CHAPTER 2
AI AND PROBLEM SOLVING

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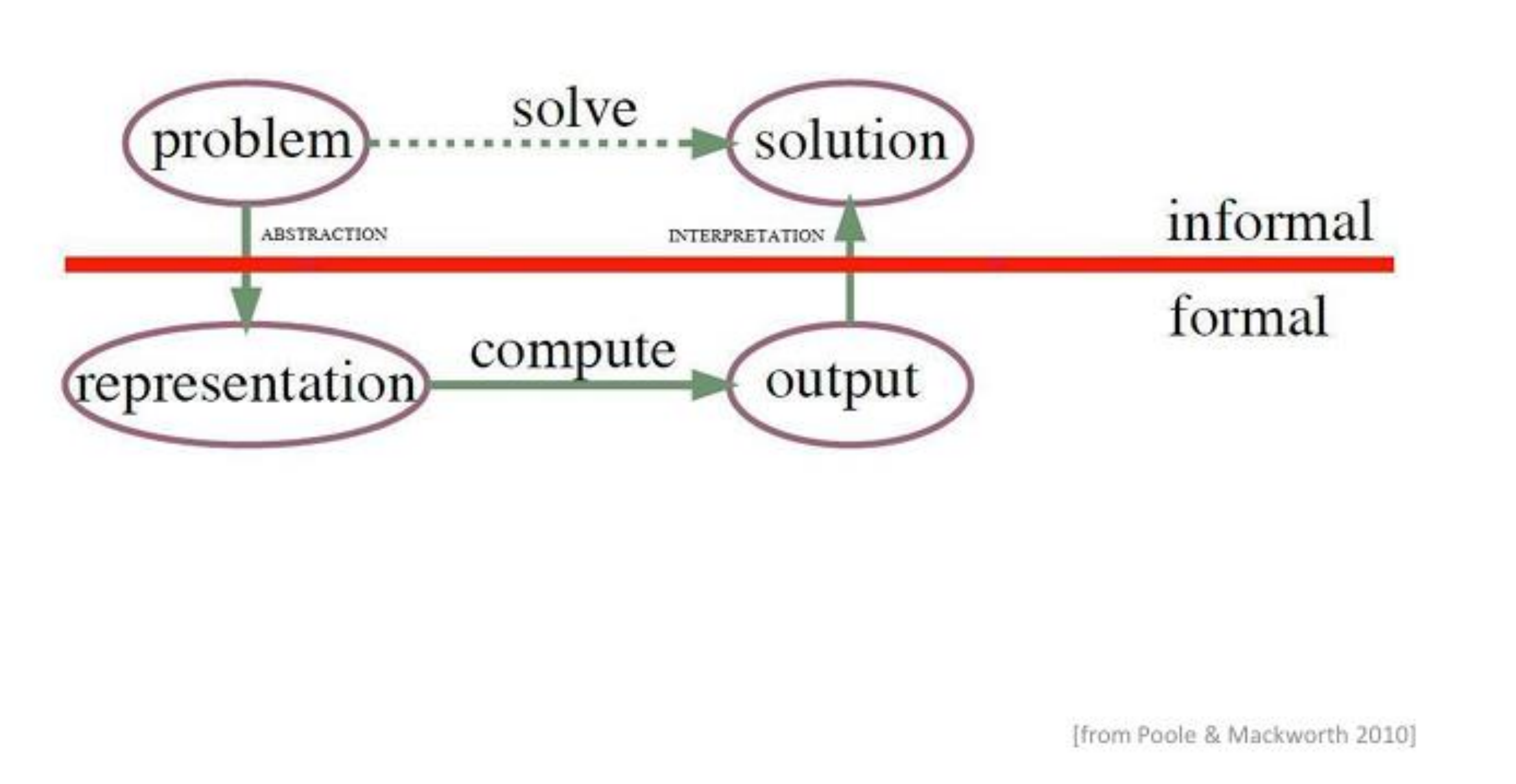
Outline

- Overview
- AI approach to solving a problem
  - Problem types
  - Problem formulation
- Solution construction steps
- Measuring problem-solving performance
- Examples

