

# INTELLIGENT AGENTS

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

# Outline

- ◇ Agents and Environments
- ◇ Rationality
- ◇ Environment Specification and Types
- ◇ Agent Functions, Programs, and Types

# 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
<u>Observable??</u>				
<u>Deterministic??</u>				
<u>Episodic??</u>				
<u>Static??</u>				
<u>Discrete??</u>				
<u>Agents??</u>				

## Environment Dimensions: Examples

	Crossword	Backgammon	Tutor	Taxi
<u>Observable??</u>	Yes	Yes	No	No
<u>Deterministic??</u>	Yes	No	No	No
<u>Episodic??</u>	No	No	No	No
<u>Static??</u>	Yes	Yes	No	No
<u>Discrete??</u>	Yes	Yes	Yes	No
<u>Agents??</u>	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 ← APPEND(percept, percepts)
  action ← 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

## 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