Intelligent Agents

Chapter 2

Outline

◇ PAGE (Percepts, Actions, Goals, Environment)

◇ Environment types

◇ Agent types

PAGE

Must first specify the setting for intelligent agent design

Consider, e.g., the task of designing an automated taxi:

Percepts??

Actions??

Goals??

Environment??

PAGE

Must first specify the setting for intelligent agent design

Consider, e.g., the task of designing an automated taxi:

Percepts?? video, accelerometers, gauges, engine sensors, microphone, GPS, . . .

Actions?? steer, accelerate, brake, horn, speak/display, . . .

Goals?? safety, reach destination, maximize profits, obey laws, passenger comfort, . . .

Environment?? US urban streets, freeways, traffic, pedestrians, weather, customers, . . .

Environment types

	Chess	Backgammon	Taxi
Accessible??			
Deterministic??			
Episodic??			
Static??			
Discrete??			

Environment types

	Chess	Backgammon	Taxi
Accessible??	Yes	Yes	No
Deterministic??	Yes	No	No
Episodic??	No	No	No
Static??	Yes	Yes	No
Discrete??	Yes	Yes	No

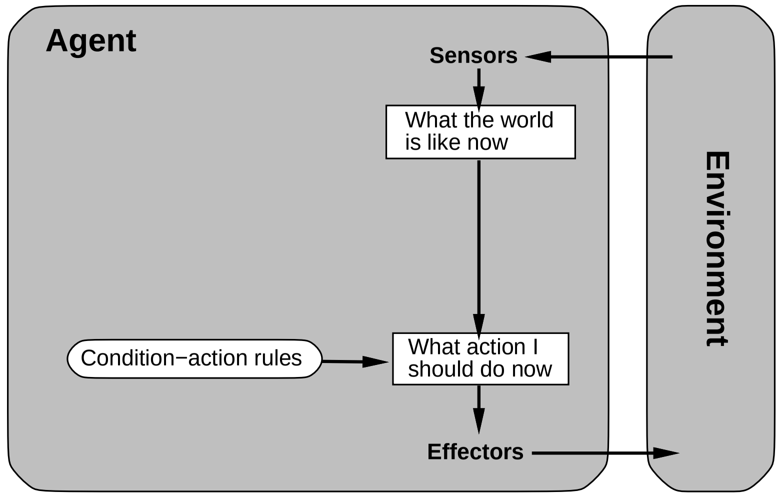
The environment type largely determines the agent design

The real world is (of course) inaccessible, stochastic, sequential, dynamic, continuous

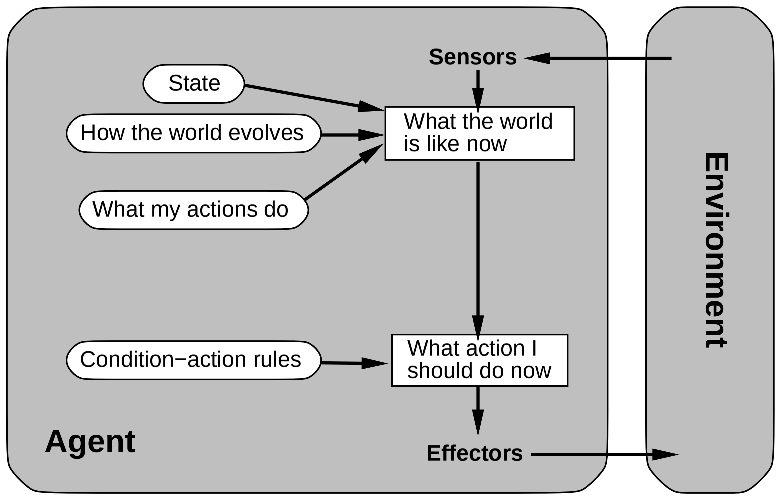
Agent types

Four basic types in order of increasing generality:
- simple reflex agents
- reflex agents with state
- goal-based agents
- utility-based agents

