Introduction to Artificial Intelligence
Assignment 1: Compass and Pirates

Deadline

Week 9 (24.10.22 23:59)

Submission

- Only one Java file with the code has to be uploaded to Moodle. Input and output files are NOT allowed. Name of the file should be like this *NameSurname.java* (For example, *IvanIvanov.java*). No other symbols allowed
- Report describing each algorithm flow in plain English (not more than 2, 3 paragraphs), statistical comparison among algorithms and PEAS description with respect to the Actor agent. Name of the file should be like this *NameSurname.pdf* (For example, *IvanIvanov.pdf*). No other symbols allowed
- Also, report should include Graphical representation of maps that were impossible to solve. You can generate the maps directly through the code or hand draw them for the report after testing them on both algorithms
- Report may include any interesting outcome/map worth highlighting

Programming Language

Java (JDK 17)

Requests

- The program must work, the code should be readable, well-structured and should contain JavaDoc
- It has to be only one **.java* file and report **.pdf* file
- It is allowed to use only standard Java libraries
- NO extension of a deadline. Works sent after the deadline will NOT be evaluated
- Assignment is individual
- We will be using MOSS (Measure of Software Similarity) as a test for plagiarism. Be reminded that a score of 0 will be assigned to any submissions suspected of plagiarism pending a full investigation as per IU policies

Grading Criteria

- 60% for the code correctness
- 10% for readability of code (follow Java Code Conventions) and JavaDoc
- 30% for the well-structured and informative report

Task

According to popular movie Pirates of the Caribbean: Dead Man's Chest the pirate Captain Jack Sparrow has a magical compass, which points to the thing the owner wants most. For crossing seas, the Jack Sparrow uses its own ship called “Black Pearl”. However, the compass just allows to show a general direction, not foresee all troubles on the way to the innermost desire. Therefore, it may be completely unsafe to follow the expected shortest path, the pirate may die.

Jack Sparrow while sailing on the “Black Pearl” may be attacked and destroyed by a formidable and dangerous “Flying Dutchman” ship commanded by tyrannical captain Davy Jones. Davy Jones is almost immortal, he may be killed only by termination of his heart. Therefore, the control over the heart of Davy Jones gives a control over him indirectly over his ship “Flying Dutchman” and the KRAKEN!

The Kraken is a legendary sea monster, a leviathan sent to prey on unwary ships and mariners. It may appear from the deep and destroy the “Black Pearl” together with Jack Sparrow. At the same time the Kraken only listens to commands of Davy Jones. And the Kraken was told to stay on the same position and to wait for a “Black Pearl”. Fortunately, the Kraken is not immortal, but still very powerful enemy, to neutralize it Jack Sparrow has a brilliant plan, which requires him to reach the Island of Tortuga, famous for being pirates’ lair. On Tortuga Jack has a plenty of rum casks, which may be fired and blown-up while being caught by tentacles of the beast. And the remaining rum is never excess for pirates…Yo-ho-ho…By bursting the rum casks held by the monster, Jack Sparrow is able to injure the Kraken significantly, so it will hide in the deep of the sea till the end of the game. Visiting Tortuga is not a requirement, because it may increase the path.

One more danger is purely natural and represented by a stormy sea with strong waves. Jack Sparrow is an experienced seaman, but even this can’t help his ship to survive after crashing into the rocks in the stormy weather.

You need to help Jack Sparrow to find the thing he wishes to have, which is the dead man’s chest, containing the heart of Davy Jones. This chest is buried on the tiny island, which location is known to captain Jack Sparrow because of having compass. Your environment is 9*9 square lattice, which represents a partial map of Caribbean Sea (see Figure 1).

Captain Jack Sparrow

You start from top left map corner. Your goal is to find the shortest path till Dead Man’s Chest by using compass. Your ability to perceive troubles is defined in the “*variants section”* below. Your algorithms will work on both variants. The captain can move one step per turn and can move horizontally, vertically and diagonally. Jack Sparrow is also called Actor in this assignment context.

PIRATES of the CARIBBEAN

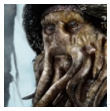
	0	1	2	3	4	5	6	7	8
0									
1									
2									
3									
4									
5									
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Figure 1. Sea Map Example

Davy Jones

The “Flying Dutchman” together with Davy Jones is randomly generated on the map except inside the Tortuga and Dead Man’s Chest isles, positions of the Kraken, the Rock and where the Jack Sparrow starts. The Davy Jones can perceive Jack Sparrow’s ship by looking through the spyglass to consecutive cells (Moore neighborhood), shown below in Figure 2. Facing the Davy Jones or its perception zone leads to death. Its position is unknown to you, because your compass can show only a single direction at a time and obviously meeting the Davy Jones can’t be Jack’s innermost desire.

