Inf2D 01: Intelligent Agents and their Environments

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15/01/19

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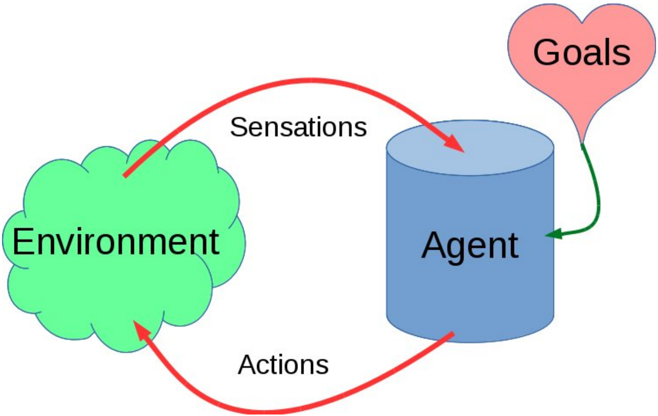
Structure of Intelligent Agents

An agent:

- Perceives its environment,
- Through its sensors,
- Then achieves its goals
- By acting on its environment via actuators.

Structure of Intelligent Agents



Examples of Agents 1

- Agent: mail sorting robot
- Environment: conveyor belt of letters
- Goals: route letter into correct bin
- Percepts: array of pixel intensities
- Actions: route letter into bin

Side info: https://en.wikipedia.org/wiki/Mail_sorter

Examples of Agents 2

- Agent: intelligent house
- Environment:
  - occupants enter and leave house,
  - occupants enter and leave rooms;
  - daily variation in outside light and temperature
- Goals: occupants warm, room lights are on when room is occupied, house energy efficient
- Percepts: signals from temperature sensor, movement sensor, clock, sound sensor
- Actions: room heaters on/off, lights on/off

Side info: https://en.wikipedia.org/wiki/Home_automation

Examples of Agents 3

- Agent: autonomous car.
- Environment: streets, other vehicles, pedestrians, traffic signals/lights/signs.
- Goals: safe, fast, legal trip.
- Percepts: camera, GPS signals, speedometer, sonar.
- Actions: steer, accelerate, brake.

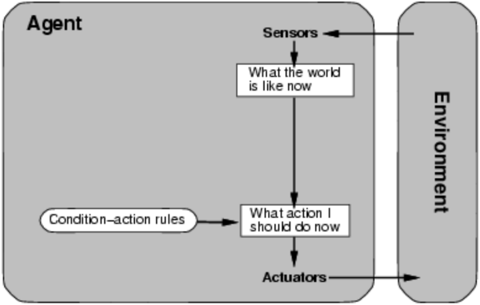
Side info: https://en.wikipedia.org/wiki/Autonomous_car

Simple Reflex Agents

- Action depends only on immediate percepts.
- Implement by condition-action rules.
- Example:
  - Agent: Mail sorting robot
  - Environment: Conveyor belt of letters
  - Rule: e.g. *city=Edinburgh → put Scotland bag*

https://en.wikipedia.org/wiki/Intelligent_agent

Simple Reflex Agents

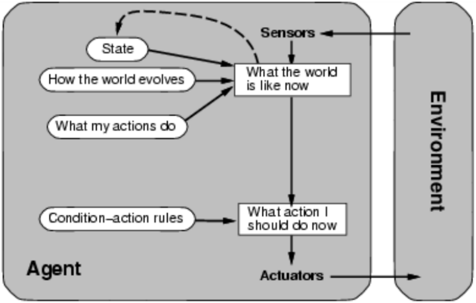


```
function SIMPLE-REFLEX-AGENT(percept)
returns action
  persistent: rules (set of condition-action rules)
              state ← INTERPRET-INPUT(percept)
              rule ← RULE-MATCH(state, rules)
              action ← rule.ACTION
return action
```

Model-Based Reflex Agents

- Action may depend on history or unperceived aspects of the world.
- Need to maintain internal world model.
- Example:
  - Agent: robot vacuum cleaner
  - Environment: dirty room, furniture.
  - Model: map of room, which areas already cleaned.
  - Sensor/model trade-off.