Overview

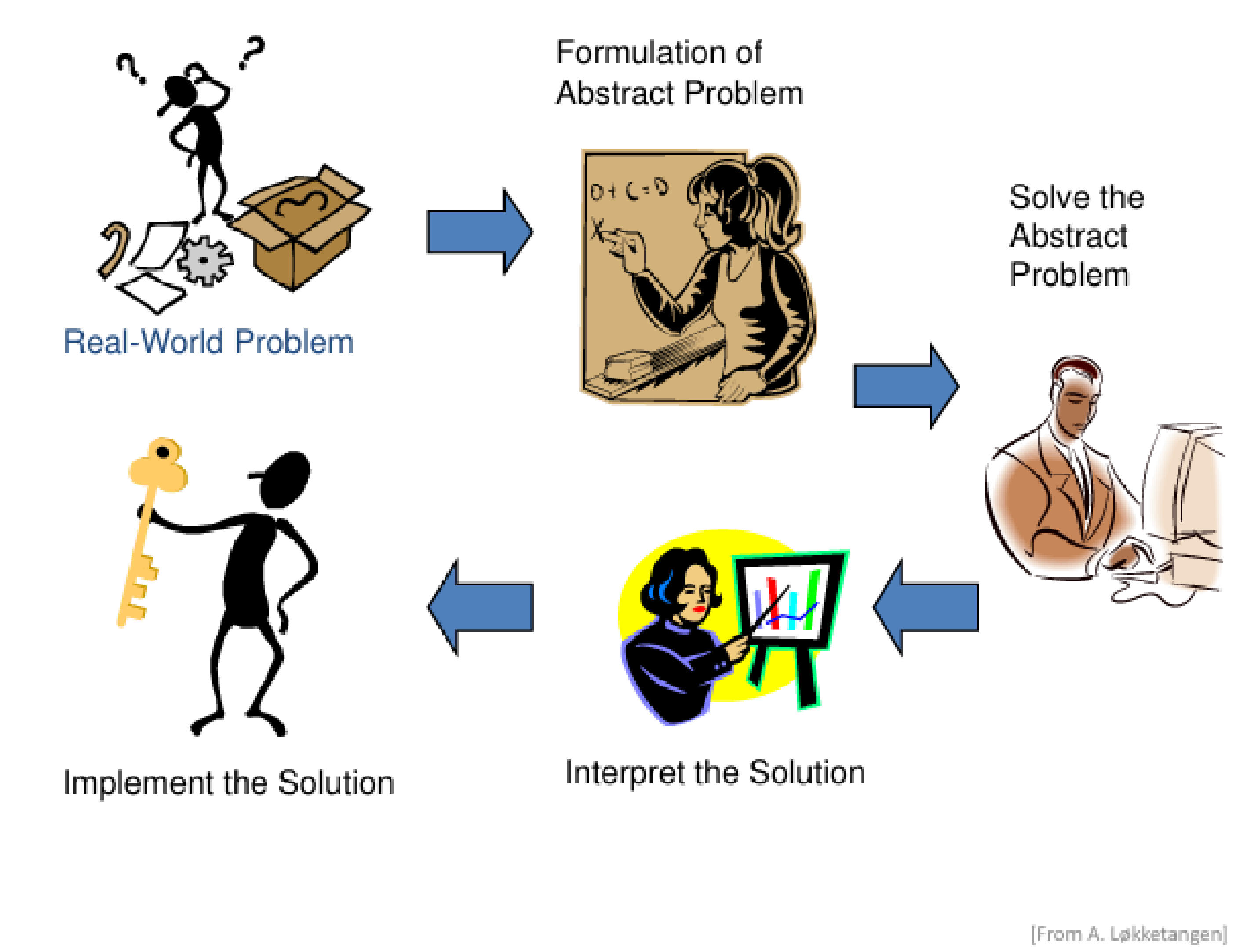
- Problem solving is very challenging in AI,
- It is a process of generating solutions from observed or given data.
  - *It is not always possible to use direct methods (i.e. go directly from data to solution).*
  - *Instead, problem solving often needs to use indirect or modelbased methods*

Overview



problem
solve
solution
ABSTRACTION
INTERPRETATION
informal
formal
representation
compute
output
[from Poole & Mackworth 2010]

