Intelligent Agents

COEN166

Artificial Intelligence

Outlines

- Agents and environments
- The concept of rationality
- Environment types
- The structure of agents

Agents

- Agent: an entity that perceives its environment through sensors and acts upon that environment through actuators.
- Agents interact with environments through sensors and actuators

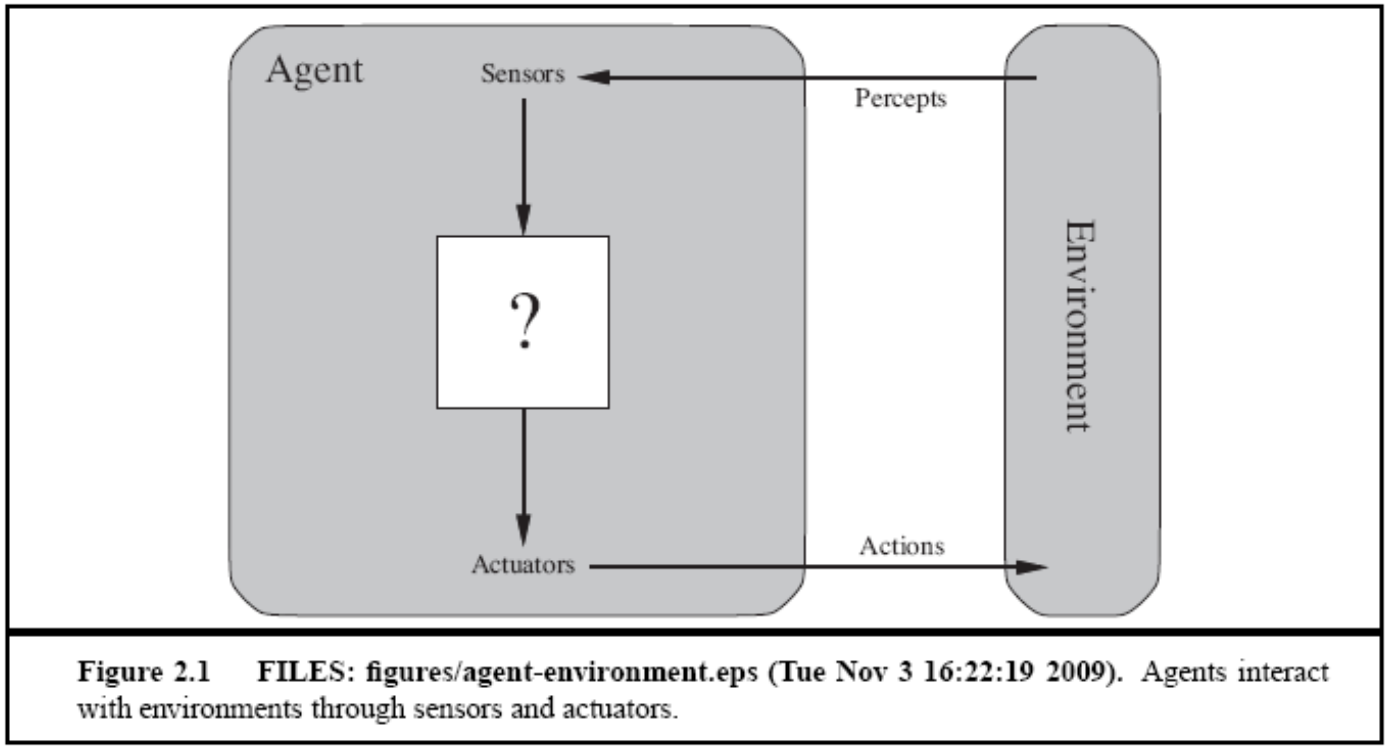


Figure 2.1 FILES: figures/agent-environment.eps (Tue Nov 3 16:22:19 2009). Agents interact with environments through sensors and actuators.

