

CENG 466

Artificial Intelligence

Lecture 3

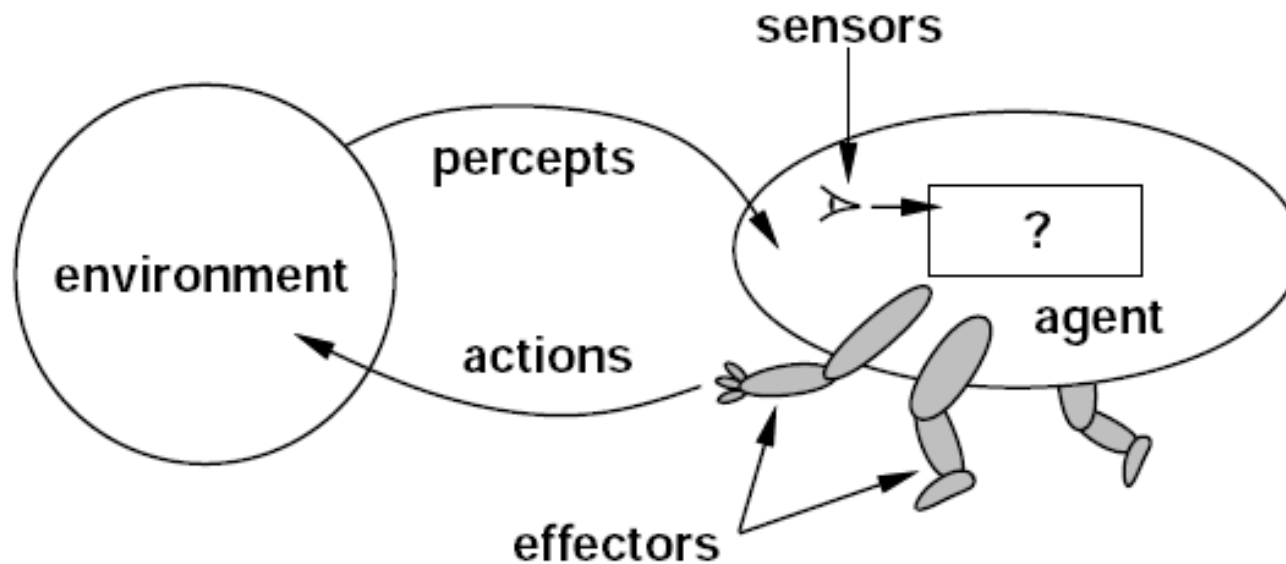
Solving Problems by Searching (I)

Topics

- ▶ Example Intelligent Agents
- ▶ Goal Formulation
- ▶ Problem Formulation
- ▶ States and State-Spaces
- ▶ Well-defined Problems
- ▶ Searching

Intelligent Agents

- ▶ An agent is something that perceives and acts in an environment
- ▶ An ideal agent always takes actions that maximizes its performance
- ▶ An agent adopts a goal and searches the best path to reach that goal



Rational Agent

- ▶ A rational agent is an agent which does the right action
- ▶ The right action will cause the agent to be most successful

