

# CS 175: Project in AI (in Minecraft): Winter 2021

## Assignment 1: Finding the Shortest Path

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### 1 Task Description

In this assignment, you have to guide the player agent in Minecraft through a maze to reach the goal block. For this exercise, we will assume that the agent can see the whole maze, i.e. it is completely observable. Given this information, the agent has to reach the goal in the minimum number of moves.

This assignment is based heavily on `tutorial_7.py` in the Malmo Python tutorials, so please follow the tutorials 1 through 5 to familiarize yourself with the API and the Malmo platform (tutorial 6 is not relevant yet).

#### 1.1 Provided Source Code

We have provided two Python files. The most important one is `assignment1.py` which contains the complete code to setup the Malmo environment with different mazes, and have the agent run through it. The provided implementation is incomplete, and the agent needs your help to solve the maze most efficiently. We have also provided `priorit_dict.py`, a simple implementation of a heap-based priority queue. See the implementation for details, and discuss on Campuswire if you have any doubts. You can ignore this implementation if you prefer.

#### 1.2 Setup and Running the Code

Assuming you have installed Malmo and started working your way through the tutorials, all you need to do to run this assignment is to copy the two files above to the `Python_Examples` folder, and after launching Minecraft, run `python assignment1.py` (Python 3 or higher). If everything runs successfully, the agent should do nothing while the timer counts down for each of the ten missions. The output in the terminal should look like the following:

```
Size of maze: 6
Waiting for the mission 1 to start
Mission 1 running.
Output (start,end) 1 : (None, None)
Output (path length) 1 : 0
Output (actions) 1 : []
Error: out of actions, but mission has not ended!
Error: out of actions, but mission has not ended!

Mission 1 ended
Size of maze: 6
Waiting for the mission 2 to start
Mission 2 running.
Output (start,end) 2 : (None, None)
Output (path length) 2 : 0
Output (actions) 2 : []
Error: out of actions, but mission has not ended!
Error: out of actions, but mission has not ended!
```

#### 1.3 Overview of the Code

As mentioned before, much of this assignment is based on `tutorial_7.py`, so please refer to the Malmo Tutorials in the `Python_Examples` directory. The source code creates a series of increasing difficult mazes made of `diamond_block` blocks as the floor, each with a start (`emerald_block`) and an end (`redstone_block`) block. The mission starts with the player at the start block, and ends when the player reaches the end block. Make sure you are at least somewhat familiar with the whole source code, however the main control code that is relevant for your implementation are in the following lines:

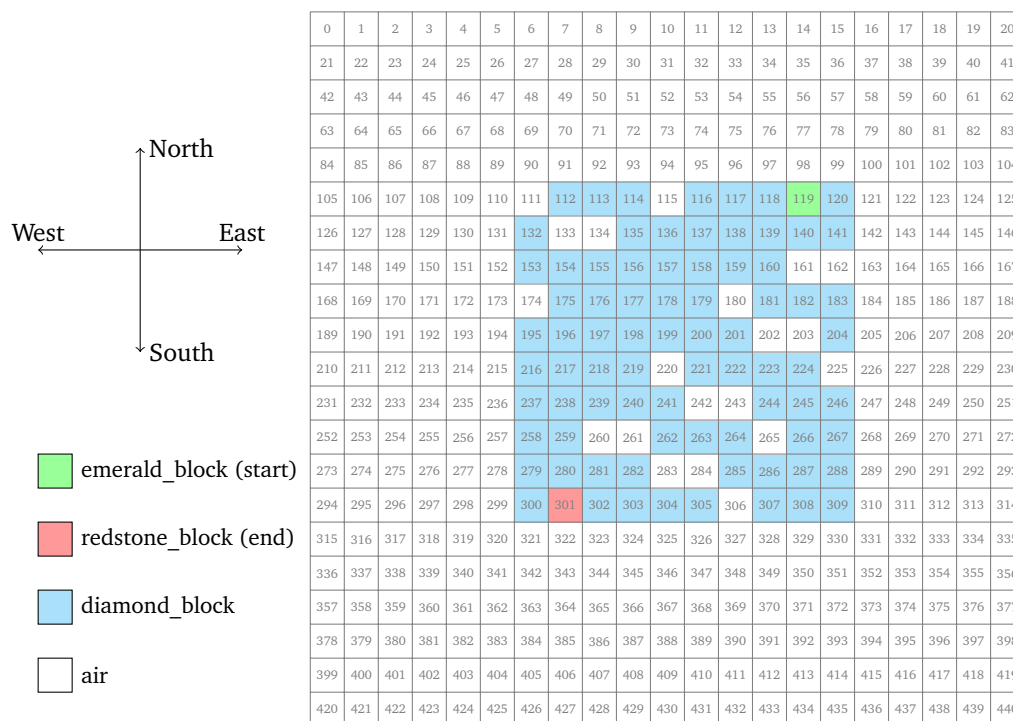


Figure 1: **Grid Layout:** Layout of the two-dimensional grid laid out as a one-dimensional array. The location of the maze, especially the start and end blocks, may be different in the assignment. The array contains string-values representing the four types of possible blocks.

```

223 grid = load_grid(world_state)
224 start, end = find_start_end(grid) # implement this
225 path = dijkstra_shortest_path(grid, start, end) # implement this
226 action_list = extract_action_list_from_path(path)