Agents

- Human agent
  - Sensors: eyes, ears, …
  - Actuators: hands, legs, …
- Robotic agent
  - Sensors: cameras, infrared range finders, …
  - Actuators: motors
- Software agent
  - Sensors:
    - file contents, network packets
    - Keyboard, mouse, touchscreen, voice
  - Actuators: Writing files, sending network packets, displaying information, and generating sounds, …

Agents

- Percept: the agent's perceptual inputs at any given instant
- Percept sequence: the complete history of everything the agent has ever perceived

- Agent function: maps any given percept sequence to an action

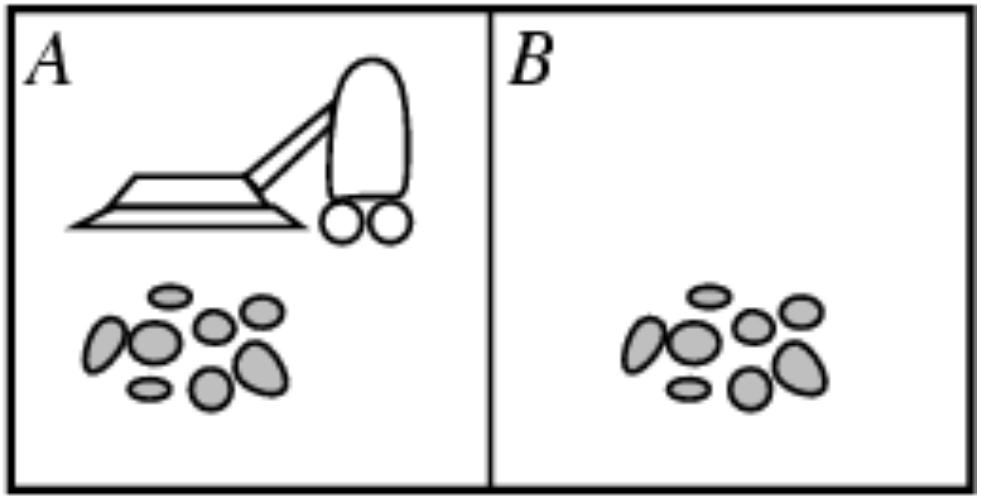
$$f: percepts \rightarrow action$$

  - An abstract mathematical description

Agents

- Agent program: implements the agent function
  - A concrete implementation, running with some physical system

Vacuum-Cleaner World



Percept sequence	Action
{A, Clean}	Right
{A, Dirty}	Suck
{B, Clean}	Left
{A, Clean},{A, Clean}	Right
{A, Clean},{A Dirty}	Suck
…	…

Rationality

- Whether an agent is rational depends on
  - Performance measure: an objective criterion for the success of an agent's behavior
    - E.g., performance measure of a vacuum-cleaner agent: the amount of dirt cleaned up, amount of time taken, amount of electricity consumed, amount of noise generated, etc.
  - Agent's prior knowledge of the environment
  - Actions that the agent can perform
  - Agent's percept sequence to date

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 is distinct from omniscience (all-knowing with infinite knowledge).

- An agent is autonomous if its behavior is determined by its own percepts & experience (with ability to learn and adapt) without depending solely on build-in knowledge.

Vacuum Cleaner World

- Agent's prior knowledge:
  - Geography: known
  - Dirt distribution and location: unknown
- The available actions: left, right, up, down, and suck
- The agent correctly perceives its location and whether the location is dirty
- Performance measure: awarded 1 point for each clean room over a lifetime of 1,000 time steps

Example

- An agent that senses only partial information about the state cannot be perfectly rational.

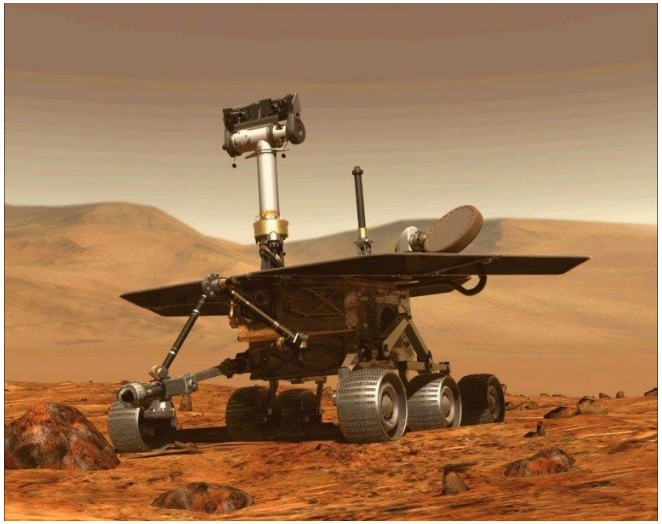
  a) True, b) False

- Answer:
- b) False. The vacuum-cleaning agent is rational but doesn't observe the state of the square that is adjacent to it