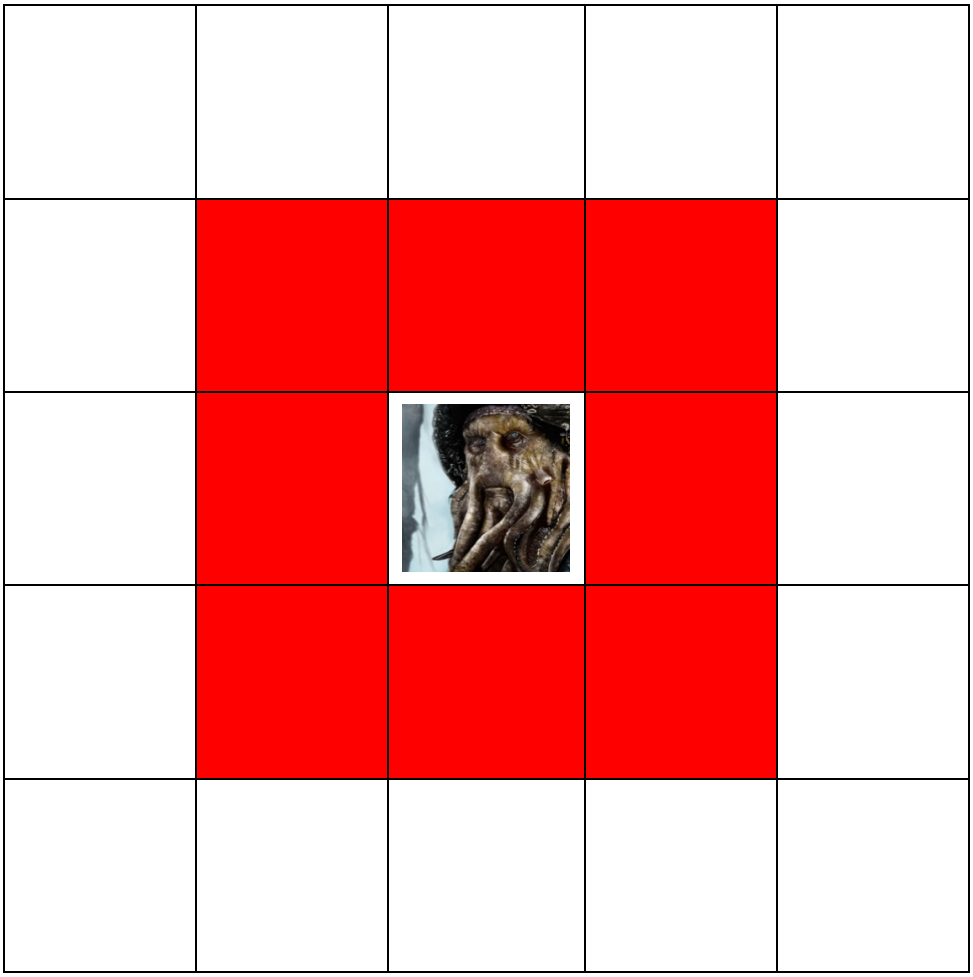

Figure 2. Davy Jones Perception Zones

The Kraken

The Kraken is randomly generated on the map except inside the Tortuga and Dead Man's Chest isles, position of the Davy Jones and where the Jack Sparrow starts. The monster may be generated in the Rock's cell, because under the water there may be a cave. The Kraken's perception is only neighbour non-diagonal cells (von Neumann neighborhood), shown below in Figure 3. Facing the Kraken or its perception zone leads to death. Its position is unknown to you, because your compass can show only a single direction at a time and obviously meeting the Kraken can't be Jack's innermost desire. By injuring the Kraken its perception zones and its position automatically disappears and becomes safe from Kraken. The Kraken can be injured by Jack Sparrow only from consecutive diagonal cells (4 at most).