```

We first get the array of blocks that consists of the 2-dimensional maze from Malmo in `load_grid`. Then, we want to identify the start and the end blocks (each represented by an integer index into the `grid` array). Given the start and the end blocks, and the whole maze, we want to compute the shortest path of blocks from the start to the end, computed using Dijkstra's algorithm. Finally, we convert these list of blocks into Malmo *actions* that are carried out by the agent. We provide the correct implementation of the first and the last functions, but leave the correct implementation of the second and the third functions to you (more on this later).

## 1.4 Grid Layout

It is important for you to understand how the grid is laid out. We have requested the  $21 \times 21$  grid of blocks from the world that lie at the floor of the player, with the player at the center of it ((10,10), if zero-indexed). This two-dimensional is laid out as a single-dimensional array of strings (representing the type of the block) in a row-major way (where row is the east-west direction), i.e. the  $(i, j)$  coordinate is represented by the index  $j \times 21 + i$ , where  $j$  is the east-west coordinate, and  $i$  is the north-south coordinate. For the precise indexing, see the illustration in Figure 1.

Since the grid is represented by a single-dimensional array, you need to get the neighboring blocks of the current block, represented by an integer index  $i$ . Looking at `extract_action_list_from_path` should give you a hint; the blocks to the immediate left (west) and right (east) are of course represented by  $i - 1$  and  $i + 1$ , while the blocks in the north and south require jumping one whole row, thus  $i - 21$  and  $i + 21$ , respectively. The function `extract_action_list_from_path` uses this to go the other way: if block  $i$  and  $j$  are next to each other on the grid, the action to get from  $i$  to  $j$  is represented by  $j - i$ , i.e. if  $j - i$  is  $+1$ , the move is `moveeast`, if  $-1$ , the move is `movewest`, if  $-21$ , the move is `movenorth`, and if  $+21$ , the move is `movesouth`.

**Note:** The player is facing south, so do not get confused if `movesouth` is *forward*.

## 2 What Do I Submit?

**Note:** On Canvas, after pasting your code, highlight all the lines, click on the drop down that says "Paragraph", then select "Preformatted". The font of those lines should change. When you submit those lines will be formatted as code.

Here we'll describe what exactly you need to submit to the assignment on Canvas.

1. **Code: Finding Start and End Blocks (5 points):** As a simple exercise, implement the `find_start_end` function, that takes the grid as an array of string describing the block types, and returns the indices of the start and the end block. This should only require, at maximum, a few lines of code. Submit this snippet as your submission.
2. **Output: Start and End Block Indices (5 points):** Run the code with the above implemented, and look at the output lines that start with `Output (start,end)` and paste them as your submission. There should be 10 lines, one for each mission.
3. **Code: Shortest Path Implementation (50 points):** Implement Dijkstra's algorithm in order to find the shortest path from the source to the destination. The set of possible actions from each block is one step in north, south, east, or west directions, i.e. taking multiple or diagonal steps is not allowed. The path you compute should be shortest in terms of number of moves (all of them cost the same), should be a list of block indices (integers), should include both the start and the end blocks, and of course, should not contain any air blocks. Submit the complete implementation of your function.
4. **Output: Length of the Shortest Paths (30 points):** Run the code with the above implemented, and look at the output lines that start with `Output (path length)` and with `Output (actions)` and paste them as your submission. There should be 20 lines, two for each mission.
5. **Comments:** Any comments about your submission that you want to bring to our attention as we are grading it. This is completely optional, I expect most of you to leave this empty.
6. **Statement of Collaboration (10 points):** It is **mandatory** to include a *Statement of Collaboration* with respect to the guidelines below. Include the names of everyone involved in the discussions (especially in-person ones), and what was discussed. You should also include the links to all online resources you used for the assignment in this section.

All students are required to follow the academic honesty guidelines posted on the course website. For programming assignments, in particular, I encourage the students to organize (perhaps using Campuswire) to discuss the task description, assignment requirements, bugs in our/Malmo code, and the relevant technical content *before* they start working on it. However, you should *not* discuss the specific solutions, and, as a guiding principle, you are not allowed to take anything written or drawn away from these discussions (i.e. no recordings/screenshots, or if in person, photographs of the blackboard, written notes, etc.). The same holds for online resources: you are allowed to read the description of algorithms, but your code should be your own. Especially *after* you have started working on the assignment, try to restrict the discussion to Campuswire as much as possible, so that there is no doubt as to the extent of your collaboration.

## Acknowledgements

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