INF5390-2102 – Kunstig intelligens

Exercise 1 Solution

Roar Fjellheim

Exercise 1.1: Solving Problems by Searching (INF5390-03)

- You have 3 containers that may hold 12 liters, 8 liters and 3 liters of water, respectively, as well as access to a water faucet. You can fill a container from the faucet, pour it into another container, or empty it onto the ground. The goal is to measure out exactly one liter of water.
- a. Give a precise specification of the task as a search problem.
  b. Select and provide arguments for a particular uninformed search algorithm to solve the problem
  c. Draw a picture of a search tree for a solution (or program the algorithm)

Formulation of a problem

- Initial state
  - Initial state of environment
- Actions
  - Set of actions available to agent
- Path
  - Sequence of actions leading from one state to another
- Goal test
  - Test to check if a state is a goal state
- Path cost
  - Function that assigns cost to a path
- Solution
  - Path from initial state to a state that satisfies goal test

Defines the *state space*

States and actions

- State: [x, y, z] - Contents of 12, 8 and 3 liter jug
- Initial state: [0, 0, 0]
- Fill actions:
  - [x, y, z] ⇒ [12, y, z]
  - [x, y, z] ⇒ [x, 8, z]
  - [x, y, z] ⇒ [x, y, 3]
- Empty actions:
  - [x, y, z] ⇒ [0, y, z],
  - [x, y, z] ⇒ [x, 0, z],
  - [x, y, z] ⇒ [x, y, 0]
- Pour actions:
  - Contents of 12 liter ⇒ 8 l jug
  - [x, y, z] ⇒ [x-min(x, 8-y), y+min(x, 8-y), z]
  - E.g. [10, 5, 2] ⇒ [7, 8, 2]
  - Similar for 12 ⇒ 3, 8 ⇒ 3, 8 ⇒ 12, 3 ⇒ 12, 3 ⇒ 8 l jugs
  - 6 pour actions
- In all 12 actions (some may be «no-ops» in a given state)

Goal and solution cost

- Goal test:
  - √ [1, y, z] or [x, 1, z] or [x, y, 1]
- Path cost:
  - √ Number of actions in path from initial to goal state

(Uninformed) search algorithm

- Search path may be of infinite depth (without state duplication check)
  - √ Depth first search not recommended
- With a branching factor of 12, search tree rapidly becomes large (e.g. $12^5 = 248832$)
  - √ Breadth first search not recommended
- **Iterative deepening depth first search is recommended**

Iterative deepening search

```
function ITERATIVE-DEEPENING-SEARCH(problem)
                                   returns a solution or failure
  for depth <= 0 to ∞ do
      result <= DEPTH-LIMITED-SEARCH(problem, depth)
      if result ≠ cutoff then return result
```

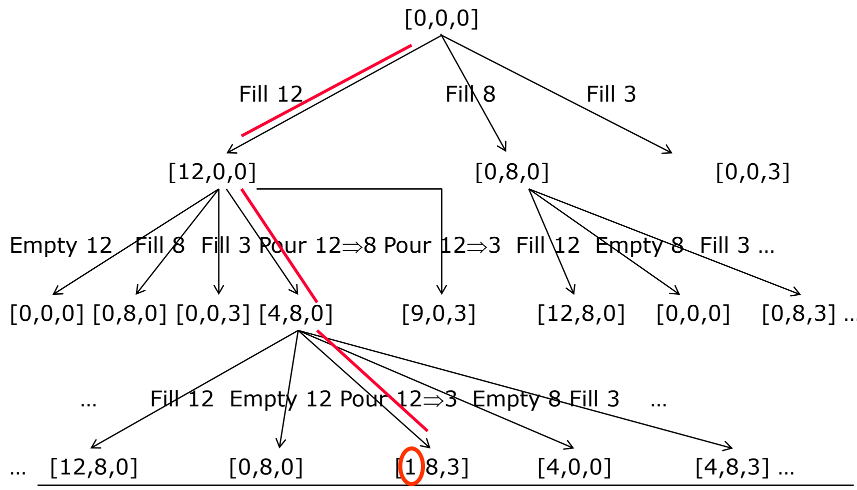
- Modifies depth-limited search by iteratively trying all possible depths as the cutoff limit
- Combines benefits of depth-first and breadth-first

Complexity of iterative deepening search

- May seem wasteful, since many states are expanded multiple times (for each cutoff limit)
- In exponential search trees most nodes are at lowest level, so multiple expansions at shallow depths do not matter much
- Time complexity is $O(b^d)$, space complexity $O(bd)$