Agent Types

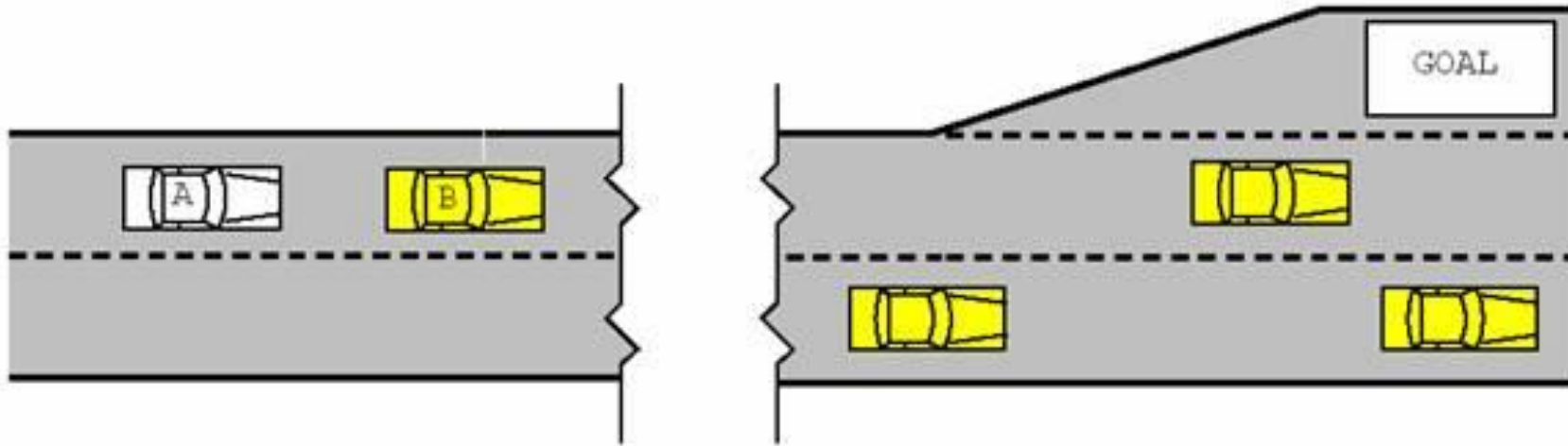
- ▶ Simple Reflex agent
- ▶ Agents that can remember
- ▶ Goal-based agents
- ▶ Utility-based agents

Some Examples of Intelligent Agents (1)

Automated driving

- ▶ This is a utility based agent.
- ▶ **Percepts:** Cameras are used to gain positions of car, the edges of lanes, and the position of the goals.
- ▶ **Actions:** The car can speed up, slow down, change lanes, turn, park, pull away

Some Examples of Intelligent Agents (1)



http://www.ri.cmu.edu/research_project_view.html?menu_id=261

Some Examples of Intelligent Agents (2)

A.L.I.C.E. - an online chat bot

- ▶ A.L.I.C.E. is a learning reflex agent.
- ▶ Given certain keywords the bot has a pre-determined response
- ▶ But if the bot doesn't know how to reply then it will ask a question which will help it to learn the answer to the question.
- ▶ This builds up a large amount of condition-action rules.

Some Examples of Intelligent Agents (2)



A.L.I.C.E. and judge

You said:

A.L.I.C.E.:

You say:

Say

- ▶ <http://www.pandorabots.com/pandora/talk?botid=f5d922d97e345aa1>

Some Examples of Intelligent Agents (3)

Goal-Oriented Web Search User Interfaces

- ▶ GOOSE (GOal-Oriented Search Engine interface) is an adaptive search engine interface that uses natural language processing
- ▶ It parses a user's search goal, and uses "common sense" reasoning to interpret this goal.
- ▶ Then it uses the goal to create an effective query.

Some Examples of Intelligent Agents (3)



<http://agents.media.mit.edu/projects.html>

Problem Solving Agents

- ▶ Intelligent agents are supposed to act in such a way that their performance measure is maximized.
- ▶ Problem-solving agents decide what to do by finding sequences of actions that lead to their desirable states (goals).
- ▶ Therefore, the agent
 - ▶ defines the goals and
 - ▶ finds the path to reach that goal

Goal Formulation

- ▶ An intelligent agent should define its goals together with the limiting factors. This is called **Goal Formulation**
- ▶ Example:
- ▶ If the goal is going to a specific city, the limiting factors can be:
 - ▶ Time to arrive,
 - ▶ The cities/roads that should be avoided
 - ▶ The maximum distance of the travel
- ▶ Goal Formulation is the first step in problem solving.

Problem Formulation

- ▶ To reach the goal, the agent should decide about the necessary actions
- ▶ **Problem formulation** is the process of deciding what actions and states to consider to reach the goal
- ▶ Problem Formulation follows goal formulation.