Overview

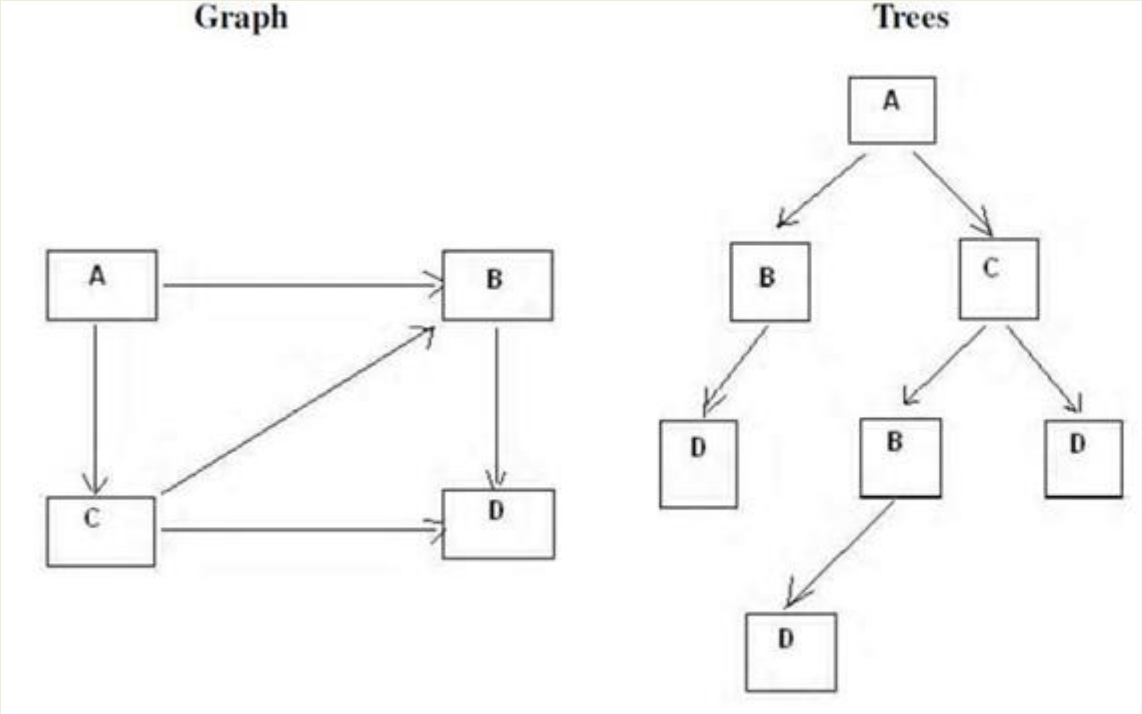


Formulation of
Abstract Problem
Real-World Problem
Solve the
Abstract
Problem
Implement the Solution
Interpret the Solution
[From A. Løkketangen]

AI approach to solving a problem

- **Problem solving** may be characterized as a systematic **search** through a range of possible actions to reach some predefined goal or solution.
- **Problem space** is represented by a directed graph, where nodes represent search state and paths represent the operators applied to change the state.
- **State** is a collection of information that represents the current status of an AI system at a given moment. It involves the representation of variables, data, and conditions essential for decision-making,
- **Search space (state space):** Search space represents a set of possible solutions, which a system may have.
- A ‘search’ refers to the search for a solution in a problem space.
  - *Search proceeds with different types of ‘search control strategies’.*
  - *The depth-first search and breadth-first search are the two common searches*

AI approach to solving a problem



Problem types

- Single-state problem: state is exactly known
  - *observable (at least the initial state):* When an agent sensor is capable to sense or access the complete state of an agent at each point in time, it is said to be a fully observable environment else it is partially observable.
    - **Chess –** the board is fully observable, and so are the opponent's moves.
    - **Driving –** the environment is partially observable because what's around the corner is not known.
  - *Deterministic:* When a uniqueness in the agent's current state completely determines the next state of the agent, the environment is said to be deterministic.
    - **Chess –** there would be only a few possible moves for a chess piece at the current state and these moves can be determined.
    - **Self-Driving Cars-** the actions of a self-driving car are not unique, it varies time to time.