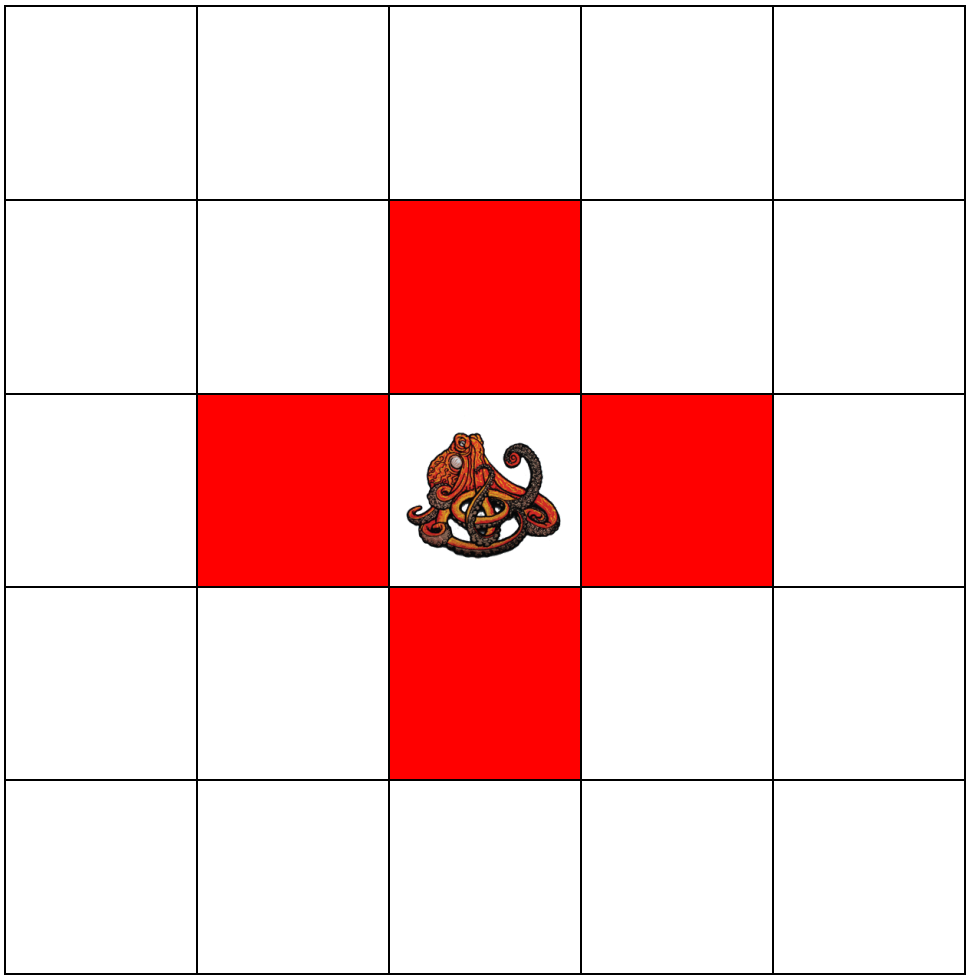

Figure 3. Kraken Perception Zones

The Rock

The rock is randomly generated on the map except inside the Tortuga and Dead Man's Chest isles, position of the Davy Jones (not danger zone!) and where the Jack Sparrow starts. The Rock has no intellect and thus no perception zone is provided for it. Facing the Rock leads to death. Its position is unknown to you, because your compass can show only a single direction at a time and obviously finding the Rock can't be Jack's innermost desire.

Dead Man's Chest

The Dead Man's Chest Island is randomly generated on the map except inside the danger zones (enemies and their perception zones) and where the Jack Sparrow starts. You know the location of the Dead Man's Chest because of having the compass.

Tortuga

The island which position is randomly generated on the map except inside danger zones (enemies and their perception zones) and where the Dead Man's Chest Island is located. On this island rum casks are stored. You know the location of Tortuga because of having the compass.

Algorithms

- A backtracking search
- A*

You are allowed to use modified versions of algorithms, do not forget to describe modifications in the report, if there will be any

Variants

The algorithms consider two scenarios:

1. You can perceive the enemy and its perception zones by using a spyglass (see Figure 4) similar to the one that is owned by Davy Jones in same Moore neighborhood cells. This can be done if you are standing next to their perception zone or even next to them in case of some enemies, shown below in Figures 5a and 5b. In figure 5a, you are able to perceive 3 orange cells, in Figure 5b only 1. Orange cells indicate the Actor's perception of the enemy and its zones

Figure 4. Jack Sparrow's Spyglass (variant 1)

Figure 5a. Jack Sparrow's Perception Zones (variant 1)

Figure 5b. Jack Sparrow's Perception Zones (variant 1)

2. You can perceive the enemy and its perception zones by using a SUPER SPYGLASS (see Figure 6), which extends your vision abilities till Manhattan distance with radius equal to 2, shown below in Figures 7a and 7b. In Figure 7a from the Actor's cell, you are able to perceive 4 orange cells. In Figure 7b, you can perceive only 1 orange cell.

