Intelligent Agents and their Environments

Michael Rovatsos

School of Informatics
University of Edinburgh

12 January 2016

Structure of Intelligent Agents

An agent:

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

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

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

Examples of Agents 3

- **Agent**: automatic 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: http://en.wikipedia.org/wiki/2005_DARPA_Grand_Challenge

Simple Reflex Agents

- Action depends only on immediate percepts.
- Implement by *condition-action rules*.

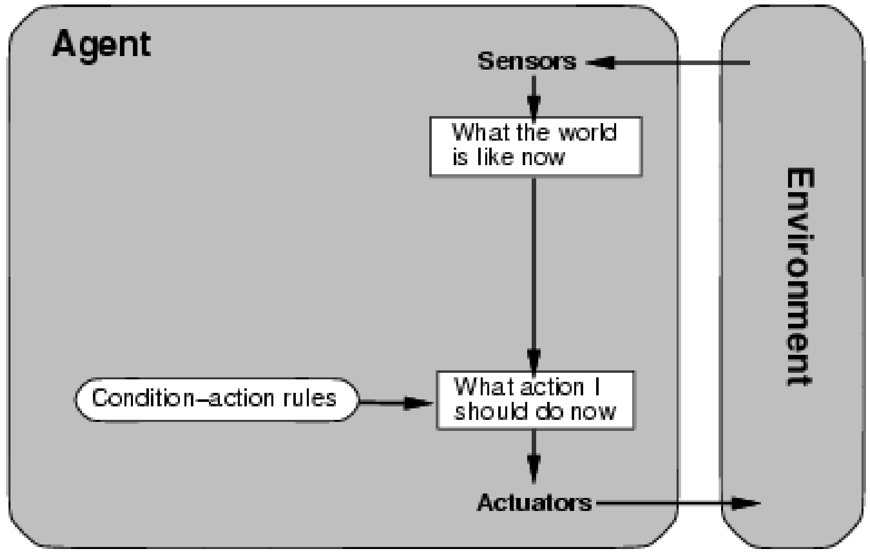
Example:

– Agent: Mail sorting robot

– Environment: Conveyor belt of letters

– Rule: e.g. *city=Edin* → *put Scotland bag*

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*

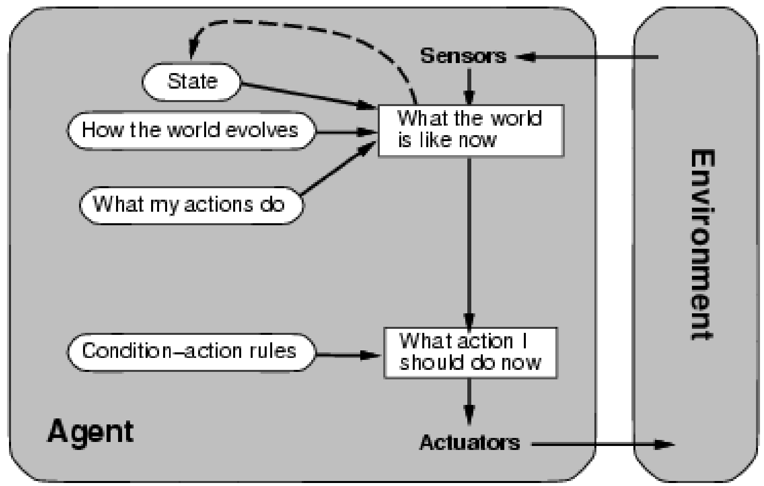
Model-Based Reflex Agents

- 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 tradeoff.