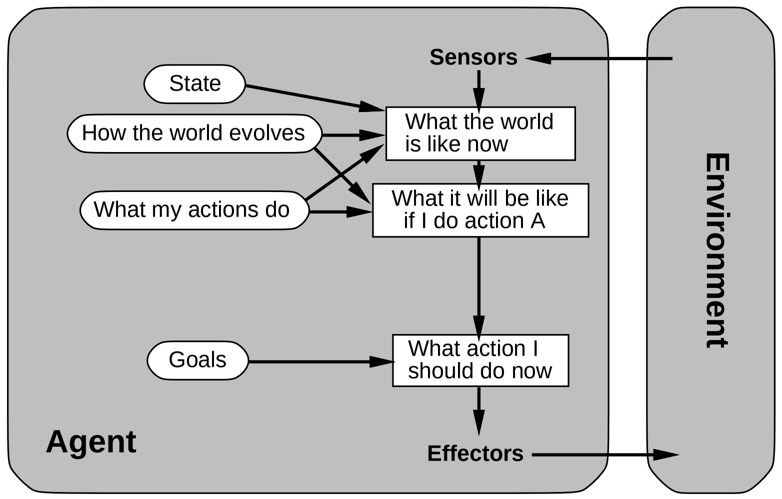
Simple reflex agents



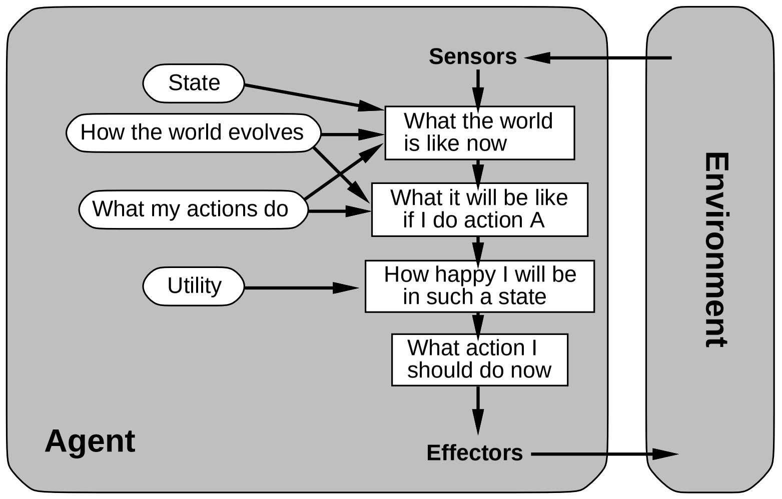
Reflex agents with state



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
Effectors
Environment

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
Agent
Effectors
Environment

Problem solving and search

Chapter 3

Outline

◊ Problem-solving agents

◊ Problem types

◊ Problem formulation

◊ Example problems

◊ Basic search algorithms

Problem-solving agents

Restricted form of general agent:

```
function SIMPLE-PROBLEM-SOLVING-AGENT(p) returns an action
   inputs: p, a percept
   static: s, an action sequence, initially empty
           state, some description of the current world state
           g, a goal, initially null
           problem, a problem formulation

   state ← UPDATE-STATE(state, p)
   if s is empty then
      g ← FORMULATE-GOAL(state)
      problem ← FORMULATE-PROBLEM(state, g)
      s ← SEARCH(problem)
   action ← RECOMMENDATION(s, state)
   s ← REMAINDER(s, state)
   return action
```

Note: this is *offline* problem solving.
Online problem solving involves acting without complete knowledge of the problem and solution.

