Course: Introduction to AI

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Chapter 2

Intelligent Agents

Outline

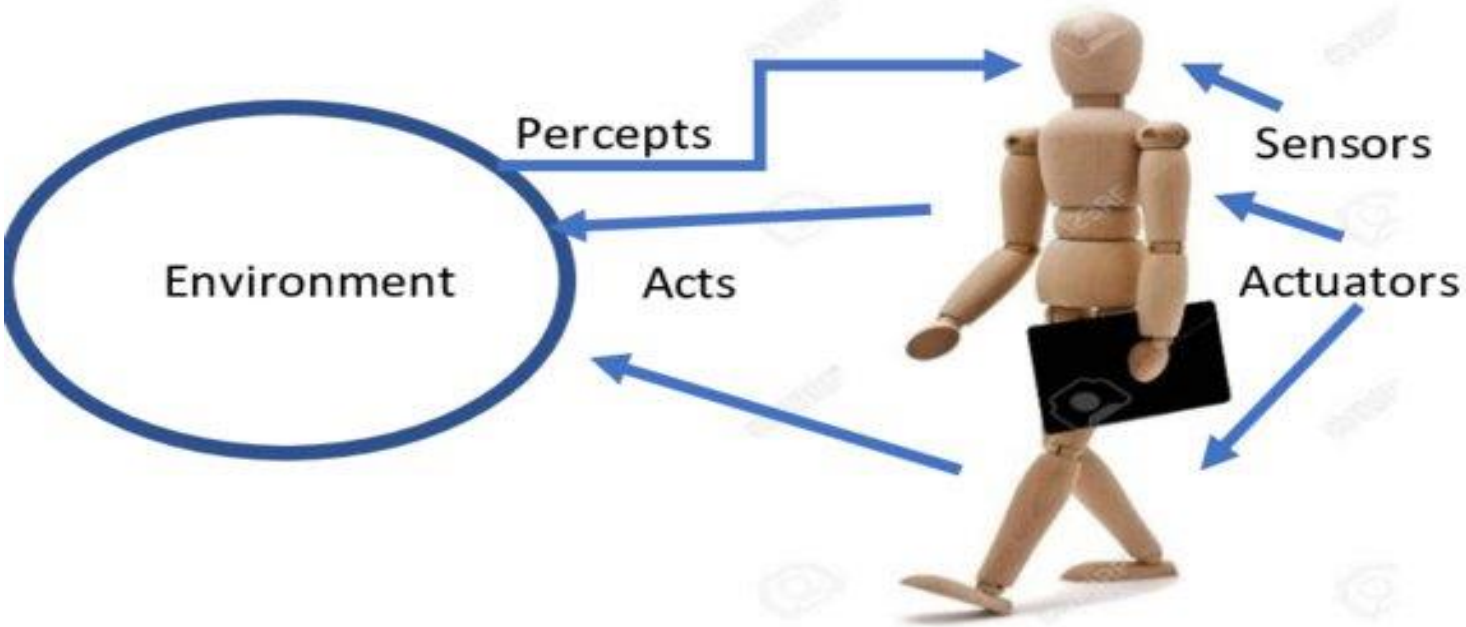
- Agents and Environments
- Good Behavior: The Concept of Rationality
  - Rationality
  - Omniscience, learning, and autonomy
- The Nature of Environments
  - Specifying the task environment
  - Properties of task environments
- THE STRUCTURE OF AGENTS
  - Agent programs
  - Simple reflex agents
  - Model-based reflex agents
  - Goal-based agents
  - Utility-based agents
  - Learning agents
  - How the components of agent programs work

Aim of this chapter

- **Rational agents** as central to "our" approach to artificial intelligence
- The concept of **rationality** can be applied to a wide variety of agents operating in any imaginable environment
- Use this concept to develop a small set of design principles for building successful agents—systems that can reasonably be called **intelligent**.