States and State-Spaces

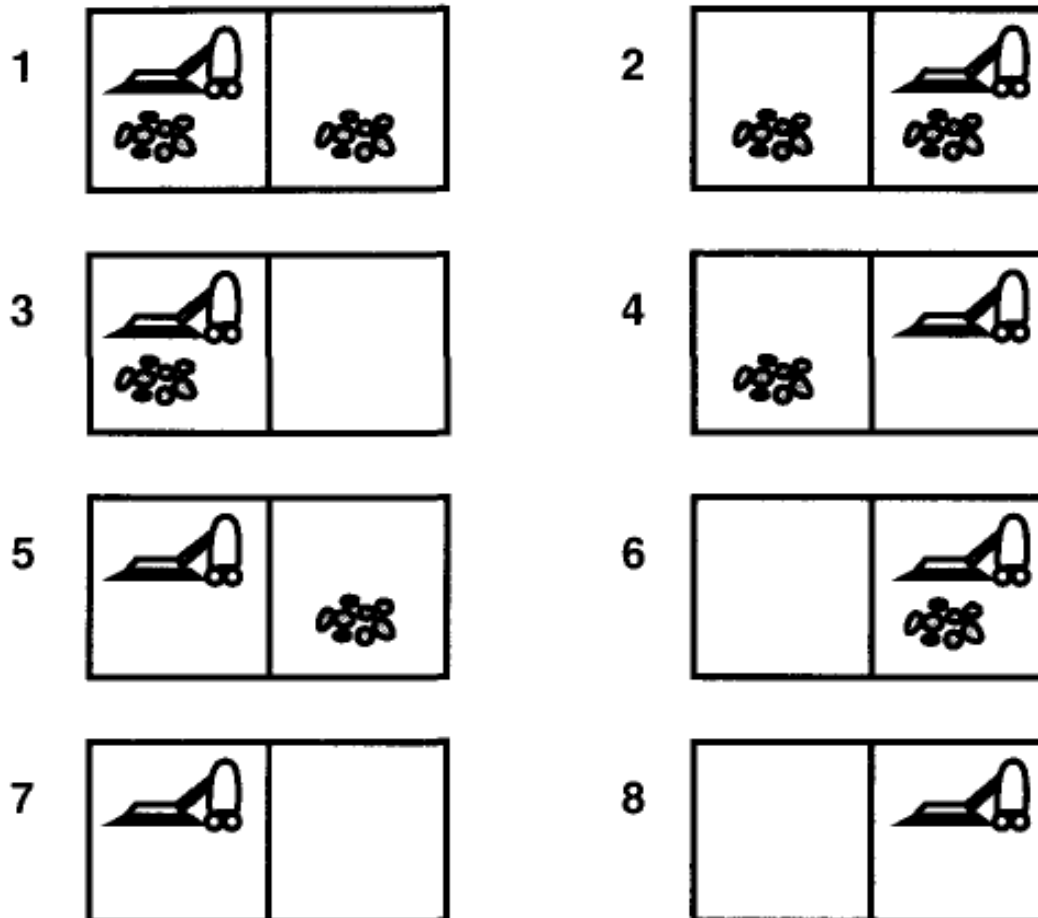
- ▶ **State:** The set of all information items that describe a system at a given time.
- ▶ **State Space:** a set of states that a problem can be in.
- ▶ The set of states forms a **graph** where two states are connected if there is an **action** that can be performed to transform the first state into the second.

States and State-Spaces

- ▶ **State space** is the set of states that an intelligent agent can be in.
- ▶ An **action** takes the agent from one state to another one.
- ▶ **State space search** is finding a sequence of states starting from the initial state to the goal
- ▶ Searching in AI differs from traditional computer science search methods because the state space is often implicit (too big to fit into the memory)

Example 1

Assume a vacuum cleaner can be in one of the two possible positions. The state space is:



Example 1 (cont.)

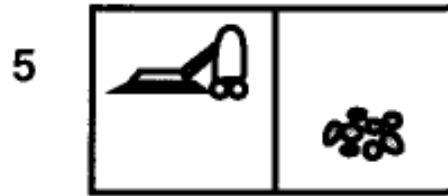
- ▶ The actions available are:
 - ▶ Left : The agent goes to the left side room
 - ▶ Right : The agent goes to the right side room
 - ▶ Clean : The agent cleans the current place

Example 1 (cont.)