Example

- Imagine a Mars-rover which does not have a program to plan its route. As a result of this the Mars-rover is performing suboptimal. From this we can deduce that this Mars-rover is not a rational agent.

  a) True, b) False



- Answer:
- a) True. Since we know there is a better algorithm (one that includes route planning)

Task Environment

- To design a rational agent we must specify its task environment
- **PEAS** description of the environment

  Performance measure

  Environment

  Actuators

  Sensors

PEAS Example

- **Agent = taxi driver**
- **Performance measure:** safety, fast, legal, comfortable trip, maximize profits ...
- **Environment:** Roads, traffic, pedestrians, weather, ...
- **Actuators:** steering wheel, accelerator, brake, horn, signal, touch pad,…
- **Sensors:** camera, sonar, GPS, odometer, engine sensor, …

PEAS Example

- **Medical Diagnosis System**
- **Performance measure:**
  - (a) Correct diagnosis
  - (b) Minimize costs (equipment usage & treatment, time spent)
- **Environment:**
  - Patient, doctor, hospital, emergency rooms, clinic, staff

PEAS Example

- **Medical Diagnosis System**
- **Sensors:**
  - Keyboard entry of symptoms, findings, patient's answer
- **Actuators:**
  - Questions asked by doctors, tests, treatments, diagnoses

PEAS Example

- **The Agent of Water Jug**

  You are given two jugs with no measuring marks,

  a 4-gallon one and a 3-gallon one. There is a pump to fill the jugs with water from a pool. How can you get exactly 2 gallons of water into the 4-gallon jug? For the agent of water jug, develop a **PEAS** description of this task environment.

- **Performance measure:**
- (a) correctness. (successfully reach the goal?)
- (b) speed (how many steps this agent takes?)

PEAS Example

- **The Agent of Water Jug**

  You are given two jugs with no measuring marks,

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Environment:

- (a) the jugs
- (b) the pool

PEAS Example

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- **Actuators:**
- The pump

PEAS Example

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- **Sensors:**
- Human eyes/cameras (if the agent has one)

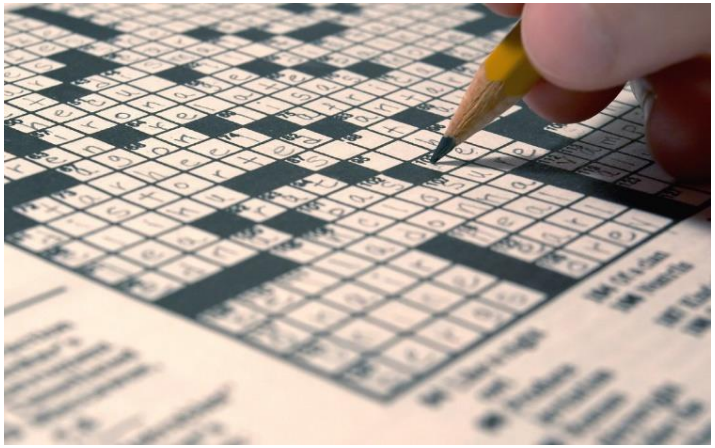
Environment Types (Fully/Partially Observable)

- **Fully observable**
  - If an agent's sensors give it access to the complete state of the environment at each point in time
- **Partially observable**
  - Noisy and inaccurate sensors, or
  - Parts of the state are missing from the sensor data
    - e.g. A vacuum agent with a local dirt sensor
- **Unobservable**
  - No sensors

Environment Types

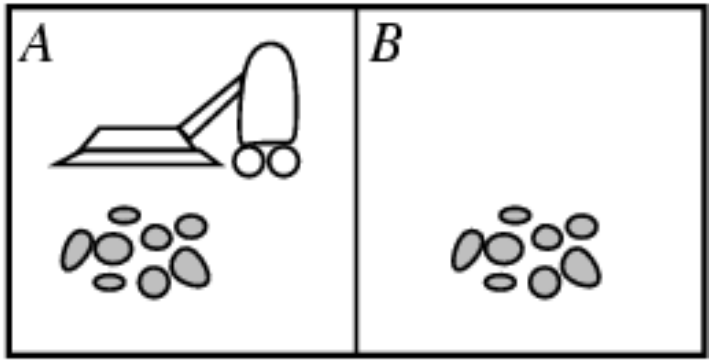
- **Deterministic (vs. stochastic):**
  - The next state of the environment is completely determined by the current state and the action executed by the agent.
  - An environment is uncertain if it is not fully observable or not deterministic.