Iterative deepening is the preferred (uninformed) search strategy when there is a large search space and the solution depth is unknown

Search tree with solution path

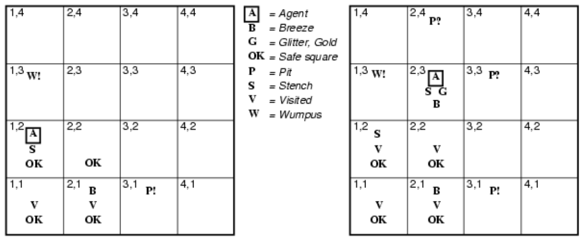


Cost = 3

Exercise 1.2: Logical Agents (INF5390-04)

- Ref. figure 7.4 (a) in the AIMA text book, showing the agent in square [1,2], after having sensed nothing in [1,1], a breeze in [2,1] and a stench in [1,2]. The agent is now concerned with the contents of [1,3], [2,2] and [3,1]. Each may contain a pit, and at most one can contain the monster (wumpus).
- Use a truth table to show that the wumpus is in [1,3], i.e. that the statement "There is a wumpus in [1,3]" is implied by the agent's knowledge base KB.

Exploring the Wumpus world (cont.)



(a) (b)

- Fourth percept: [Stench, None, None, None, None]
- Deduction: Wumpus must be in [1,3], pit in [3,1]
- Action: Move right, etc.

- What does an intelligent agent need to know and how can it reason to succeed in the Wumpus world?

Propositional inference by checking

- Construct truth table with one row for each combination of truth values of the propositional symbols in the sentence
- Calculate truth value of the KB sentences for each row; if all are true, the row is a model of the KB
- All other sentences that are true in the same rows as the KB is true, are entailed by the KB

Wumpus - Model checking by truth table

P[1,2]	P[2,2]	P[3,1]	KB	α_1 =Not P[1,2]	α_2 =Not P[2,2]
T	T	T	F	F	F
T	T	F	F	F	F
T	F	T	F	F	T
T	F	F	F	F	T
F	T	T	**T**	T	F
F	T	F	**T**	T	F
F	F	T	**T**	T	T
F	F	F	F	T	T

Exercise 1.2 based on INF5390-04 case

- "The agent is now concerned with the contents of [1,3], [2,2] and [3,1]. Each may contain a pit, and at most one can contain the wumpus"
- Modify INF5390-04 case
  - √ Replace P[1,2] with P[1,3]
  - √ Add columns for W[1,3], W[2,2] and W[3,1]
  - √ Would normally result in a truth table with 2^6 lines
  - √ However, restriction that there is only one wumpus eliminates one half of the table (see next slides)
- Just one statement to check: α = W[1,3]
- Rest similar to INF5390-04 case

Truth table – 1. half

P[1,3]	P[2,2]	P[3,1]	W[1,3]	W[2,2]	W[3,1]	KB	α = W[1,3]
T	T	T	T	F	F	F	T
T	T	F	T	F	F	F	T
T	F	T	T	F	F	F	T
T	F	F	T	F	F	F	T
F	T	T	T	F	F	F	T
F	T	F	T	F	F	F	T
F	F	T	T	F	F	T	T
F	F	F	T	F	F	F	T
T	T	T	F	T	F	F	F
T	T	F	F	T	F	F	F
T	F	T	F	T	F	F	F
T	F	F	F	T	F	F	F
F	T	T	F	T	F	F	F
F	T	F	F	T	F	F	F
F	F	T	F	T	F	F	F
F	F	F	F	T	F	F	F

Truth table – 2. half

P[1,3]	P[2,2]	P[3,1]	W[1,3]	W[2,2]	W[3,1]	KB	α = W[1,3]
T	T	T	F	F	T	F	F
T	T	F	F	F	T	F	F
T	F	T	F	F	T	F	F
T	F	F	F	F	T	F	F
F	T	T	F	F	T	F	F
F	T	F	F	F	T	F	F
F	F	T	F	F	T	F	F
F	F	F	F	F	T	F	F
T	T	T	F	F	F	F	F
T	T	F	F	F	F	F	F
T	F	T	F	F	F	F	F
T	F	F	F	F	F	F	F
F	T	T	F	F	F	F	F
F	T	F	F	F	F	F	F
F	F	T	F	F	F	F	F
F	F	F	F	F	F	F	F