- ▶ Case 1: The vacuum cleaner cannot percept its environment.
- ▶ Problem formulation:
(Left, Clean, Right, Clean)

Example 1 (cont.)

- ▶ Case 2: The vacuum cleaner can percept the environment.
- ▶ The cleaner formulates the problem based on its current state
- ▶ E.g. Current state is



then action is [Right, Clean]

Well-defined Problems

- ▶ A problem is well-defined if we can determine the followings:
 1. **The initial state**
 2. The set of **possible actions** available to the agent.
 3. **The goal test:** The agent can apply to a single state to determine if it is a goal state.
 4. **A path cost function:** A function that assigns a cost to a path.

Measuring Problem Solving Performance

- ▶ The effectiveness of a search can be measured in at least three ways.
 1. First, does it find a solution at all?
 2. Second, is it a good solution (one with a low path cost)?
 3. Third, what is the **search cost**? (the time and memory required to find a solution)
- ▶ The **total cost** of the search is the sum of the **path cost** and the **search cost**.

Choosing States and Actions

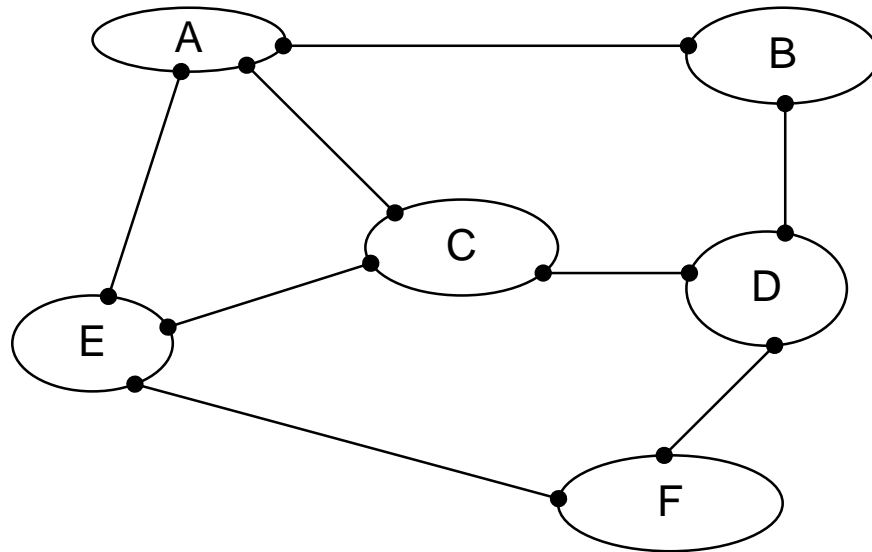
- ▶ An intelligent agent can decide what to do by first **examining** the different possible *sequences* of actions, and then choosing the best one.
- ▶ This process of looking for such a sequence is called **search**.
- ▶ A search algorithm takes a problem as input and returns a **solution** in the form of an action sequence.

Executing Solutions

- ▶ When a solution is found, the actions it recommends can be carried out. This is called the execution phase.
- ▶ Thus, we have a simple "formulate, search, execute" design for the agent

Example 2

- ▶ **Travelling Salesperson Problem:** Assume N cities are given in a graph. Visit every city in this graph at least once, starting and ending in the first city.
- ▶ E.g. Cities $\{A, B, C, D, E, F\}$



- ▶ **States:** Current city and the list of cities visited so far
 - ▶ Initial state = A
 - ▶ Other states: , AB, AC, ABD, ACE, ABDF,....

Example 2 (Cont.)

- ▶ The traveling Salesperson problem can be modified by adding distances between cities.
- ▶ A cost function can compute the path cost and total cost using these distance values

Searching

- ▶ Assuming that the agent knows:
 - ▶ how to define a problem,
 - ▶ how to recognize a solution (goal),
- ▶ finding a solution is done by a search through the state space.