    e.g. Game with dice: uncertainty, unpredictable
  - If the environment is deterministic except for the actions of other agents, then the environment is strategic



Environment Types (Episodic vs. Sequential)

- **Episodic**
  - The agent's experience is divided into atomic "episodes"
  - In each episode: the agent receives a percept, and then performs a single action
  - The next episode does not depend on the actions taken in previous episodes
  - Simple reflex vacuum cleaner, part-picking robot



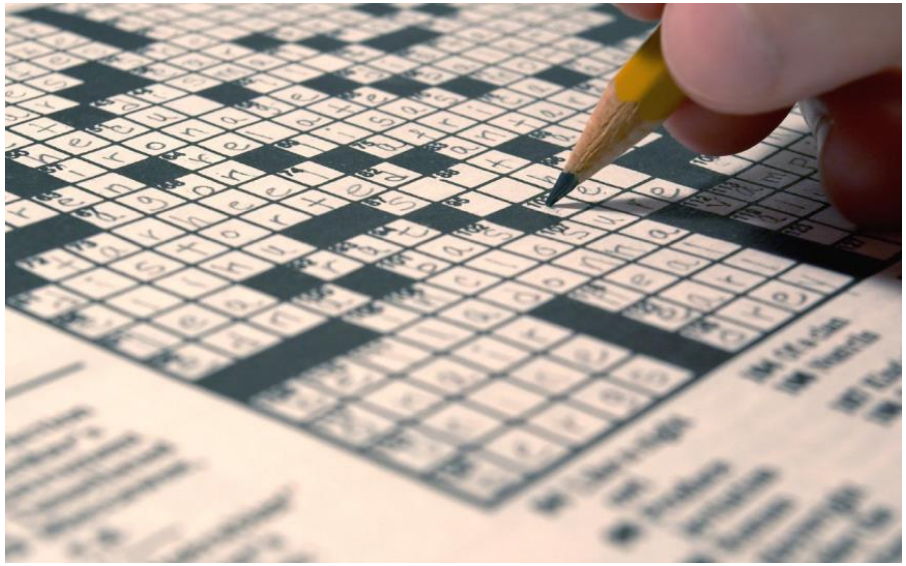
Environment Types (Episodic vs. Sequential)

- **Sequential**
  - The current decision could affect all future decisions
  - Chess and taxi driving

- Which is simpler, episodic or sequential?

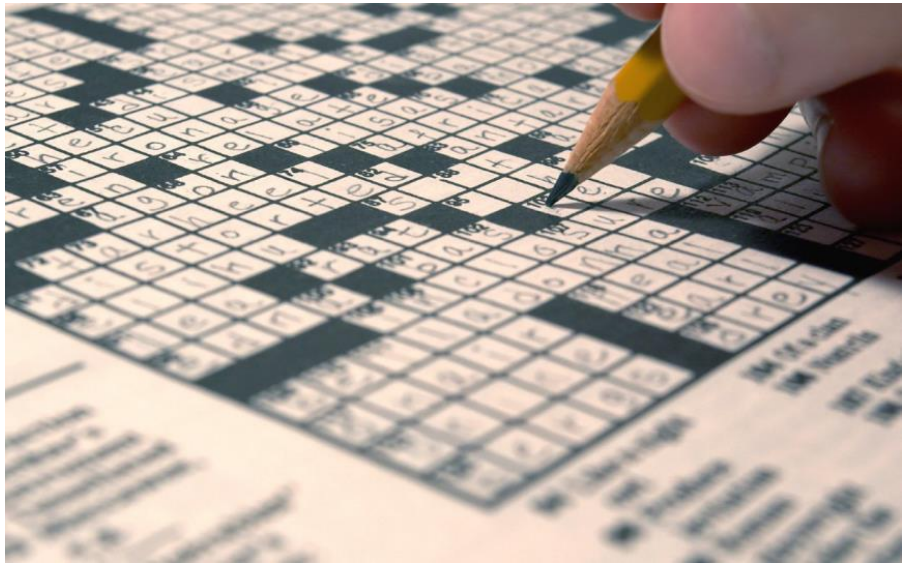
Environment Types

- **Single agent (vs. Multi-agent):**
  - An agent operating by itself in an environment.
  - Crossword puzzle vs. chess