Model-Based Reflex 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*

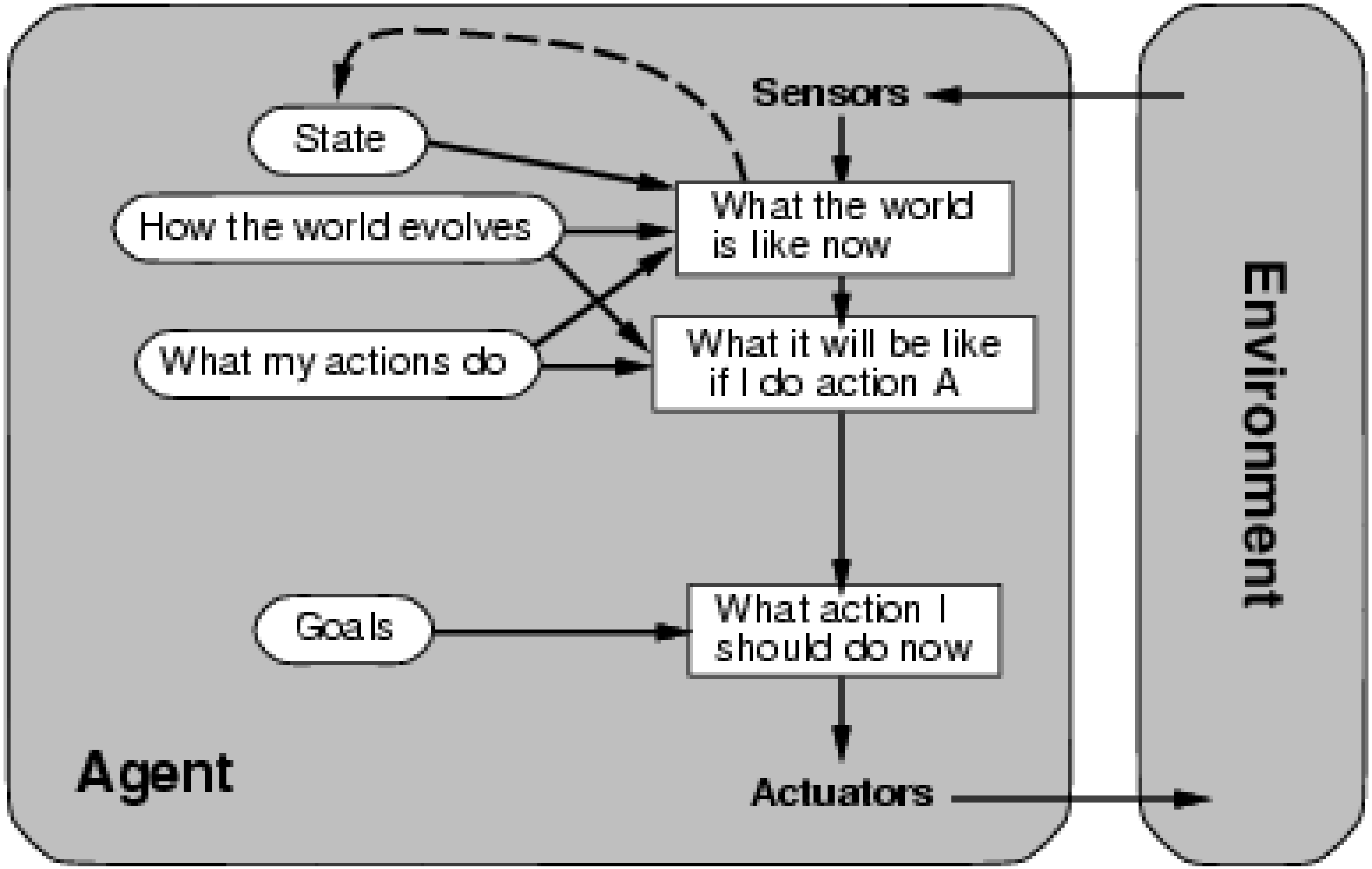
Goal-Based Agents

- Agents so far have fixed, implicit goals.
- We want agents with variable goals.
- Forming plans to achieve goals is later topic.

Example:

- Agent: robot maid
- Environment: house & people.
- Goals: clean clothes, tidy room, table laid, etc

Goal-Based Agents



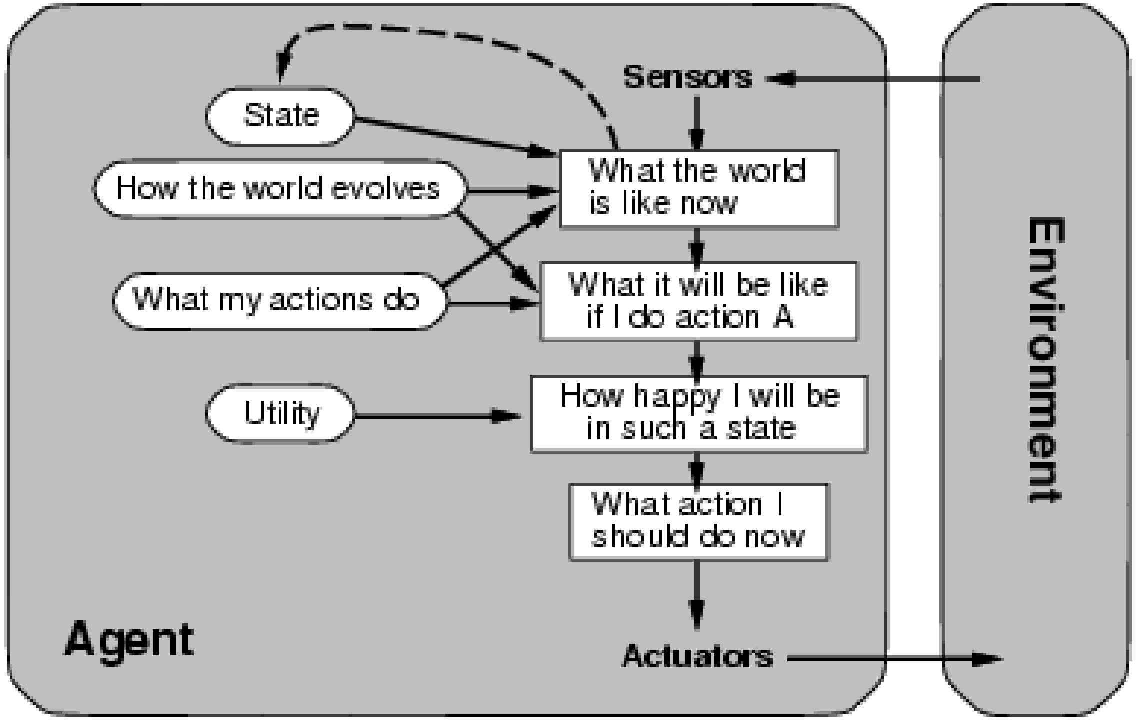
Utility-Based Agents

- 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



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 discussed in Russell & Norvig, Chapters 18-21.

Mid Lecture Exercise

Consider a chess playing program.

What sort of agent would it need to be?

Solution

- 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.

Types of Environment 1

- Fully Observable vs. Partially Observable:

  Observable: agent's sensors describe environment fully.

  Playing chess with a blindfold.

- Deterministic vs. Stochastic:

  Deterministic: next state fully determined by current state and agent's actions.

  Chess playing in a strong wind.

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

Types of Environment 2

- Episodic vs. Sequential:

  Episodic: next episode does not depend on previous actions.

  Mail-sorting robot *vs* crossword puzzle.

- Static vs. Dynamic:

  Static: environment unchanged while agent deliberates.

  Robot car *vs* chess.

  Crossword puzzle *vs* tetris.

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 might 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