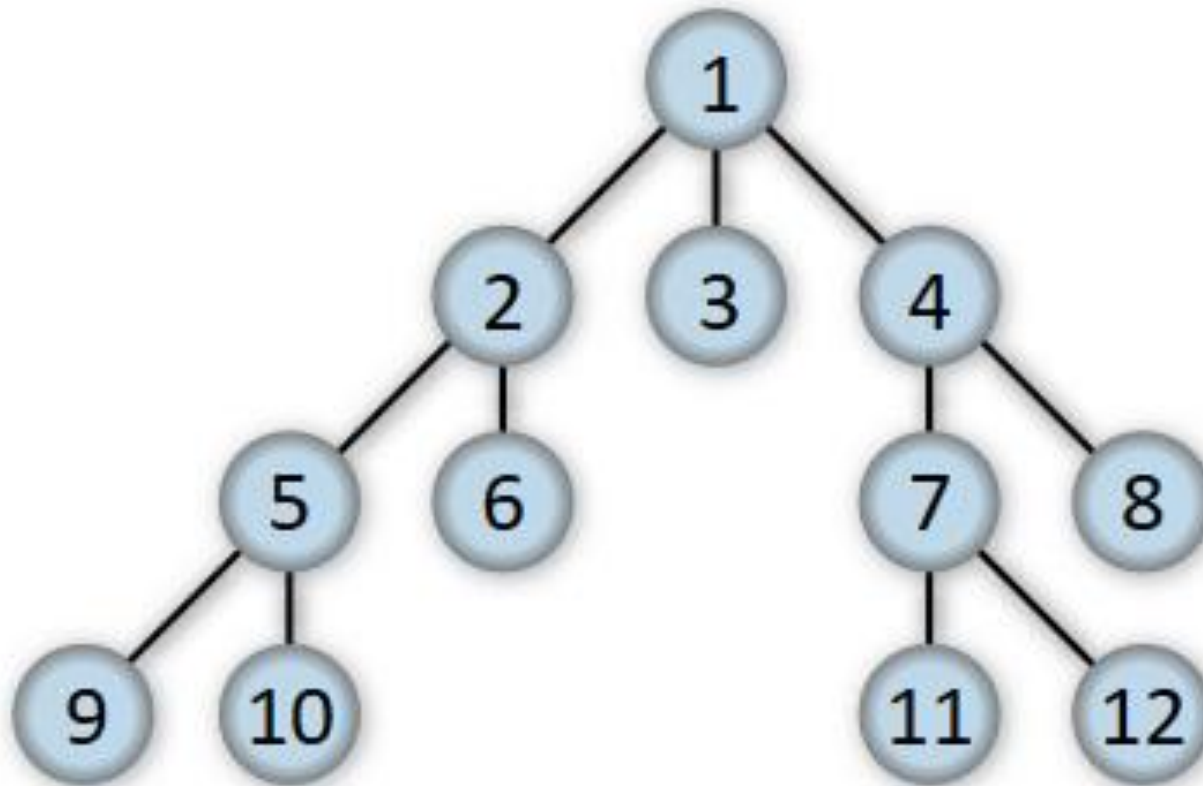
Data Structures

- ▶ In the search process we will build up a **search tree**
 - ▶ Root of the tree is the initial state
 - ▶ Each node of this tree is a state in the state space
 - ▶ The leaf nodes of the tree correspond to states that do not have successors in the tree, because:
 - ▶ They have not been expanded yet
 - ▶ They were expanded, but generated the empty set.

Breadth-First Search

- ▶ In breadth first search we start from the root node
- ▶ Then visit all nodes at distance 1 from the root
- ▶ Next all nodes at distance 2 from the root
- ▶ Until
 - ▶ A goal is found
 - ▶ All nodes are visited

Example



When to Use Breadth First Search?

- ▶ When the search tree (state space) is too big.
 - ▶ e.g. Playing Chess
- ▶ When a close solution is expected

Questions?