Example: Romania

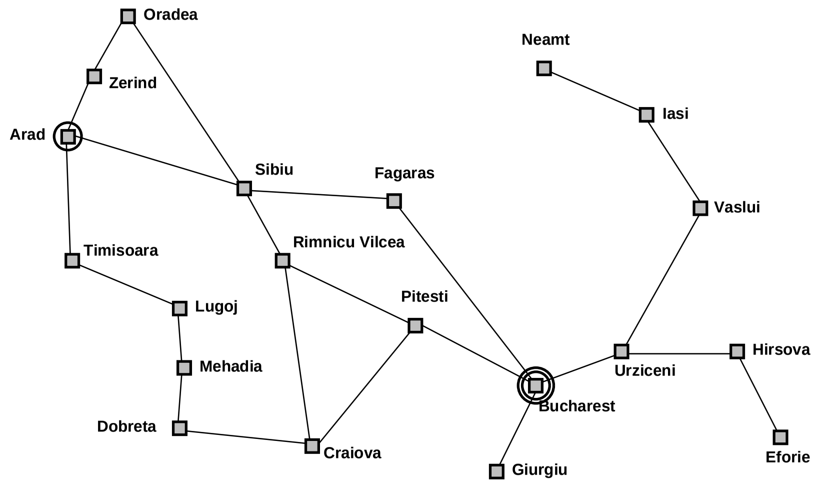
On holiday in Romania; currently in Arad.
Flight leaves tomorrow from Bucharest

Formulate goal:
    be in Bucharest

Formulate problem:
    states: various cities
    operators: drive between cities

Find solution:
    sequence of cities, e.g., Arad, Sibiu, Fagaras, Bucharest

Example: Romania



Problem types

<u>Deterministic, accessible</u> $\Longrightarrow$ *single-state problem*
<u>Deterministic, inaccessible</u> $\Longrightarrow$ *multiple-state problem*

<u>Nondeterministic, inaccessible</u> $\Longrightarrow$ *contingency problem*
must use sensors during execution
solution is a *tree* or *policy*
often *interleave* search, execution

<u>Unknown state space</u> $\Longrightarrow$ *exploration problem* ("online")

Single-state problem formulation

A *problem* is defined by four items:

<u>*initial state*</u> e.g., "at Arad"

<u>*operators*</u> (or *successor function* $S(x)$)
e.g., Arad $\rightarrow$ Zerind Arad $\rightarrow$ Sibiu etc.

<u>*goal test*</u>, can be
explicit, e.g., $x =$ "at Bucharest"
implicit, e.g., $NoDirt(x)$

<u>*path cost*</u> (additive)
e.g., sum of distances, number of operators executed, etc.

A *solution* is a sequence of operators
leading from the initial state to a goal state

Selecting a state space

Real world is absurdly complex
$\Rightarrow$ state space must be *abstracted* for problem solving

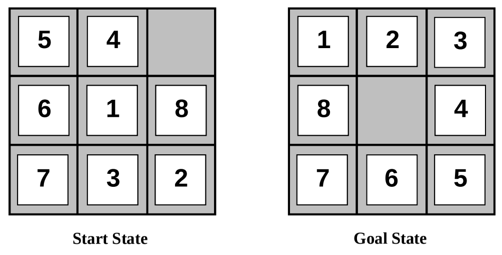
(Abstract) state = set of real states

(Abstract) operator = complex combination of real actions
e.g., "Arad $\rightarrow$ Zerind" represents a complex set
of possible routes, detours, rest stops, etc.
For guaranteed realizability, <u>any</u> real state "in Arad"
must get to *some* real state "in Zerind"

(Abstract) solution =
set of real paths that are solutions in the real world

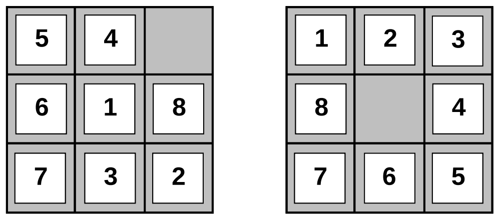
Each abstract action should be "easier" than the original problem!

Example: The 8-puzzle



<u>states</u>??
<u>operators</u>??
<u>goal test</u>??
<u>path cost</u>??

Example: The 8-puzzle


Start State Goal State

<u>states</u>??: integer locations of tiles (ignore intermediate positions)
<u>operators</u>??: move blank left, right, up, down (ignore unjamming etc.)
<u>goal test</u>??: = goal state (given)
<u>path cost</u>??: 1 per move

[Note: optimal solution of n-Puzzle family is NP-hard]

Example: service robot

<u>states</u>??:

<u>operators</u>??:

<u>goal test</u>??:

<u>path cost</u>??: