CS4725/CS6705

Chapter 2: Intelligent Agents

Intelligent Agents

- Reminder: Our goal is to design agents that behave rationally:
  - always take the action that will lead (or is most likely to lead) to the highest level of success, according to some measure of success.
- We think of an agent as anything that can perceive its environment through sensors and can act upon the environment through actuators.

Some terminology

- **Percept**: agent's perceptual inputs at any time
- **Percept sequence**: everything that agent has ever perceived
- **Agent function**: what action will the agent take, given any possible percept sequence?
- Agent function is implemented by an **agent program**

Very simple example: Vacuum-cleaner world

- Two squares, A and B
- Agent can perceive where it is and whether there is dirt in the square
- Actions available: move left, move right, suck up the dirt, do nothing
- One possible agent function: if current square is dirty, then suck, otherwise move to the other square
- Question: How do we design the “best” agent for an environment like this?

Performance Measures

- In order to determine if an agent has performed well (and in order to design an agent that will perform well), we need an objective performance measure.
- Vacuum-cleaner example:
  - Amount of dirt cleaned up?
  - Points for each clean square at each time step?
  - Penalties for electricity consumption, noise?
- General rule: design performance measures according to what one actually wants in the environment

Rationality

- What is rational at a given time depends on:
  - The performance measure
  - The agent's prior knowledge of the environment
  - The available actions
  - The agent's percept sequence so far

Definition of a rational agent

- “For each possible percept sequence, a rational agent should select an action that is expected to maximize its performance measure, given the evidence provided by the percept sequence and whatever built-in knowledge the agent has.”

Rationality ≠ perfection

- Note: A rational agent maximizes **expected** performance.
  - Given what it knows, it will choose the action that maximizes expected success.
  - It cannot be expected to perform perfectly all the time since it cannot always predict the exact effects of its actions and since it might not have complete information about its environment.

Other aspects of rational behaviour

- Information gathering
- Learning
- Autonomy

Environments

- A very important factor in how an agent should behave is the **environment** in which it is acting.
- **PEAS**: **P**erformance, **E**nvironment, **A**ctuators, **S**ensors
- Examples from the book: automated taxi driver, medical diagnosis system, satellite image analysis system, part-picking robot, etc.

Properties of task environments

- Fully observable vs. partially observable
- Single agent vs. multi-agent
- Deterministic vs. stochastic
- Episodic vs. sequential
- Static vs. dynamic (vs. semidynamic)
- Discrete vs. continuous
- Known vs. unknown

Examples of task environments

Task environment	Observ.?	Determ./ Stochastic	Episodic/ Sequential	Static/ Dynamic	Discrete/ Continuous	Agents
Crosswords	Fully	Determ.	Sequential	Static	Discrete	Single
Chess (clock)	Fully	Determ.	Sequential	Semi	Discrete	Multi
Poker	Partially	Stochastic	Sequential	Static	Discrete	Multi
Backgammon	Fully	Stochastic	Sequential	Static	Discrete	Multi
Taxi driving	Partially	Stochastic	Sequential	Dynamic	Continuous	Multi
Med. diagn.	Partially	Stochastic	Sequential	Dynamic	Continuous	Single
Image analysis	Fully	Determ.	Episodic	Semi	Continuous	Single
Part-picking robot	Partially	Stochastic	Episodic	Dynamic	Continuous	Single
Refinery ctrl.	Partially	Stochastic	Sequential	Dynamic	Continuous	Single
English tutor	Partially	Stochastic	Sequential	Dynamic	Discrete	Multi

The structure of agents

- Agent = architecture + program
- Agent programs in the textbook: take the current percept as input from the sensors and return an action to the actuators
- Many different types of agents, depending on how they make their decisions:
  - Simple reflex agents
  - Model-based reflex agents
  - Goal-based agents
  - Utility-based agents

Simple reflex agents

- An action is selected on the basis of the current percept, ignoring the rest of the percept history.
- Condition-action rules
- Need for randomization sometimes

Model-based reflex agents

- The agent maintains an internal state, which depends on the percept history and keeps track of aspects of the world that are not part of the current percept.
- Model of the world: information about how the world changes, both based on the agent's own actions and independently
- An agent's actions depend on both the current percept and the agent's internal state.

Goal-based agents

- An agent's choice of action can also depend on some goal that it is trying to achieve.
- Goals might be achievable by performing a single action, but often require search or planning to find appropriate **sequences** of actions.

Utility-based agents

- Utility: a measure of how useful or desirable a particular state of the world is
- Utility function: maps a state (or sequence of states) to a real number, representing the agent's degree of happiness in that state
- Rational utility-based agents behave in order to maximize expected utility.

Learning agents

- We will talk later in the course about how agents can learn from their experiences and use this learning to improve their performance in later situations.