Agents and Environments: Agents

- **Agent:** anything that can be viewed as perceiving its **environment** through **sensors** and acting upon that environment through **actuators. E.g.:**



https://www.researchgate.net/publication/357618741_Challenges_of_Artificial_Intelligence_--_From_Machine_Learning_and_Computer_Vision_to_Emotional_Intelligence/figures?lo=1

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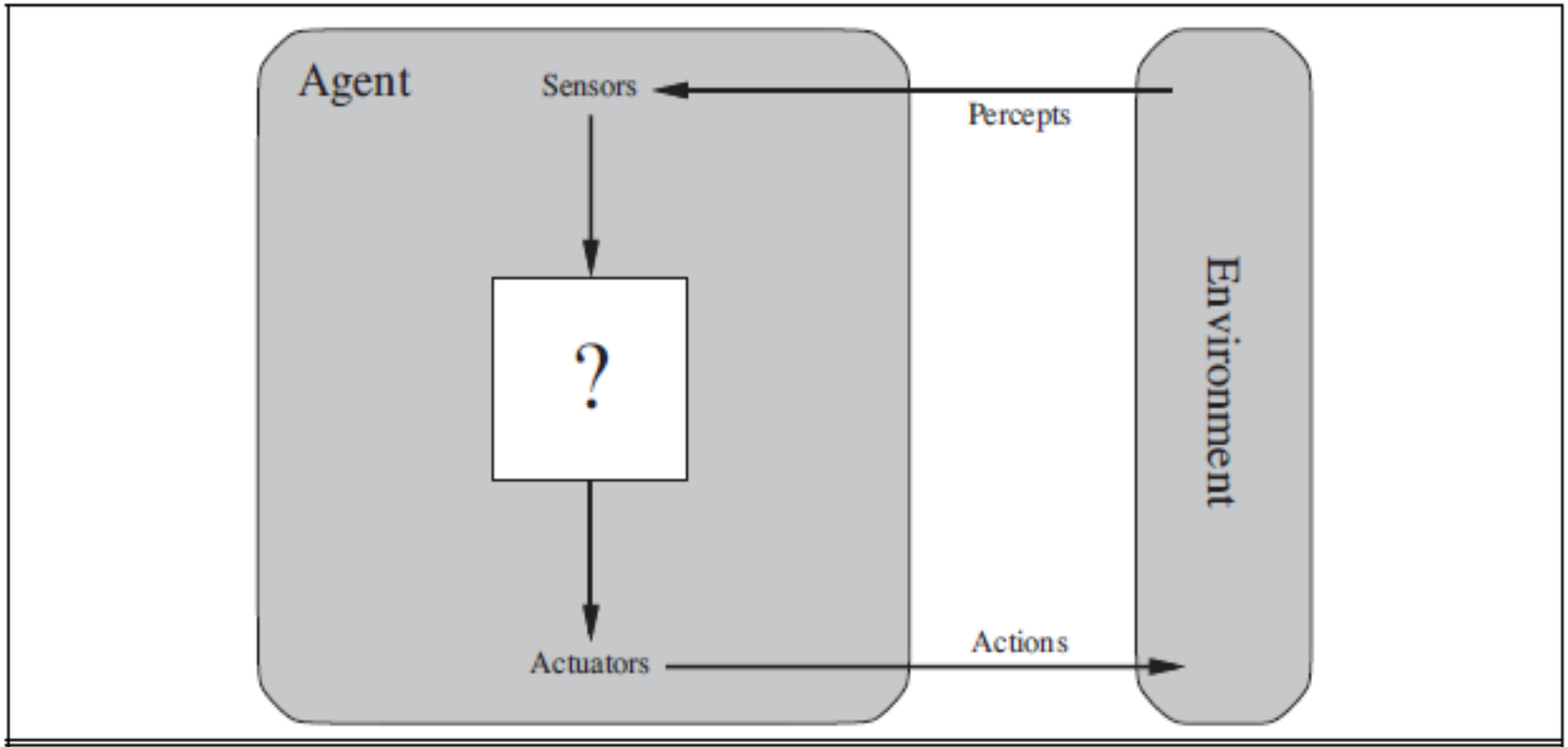

Figure 2.1 Agents interact with environments through sensors and actuators.

Agents and Environments: Agents

Examples of Agents:

- Human agent:
  - Sensors: eyes, ears, hands, …
  - Actuators: hands, legs, vocal tract, …
- Robotic agent:
  - Sensors: cameras, infrared and sonar range finders…
  - Actuators: various motors, robot arm...
- Software agent:
  - Sensory inputs: keystrokes, file contents, network packets, …
  - Actions: displaying on the screen, writing files, sending network packets, …

Agents and Environments: Agents

- **Percept:** the agent's perceptual inputs at any given instant.
- Agent's **percept sequence:** complete history of everything the agent has ever perceived.
- *An agent's choice of action at any given instant can depend on the entire percept sequence observed to date, but not on anything it hasn't perceived.*
- Mathematically speaking, we say that an agent's behaviour is described by the **agent function** that maps any given percept sequence to an action.

Agents and Environments: Agents

- The **agent function** can be pictured as a table of mappings between percept sequences and actions.
- Such a table is an external (abstract mathematical) characterization of the agent function.
- *Internally*, the agent function for an artificial agent will be implemented within some physical system by an **agent program**.

Agent example

- Vacuum-cleaner world
  - 2 locations A and B
  - Agent **perceives** which square it is in and whether there is dirt in the square
  - Actions: *move left*, *move right*, *suck up the dirt*, or *do nothing.*

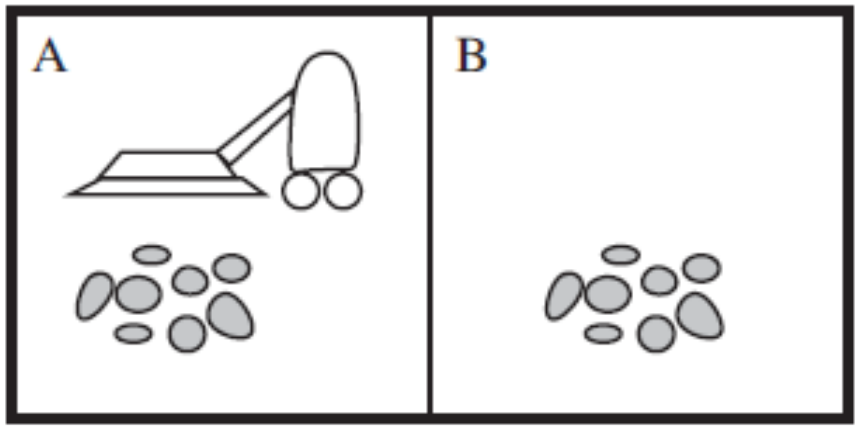

Figure 2.2 A vacuum-cleaner world with just two locations.

Partial tabulation of vacuum-cleaner agent function

Percept sequence Action	Action
[A, Clean]	Right
[A, Dirty]	Suck
[B, Clean]	Left
[B, Dirty]	Suck
[A, Clean], [A, Clean]	Right
[A, Clean], [A, Dirty]	Suck
.	.
.	.
.	.
[A, Clean], [A, Clean], [A, Clean]	Right
[A, Clean], [A, Clean], [A, Dirty]	Suck
.	.
.	.
.	.

Agent function design

- So there is a need to define the *Actions* corresponding to the percepts.
- **Question***:*
  - *What is the right way to fill out the table? (*i.e. what makes an agent good or bad, intelligent or stupid?)
- **N.B.:**
  - All areas of engineering can be seen as designing artifacts that interact with the world; but
  - **AI** operates where the artifacts have **significant computational resources** and the task environment requires **nontrivial decision making.**

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GOOD BEHAVIOR: THE CONCEPT OF RATIONALITY

- A **rational agent** is one that does the *right thing.* (i.e. every action in the table is *correct*)
- What does "right thing" ("correct action") mean?
- Obvious approach: consider the *consequences* of the agent's behaviour.

  Percepts → sequences of actions →

  environment goes through a sequence of states
- Desirability is captured by a **performance measure** that evaluates any given sequence of environment states.
- The performance measure is designed specifically for the task at stake.