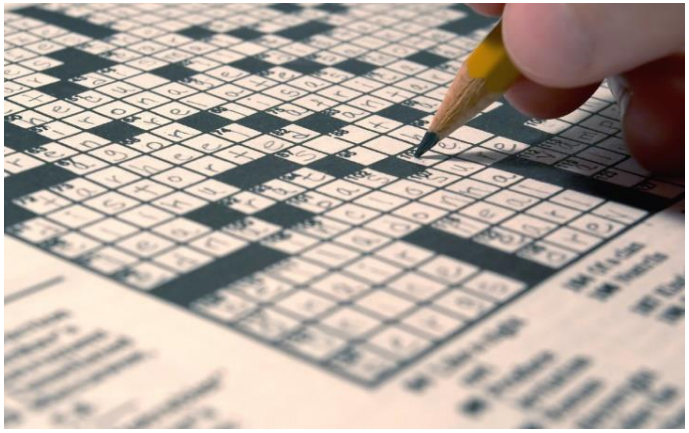
Environment Types

- **Single agent (vs. Multi-agent):**
  - Does the other agent interfere with my performance measure?
  - Examples?
  - Online bookshop, Auction



Environment Types (Static vs. Dynamic/Semidynamic)

- **Static**
  - The environment is unchanged while an agent is deliberating (passage of time)
- **Dynamic**
  - The environment changes with the passage of time



Crossword puzzles?

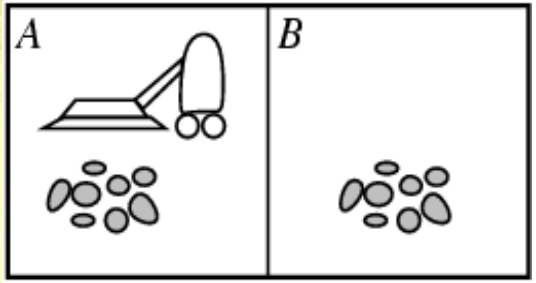
Taxi driving?

Environment Types (Static vs. Dynamic/Semidynamic)

- **Semidynamic**
  - The environment itself does not change with the passage of time but the agent's performance score does
  - Chess (when played with a clock)

Environment Types

- **Discrete (vs. continuous):**
  - States of the environment
  - Percepts and Actions of the agent
  - Limited number, distinct, clearly defined
  - Chess vs. taxi driving (infinite: speed and location are continuous values)



	Medical Diagnosis	Chess with a clock	Backgammon	Taxi driving	Vacuum Cleaner (no memory)
Observable?					
Deterministic?					
Episodic?					
Static?					
Discrete?					
Single-agent?					

Environment Types

- The simplest environment is
  - Fully observable, deterministic, episodic, static, discrete and single-agent.
- Most real situations are
  - partially observable, stochastic, sequential, dynamic, continuous, multi-agent.

The Structure of Agents

- How does the agent work?
- *agent = architecture + program*
  - Agent program: implements the agent function
    - the mapping from percepts to actions
  - Architecture: computing devices with physical sensors and actuators
- The program has to be appropriate for the architecture
  - If the program recommends actions like Walk, the architecture had better have legs

The Structure of Agents

- How does the agent work?
- Architecture: PC, robotic car w/ onboard computers, cameras, and other sensors
  - Makes the percepts from the sensors available to the program, runs the program, and feeds the program's action choices to the actuators

Example

- Every agent function is implementable by some program/machine combination.
- a) True, b) False
- Answer:
- b) False. Consider
  - an agent who perceives a bit each turn, and
  - the agent function is to return an integer that matches the value of the entire bit string perceived so far.
  - It gains a point of performance if the integer returned is correct.

  Eventually, any agent program will fail because it will run out of memory.

Summary

- **Agent:** perceives and acts in an environment
- **Agent function**: maps percept sequence to actions
- **Agent program**: implements the agent function
- **Performance measure**: defines the criterion of success
- **Rational agent**: maximize the expected value of the performance measure
- **Task environment specification** – **PEAS** **(P**erformance**,** **E**nvironment, **A**ctuators, **S**ensors**)**
- **Types of environment**
- **The structure of agents:** architecture + program