rely on percepts rather than prior – often partial and/or incorrect – knowledge)

Rational $\Rightarrow$ exploration, learning, autonomy

Specifying the Task Environment: PEAS

Task Environments: “problems” to which “agents” are solutions

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

Example: PEAS Specification for an Automated Taxi Driver Agent

- Performance Measures: correct destination, safe, fast, legal, comfortable, profitable, ...
- Environment: roads, traffic, pedestrians, customers, ...
- Actuators: steering, accelerator, brake, horn, ...
- Sensors: camera, sonar, speedometer, GPS, ...

More PEAS Examples

Text-based Conversational Tutor

- performance: maximize test score
- environment: students, testing agency
- actuators: display exercise, suggestions, corrections
- sensors: keyboard entry

What about a Speech-based Conversational Tutor?

See Figure 2.5 for more examples

NOTE: toy $\neq$ artificial environment

Environment Dimensions

Fully versus Partially Observable

- fully is with respect to observation relevance for action choice (thus depends on performance measure)
- often partial due to noise and incompleteness

Deterministic versus Stochastic

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

Episodic versus Sequential

- episodic: independent episodes (current percept, then perform a single action, e.g., assembly line)
- sequential: short term actions can have long term consequences

Static versus Dynamic

- dynamic: environment can change during thought
- semidynamic: environment doesn't change with time but performance score does

Discrete versus Continuous

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

Single versus Multi Agent

- other agents if their behavior is maximizing a performance measure based on first agent's behavior
- multi-agents can be cooperative, competitive (which can impact choice of communication actions and stochastic behavior)

What is the hardest environment?

Environment Dimensions: Examples

	Crossword	Backgammon	Tutor	Taxi
Observable??				
Deterministic??				
Episodic??				
Static??				
Discrete??				
Agents??				

Environment Dimensions: Examples

	Crossword	Backgammon	Tutor	Taxi
Observable??	Yes	Yes	No	No
Deterministic??	Yes	No	No	No
Episodic??	No	No	No	No
Static??	Yes	Yes	No	No
Discrete??	Yes	Yes	Yes	No
Agents??	Single	Multi	Multi	Multi

The environment type largely determines the agent design

The real world is (of course) partially observable, stochastic, sequential, dynamic, continuous, multi-agent

See also Figure 2.6

Agent Functions

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

- In principle, one can supply each possible sequence to see what it does. Obviously, a lookup table would usually be immense.
- One agent function (or a small equivalence class) is rational

Agent Programs

The job of AI is to design the agent program that implements the agent function – concisely

- agent = architecture + program

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

function TABLE-DRIVEN-AGENT(*percept*) **returns** an action
  static: *percepts*, a sequence, initially empty
    table, a table of actions, indexed by percept sequences, initially fully specified

  $percepts \leftarrow$ APPEND($percept, percepts$)
  $action \leftarrow$ LOOKUP($percepts, table$)
  return *action*

Agent Types

Four basic types in order of increasing generality:

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

All these can be turned into learning agents

Simple Reflex Agents

Action selection is based on the *current* percept (assumes fully observable environment)

Condition-action rules (e.g., **if** car-in-front-is-breaking **then** initiate-breaking) represent both innate and learned reflexes

See Simple Reflex Agent Figure

Simple Reflex Agent Programs: Examples

Figures 2.8 (specific to vacuum world) and 2.10 (generalization)

Note that the programs are smaller than the function they implement (Figure 2.3)

Model-Based Reflex Agents with State

State handles partial observability

State is updated with the model (how the world evolves, agent's actions): interpret-input(percept) replaced with update-state(state,action,percept)

See Reflex+State Agent Figure

Goal-Based Agents

Search and *planning* deal with tricky, goal-based action (sequence) selection

These agents consider the future (e.g., brake via reasoning, not just reflex)

See Goal-Based Agent Figure

Utility-Based Agents

Goals are just binary

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

Useful for conflicting goals and goal choice

See Utility-Based Agent Figure

Learning Agents

Previously, concerned with methods for action selection in the agent program

Learning is how programs come into being, and improve

Performance element was previously the agent; problem generator is for exploration

See Learning Agent Figure

AIMA code

The code for each topic is divided into four directories:

– `agents`: code defining agent types and programs
– `algorithms`: code for the methods used by the agent programs
– `environments`: code defining environment types, simulations
– `domains`: problem types and instances for input to algorithms

Summary

Agent: something that perceives and acts in an environment

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

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

Rational agent: acts to maximize the expected value of the performance measure given the percept sequence to date

Task environment: specification via PEAS, many dimensions (e.g. static or dynamic)

Agent program: implements the agent function

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

Learning agents: improve performance via learning

For Next Time

Send emails (if needed)

Discussion points (2.2, 2.5-2.6 for a spoken dialogue system with speech recognition errors, 2.12)

Next readings