Performance measure for vacuum cleaner agent

- Amount of dirt cleaned in a fixed period of time?
  - *Risk: agent cleans up the floor well, dumps the dirt, cleans up again, etc. ➔ not a good performance measure*
- Alternative: reward the agent for having a clean floor. ➔ it is a more suitable measure
  - Award one point for each clean square at each time step (perhaps with a penalty for electricity consumed and noise generated).
- *General rule: design performance measures according to expectations in the environment.*
- *N.B.:* "*Average* cleanliness over time" *is questionable!*

Rationality

- What is rational at any given time depends on four factors:
  - The performance measure that defines the criterion of success.
  - The agent's prior knowledge of the environment.
  - The actions that the agent can perform.
  - The agent's percept sequence to date.
- **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: vacuum-cleaner agent

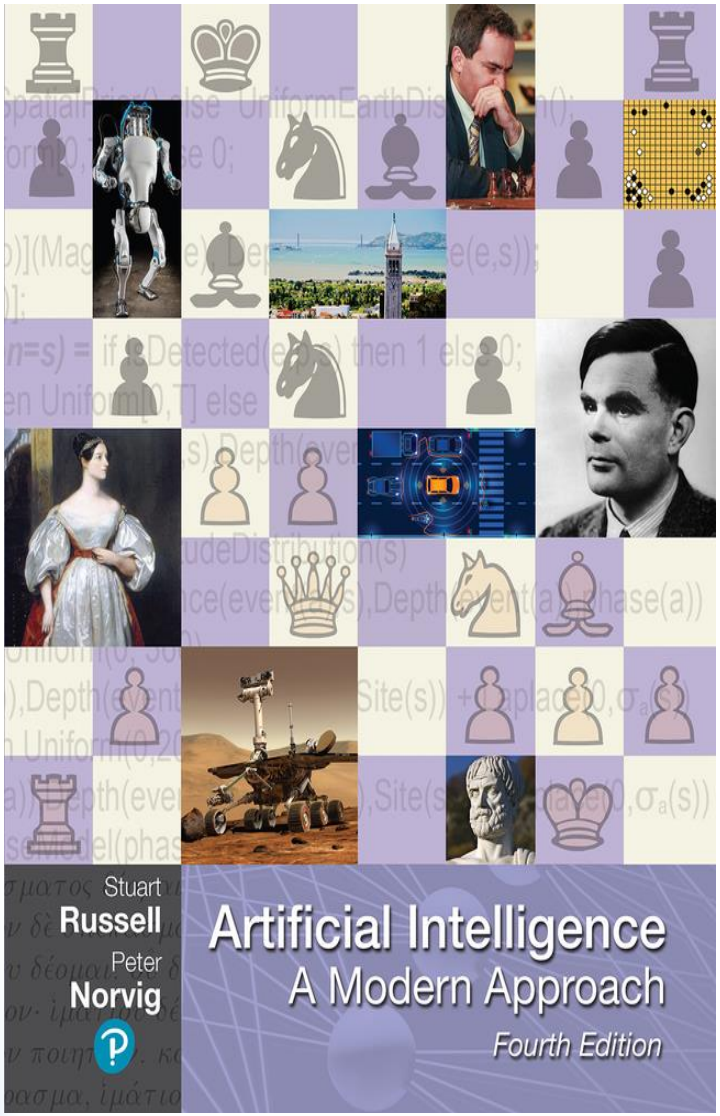
- *if square is dirty clean it; else move to the other square*. (function previously tabulated)
- Is this a rational agent?

  (Yes; left as textbook exercise.)
- We need to analyse the enunciated 4 factors.
  - Performance measure: award one point for each clean square at each time step, over 1000 time steps period.
  - Only available actions: Left, Right, and Suck.
  - Environment "geography" known a priori; but not dirt distribution nor agent initial location. Clean squares stay clean; sucking cleans current square. Left and Right actions move agent left and right except when this would take agent outside the environment, in which case agent remains where it is.
  - The agent correctly perceives its location and whether that location contains dirt.

Rationality: vacuum-cleaner agent

- Note that the same agent would be irrational under different circumstances.
- For example,
  - Once all the dirt is cleaned up, the agent will oscillate needlessly back and forth;
  - If the performance measure includes a penalty of one point for each movement left or right, the agent will perform poorly. A better agent for this case would do nothing once it is sure that all the squares are clean.
  - If clean squares can become dirty again, the agent should occasionally check and re-clean them if needed.
  - If the geography of the environment is unknown, the agent will need to explore it rather than remain in square A or B.
- (Exercise 2.2 asks you to design agents for these cases.)

Slides based on the textbook



- Russel, S. and Norvig, P. (2020) Artificial Intelligence, A Modern Approach (4th Edition), Pearson Education Limited.