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572 - Principle of Artificial Intelligence

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Problem Set 3

(50 points)

- 1) (40 pts.) Chapter 3 Exercises 11 (mc-problem) at <https://aimacode.github.io/aima-exercises/search-exercises/>. You may solve question 2 either by hand - manually showing the process of your selected search algorithm, or by coding the search algorithm.

Chapter 3 Exercise 11

The problem is usually stated as follows. Three missionaries and three cannibals are on one side of a river, along with a boat that can hold one or two people. Find a way to get everyone to the other side without ever leaving a group of missionaries in one place outnumbered by the cannibals in that place. This problem is famous in AI because it was the subject of the first paper that approached problem formulation from an analytical viewpoint Amarel:1968.

1. Formulate the problem precisely, making only those distinctions necessary to ensure a valid solution. Draw a diagram of the complete state space.

Problem Formulation

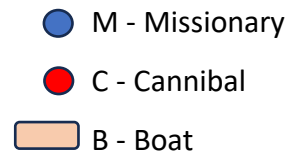
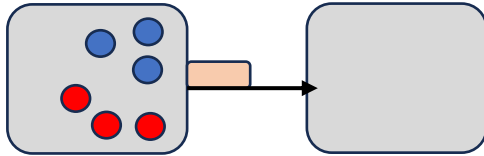
The environment is fully observable, multiagent, deterministic, sequential, static, and discrete.

State Representation

- The state can be represented as the following (M, C, B).

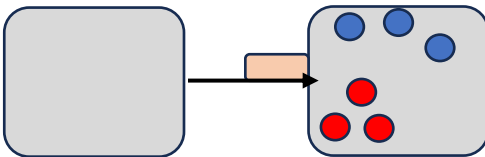
Initial State - (3, 3, 1)

- All cannibals and missionaries are in the same side of the river.
- The boat is also in the same side of the river.



Goal State – (0, 0, 0)

- All cannibals and missionaries are in the opposite side of their initial position in respect to the river.
- The boat is also in the opposite side of its initial position in respect to the river.



Legal Actions & Constraints:

- The number of missionaries on either side of the river should never be less than the number of cannibals on that side, unless there are no missionaries on that side.
- The boat may be used to transport people from one side of the river to another.
- The boat can only move one or two people at the same time.
- The boat can only move if there's one person inside of it.

Goal:

- The goal is to transport all three missionaries and three cannibals to the other side of the river.

Action Cost:

- The action cost can be 1 per each time the boat crosses the river.

2. Implement and solve the problem optimally using an appropriate search algorithm. Is it a good idea to check for repeated states?

Search Algorithm

I believe we would have no problem using Breadth First Search (BFS) as the search algorithm to find a solution for this problem. Other algorithms such as Depth First Search (DFS) or A* would work as well. However, BFS is complete and guarantees to find an optimal solution once all actions have the same cost in this example. In addition to this, the time and space complexity would not be an issue given the small state space of this problem.

I also believe that checking for repeated states is crucial for the success of any of the mentioned search algorithms to solve this puzzle. That's because the algorithm may go in circles, reexploring the same states without making any progress towards the goal if it doesn't remember the states it has been through.

Now for the solution, we have the following:

- 1) (3M,3C,B1) \leftarrow Initial State – Goal State \rightarrow (0M,0C,B0)
- 2) (3M,1C,B0) |----[go 2 cannibals] --> (0M,2C,B1)
- 3) (3M,2C,B1) <---[back 1 cannibal] --| (0M,1C,B0)
- 4) (3M,0C,B0) |----[go 2 cannibals] --> (0M,3C,B1)
- 5) (3M,1C,B1) <----[back 1 cannibal] --| (0M,2C,B0)
- 6) (1M,1C,B0) |----[go 2 missionaries] --> (2M,2C,B1)
- 7) (2M,2C,B1) <----[back 1 missionary 1 cannibal] --| (1M,1C,B0)
- 8) (0M,2C,B0) |----[go 2 missionaries] --> (3M,1C,B1)
- 9) (0M,3C,B1) <----[back 1 cannibal] --| (3M,0C,B0)
- 10) (0M,1C,B0) |----[go 2 cannibals] --> (3M,2C,B1)
- 11) (0M,2C,B1) <---[back 1 cannibal] --| (3M,1C,B0)
- 12) (0M,0C,B0) |----[go 2 cannibals] --> (3M,3C,B1)

3. Why do you think people have a hard time solving this puzzle, given that the state space is so simple?

Although it's a small fully observable state, I think people may have a hard time solving this puzzle because of the constraints of the problem. For most humans, it's difficult to think and plan over 10 steps ahead, and given this sequential environment, in which each move is decisive and requires attention and planning to avoid running into invalid spaces. As a human, it's hard for me to mentally visualize and keep track of all transactions of the agents going back and forward while making sure all constraints are being met. It's even somehow counterintuitive given the fact that an agent can already be at the target side of the river and may have to go back to the initial side in order to meet the constraints. Therefore, it's a problem that requires planning carefully ahead and a systematic sequence of actions to resolve the puzzle.