Problem types

- *Static:* An idle environment with no change in its state is called a static environment.
- *Discrete:* If an environment consists of a finite number of actions that can be deliberated in the environment to obtain the output, it is said to be a discrete environment.
  - The game of chess is discrete as it has only a finite number of moves. The number of moves might vary with every game, but still, it's finite.

Problem types

- Multiple-state problem: not exactly known but limited to a set of possible states
  - *partially observable (initial state not observable/ no sensor)*
  - *deterministic*
  - *static*
  - *discrete*
- Contingency problem
  - *partially observable (initial state not observable)–*
  - *non-deterministic*

Problem formulation

- A problem can be defined by five components:
  - *initial state or start state,*
  - *actions,*
  - *transition model,*
  - *goal test,*
  - *path cost.*

Problem formulation

- Initial/ Start State: It is a state from where agent begins the search.
- Actions: A description of the possible actions available to the agent
- Transition model: A description of what each action does
- Goal test: It is a function which observe the current state and returns whether the goal state is achieved or not.
- Path cost: It is a function which assigns a numeric cost to each path.
- The cost of a path can be described as the sum of the costs of the individual actions along the path.
- Together, the initial state, actions and transition model space of the problem implicitly defined the state – the set of all states reachable from the initial state by any sequence of actions.
- Problem-solving agents try to find action sequences that lead to desirable states

Solution construction steps

- The process of solving a problem consists of five steps.
  - ***Defining The Problem:*** *The definition of the problem must be included precisely. It should contain the possible initial as well as final situations which should result in acceptable solution.*
  - ***Analyzing The Problem:*** *Analyzing the problem and its requirement must be done as few features can have immense impact on the resulting solution.*
  - ***Identification Of Solutions:*** *This phase generates reasonable amount of solutions to the given problem in a particular range.*
  - ***Choosing a Solution:*** *From all the identified solutions, the best solution is chosen basis on the results produced by respective solutions.*
  - ***Implementation:*** *After choosing the best solution, its implementation is done*

Measuring problem-solving performance

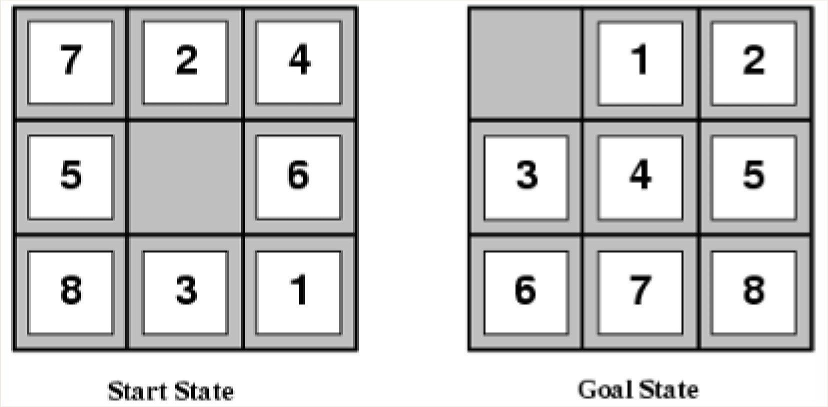
- We can evaluate an algorithm’s performance in four ways:
  - *Completeness: Is the algorithm guaranteed to find a solution when there is one?*
  - *Optimality: Does the strategy find the optimal solution?*
  - *Time complexity: How long does it take to find a solution?*
  - *Space complexity: How much memory is needed to perform the search?*

Examples

- How to formulate a problem into a state space search problem?
- Water jug problem
  - *States: amount of water in both jugs*
  - *Actions: Empty large, Empty small, Pour from small to (empty) large, Pour from large to (empty) small*
  - *Goal: specified amount of water in both jugs*
  - *Path cost: total number of actions applied*

Examples

- Toy problem: The 8-puzzle



  - *States: location of each tile and also the blank*
  - *Actions: blank moves left, right, up or down*
  - *Goal: state matches the goal configuration*
  - *Path cost: length of path (each action step cost 1)*

References

- Andreas Zell slides, After the Textbook: Artificial Intelligence After the Textbook: Artificial Intelligence, A Modern Approach by Stuart Russel and Peter Norvig (3rd Edition),