Model-Based Agents

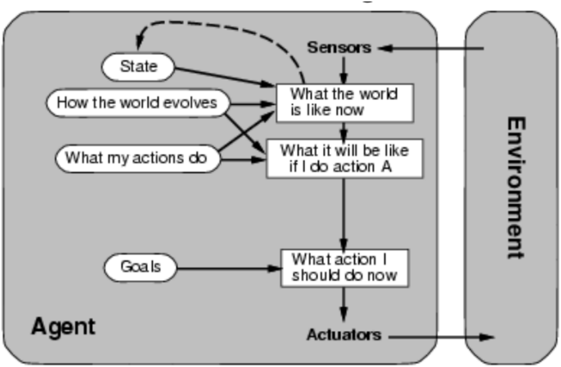


```
function REFLEX-AGENT-WITH-STATE(percept)
  returns action
  persistent: state, description of current world state
              model, description of how the next state depends on
                     current state and action
              rules,  a set of condition-action rules
              action, the most recent action, initially none
  state ← UPDATE-STATE(state, action, percept, model)
  rule ← RULE-MATCH(state, rules)
  action ← rule.ACTION
  return action
```

Goal-Based Agents

- Agents so far have fixed, implicit goals.
- We want agents with variable goals.
- Forming plans to achieve goals is later topic.
- Example:
  - Agent: household service robot
  - Environment: house & people.
  - Goals: clean clothes, tidy room, table laid, etc.

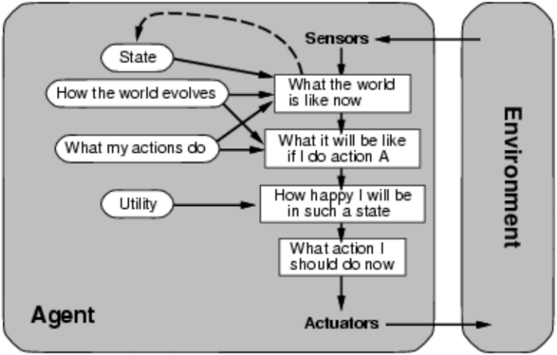
Goal-Based Agents


Sensors
State
How the world evolves
What my actions do
What the world is like now
What it will be like if I do action A
Goals
What action I should do now
Agent
Actuators
Environment

Utility-Based Agents

- Agents so far have had a single goal.
- Agents may have to juggle conflicting goals.
- Need to optimise utility over a range of goals.
- Utility: measure of *goodness* (a real number).
- Combine with probability of success to get *expected utility*.
- Example:
  - Agent: automatic car.
  - Environment: roads, vehicles, signs, etc.
  - Goals: stay safe, reach destination, be quick, obey law, save fuel, etc.

Utility-Based Agents


Sensors
State
How the world evolves
What my actions do
Utility
What the world is like now
What it will be like if I do action A
How happy I will be in such a state
What action I should do now
Environment
Agent
Actuators

We will not be covering utility-based agents, but this topic is discussed in Russell & Norvig, Chapters 16 and 17.

Learning Agents

How do agents improve their performance in the light of experience?

- Generate problems which will test performance.
- Perform activities according to rules, goals, model, utilities, etc.
- Monitor performance and identify non-optimal activity.
- Identify and implement improvements.

We will not be covering learning agents, but this topic is dealt with in several honours-level courses (see also R&N, Ch. 18-21).

Mid-Lecture Problem

Consider a chess playing program.
What sort of agent would it need to be?

Solution(s)

- Simple-reflex agent: but some actions require some memory (e.g. castling in chess: http://en.wikipedia.org/wiki/Castling).
- Model-based reflex agent: but needs to reason about future.
- Goal-based agent: but only has one goal.
- Utility-based agent: might consider multiple goals with limited lookahead.
- Learning agent: Learns from experience or self-play

Types of Environment 1

- Fully Observable vs. Partially Observable:
  - Full: agent's sensors describe environment state fully.
  - Partial: some parts of environment not visible, noisy sensors.
- Deterministic vs. Stochastic:
  - Deterministic: next state fully determined by current state and agent's actions.
  - Stochastic: random changes (can't be predicted exactly).

An environment may appear stochastic if it is only partially observable.

Types of Environment 2

- Episodic vs. Sequential:
  - Episodic: next action does not depend on previous actions.
  - Mail-sorting robot *vs.* crossword puzzle.
- Static vs. Dynamic:
  - Static: environment unchanged while agent deliberates.
  - Crossword puzzle *vs.* chess.
  - Industrial robot *vs.* robot car

Types of Environment 3

- Discrete vs. Continuous:
  - Discrete: percepts, actions and episodes are discrete.
  - Chess vs. robot car.
- Single Agent vs. Multi-Agent:
  - How many objects must be modelled as agents.
  - Crossword vs. poker.

  Element of choice over which objects are considered agents.

Types of Environment 4

- An agent may have any combination of these properties:
  - from “benign” (i.e., fully observable, deterministic, episodic, static, discrete and single agent)
  - to “chaotic” (i.e., partially observable, stochastic, sequential, dynamic, continuous and multi-agent).
- What are the properties of the environment that would be experienced by
  - a mail-sorting robot?
  - an intelligent house?
  - a car-driving robot?

Summary

- Simple reflex agents
- Model-based reflex agents
- Goal-based agents
- Utility-based agents
- Learning agents
- Properties of environments