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AI- Assignment 1

Introduction

This report describes AI- Assignment 1 submission. The **PEAS** model of the system with justifications is provided. Moreover, two different algorithms to find the shortest path to the home cell were discussed and compared. These two algorithms are *backtrack* and *breadth-first search*.

The submission code is available on https://swish.swi-prolog.org/p/hash.pl, and it was tested there. It contains two main procedures *rand(N)* and *test(N, [Xcovid1, Ycovid1], [Xcovid2, Ycovid2], [Xdoc, Ydoc], [Xhome, Yhome], [Xmask, Ymask])*. The former is used to generate a random map of size N * N, and then randomly generate the objects (Covid, mask, doctor), and show the optimal path (if there is any). The latter is used to solve the map with specific positions for the different objects given as the procedure arguments. In both procedures (*rand* and *test*), both algorithms (*backtrack* and *breadth-first search*) are used.

PEAS Model

The **P**erformance Measure for the system is to reach the home cell in the minimum number of steps (not reaching home can be expressed as infinite steps). Moreover, the **E**nvironment consists of the 2D map (9 * 9 lattice), the positions of the two Covid cells, the home cell, the mask cell, and the doctor cell. As for the **A**ctuators, the agent needs only one, and that is any tool that allows them to move in the 2D map in all allowed directions. Only two **S**ensors are needed for the system. One of them is to provide the home cell coordinates, and the other is to warn the agent if there is a covid infected cell nearby (how far the agent can detect covid infected cells differs by the variants).

The **E**nvironment, as previously described, embraces the following properties. Firstly, the agent (actor) does not have all the information about the **E**nvironment (e.g. the actor does not know where the mask is), therefore, the **E**nvironment is *partially-observed* by the agent. Moreover, the **E**nvironment has *two* types of agents (Covid, and the actor). There are two Covid agents and one actor. When considering the actor's perspective, the environment is deterministic because choosing to move to a certain cell will dictate the new state of the grid. Furthermore, a cell that is reachable in the current state can become illegal in the next state, therefore, decisions affect future states, this implies that the **E**nvironment is *sequential*. Time is not considered as a factor in the **E**nvironment, only the number of moves matter. Hence the **E**nvironment is *static*. Since there is a finite number of states possible, the **E**nvironment is discrete. Finally, the AI agent will be designed with knowledge of the rules of movements, thus the environment is known.

Backtrack

In this approach, the shortest path is found recursively by trying to build candidate paths and abandoning a candidate as soon as it determines that the candidate cannot possibly be completed to a valid solution (reach home). We start from the initial cell (at position (0, 0)), and try to travel using all eight directions until the target (home) cell is reached. As the algorithm traverses the cells, it also keeps track of the path it has followed to update the final answer when the target is reached. In short, this algorithm tries every possible path, then the minimum path among those is chosen and stored as the final answer.

Since this approach is based on brute-forcing every possible way to arrive at the home cell, it is considered to be time-consuming and inefficient. Therefore some optimizations were added to this algorithm. For example, when the current path arrives at a cell that contains a mask or a doctor, the actor, knowing that Covid does not affect them anymore, moves directly to the home cell. Another optimization is that the actor tends to avoid passing through some cell twice (unless the optimal path requires so).

Backtrack approach implementation (and performance) does not change for the two variants. That is due to the fact that the backtrack is based on the idea of brute force. It tries all possible paths regardless of how far the actor can detect the Covid zone from. The number of possible paths stays the same, therefore, the performance stays the same as well.

Breadth-First Search

As the name suggests, the algorithm traverses the closest cells to the initial cell before going to further ones. This algorithm is considered relatively fast because it guarantees that no cell will be visited twice. However, some modifications were needed to make the algorithm consider how doctor and mask cells affect the system. Similar to the backtracking approach, when a doctor or mask cell is reached, the actor travels directly to the home cell. Please note that this improvement is necessary for the breadth-first search approach to properly work.

Some optimizations were made to improve the time the breadth-first search approach takes. One of them is when the home cell is reached, the algorithm stops immediately. Since the breadth-first search explores the closest non-visited cell, then there is indeed no better path than the current one based on the BFS definition.

Statistical Analysis

The method used was to run both algorithms 10 times on random maps of size 9 * 9. The results are shown in the table below.

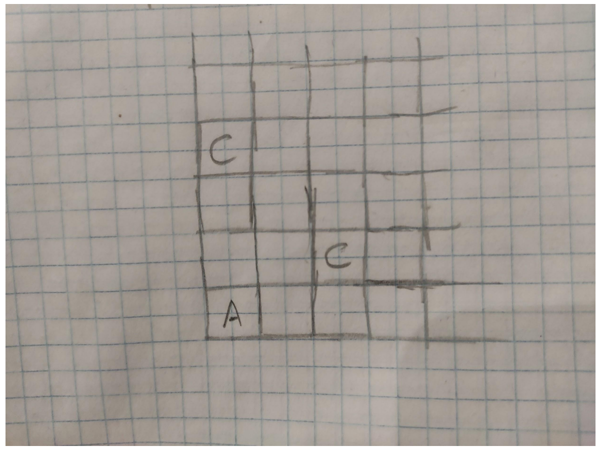
# Running	Backtrack	Breadth-first search
1	380 ms	277 ms
2	59 ms	155 ms
3	184 ms	40 ms
4	93 ms	51 ms
5	65 ms	33 ms
6	201 ms	110 ms
7	0 ms	0 ms
8	74 ms	110 ms
9	88 ms	24 ms
10	22 ms	34 ms

Some data about backtrack runs:
Average = 116.6 ms, Standard Deviation = 111.93, Variance = 12528.93.
Some date about breadth-first search:
Average = 83.4 ms, Standard Deviation = 83.28, Variance = 6935.6.

We can see that breadth-first search shows better performance than backtrack on average. Another observation can be made on the variances of the two methods. Since the backtrack has a much higher variance, its execution time is not reliable and can vary a lot. As for breadth-first search, it showed a lower variance, meaning it is a better approach to predict.

Impossible-To-Solve Maps

The first type of such maps is when the actor is surrounded by Covid infected cells that they cannot reach any of the other objects (mask, doctor, and home). In this case, the actor cannot go outside this zone, and they will be stuck there forever. A figure of this case is shown below (please note that only the bottom-left part of the map is provided, and not all objects are placed because it is sufficient to demonstrate the case).



As we can see in the previous figure, the actor (denoted as ‘A’) is initially located at cell (0, 0), and they can move only to cell (0, 1), and no other cell is reachable because the Covid agents (denoted as ‘C’) are blocking the way.
Another type of unsolvable maps is when the covid agent is generated in a cell causing the initial cell (0, 0) to be infected by covid. This can happen when Covid agent is generated at one of these cells {(0, 0), (0, 1), (1, 0), (1, 1)}. Then the agent dies at the beginning of the game. A figure of this case is shown below (please note that only the bottom-left part of the map is provided, and not all objects are placed because it is sufficient to demonstrate the case).