Figure 6. Jack Sparrow's Spyglass (variant 2)

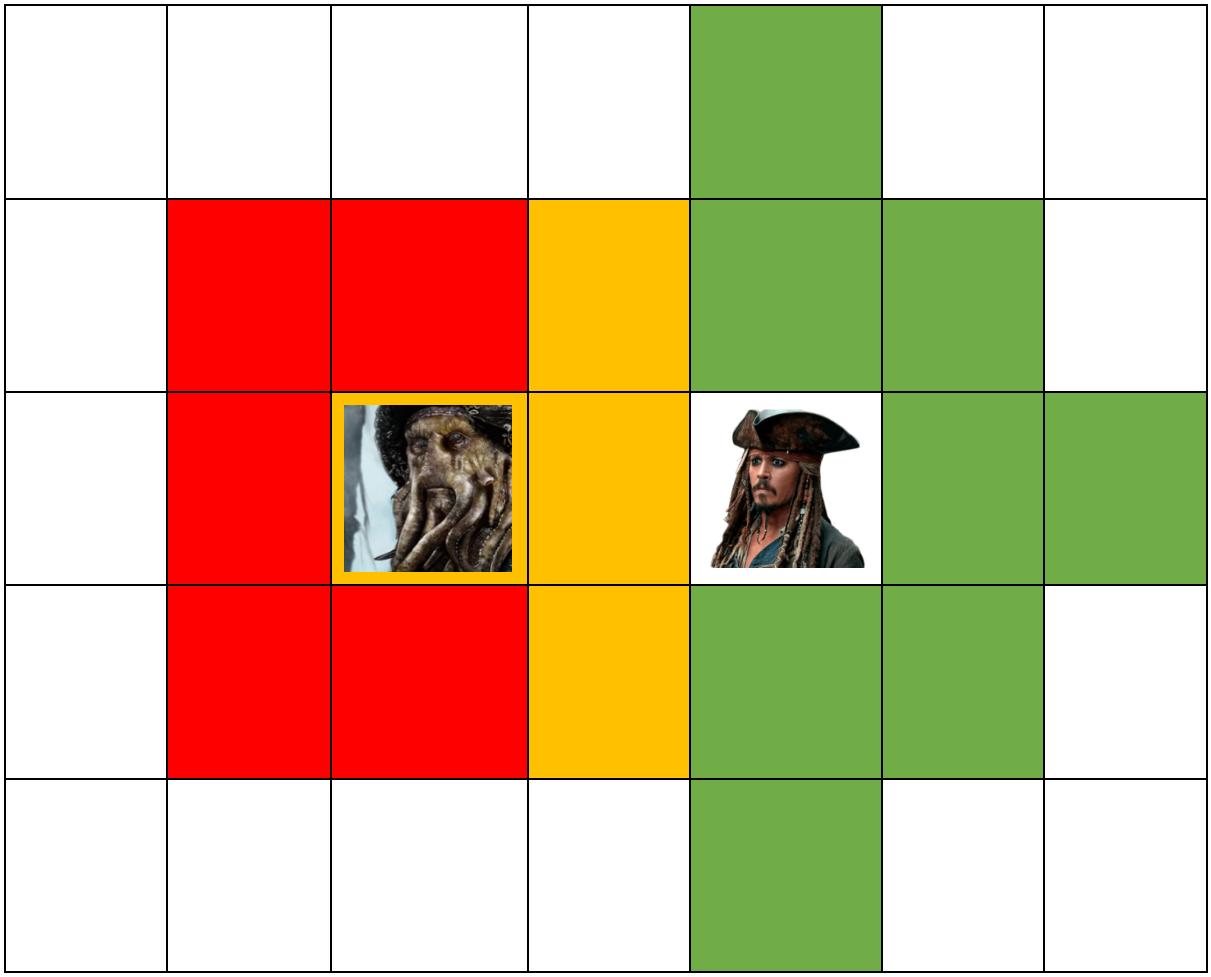

Figure 7a. Jack Sparrow's Perception Zones (variant 2)

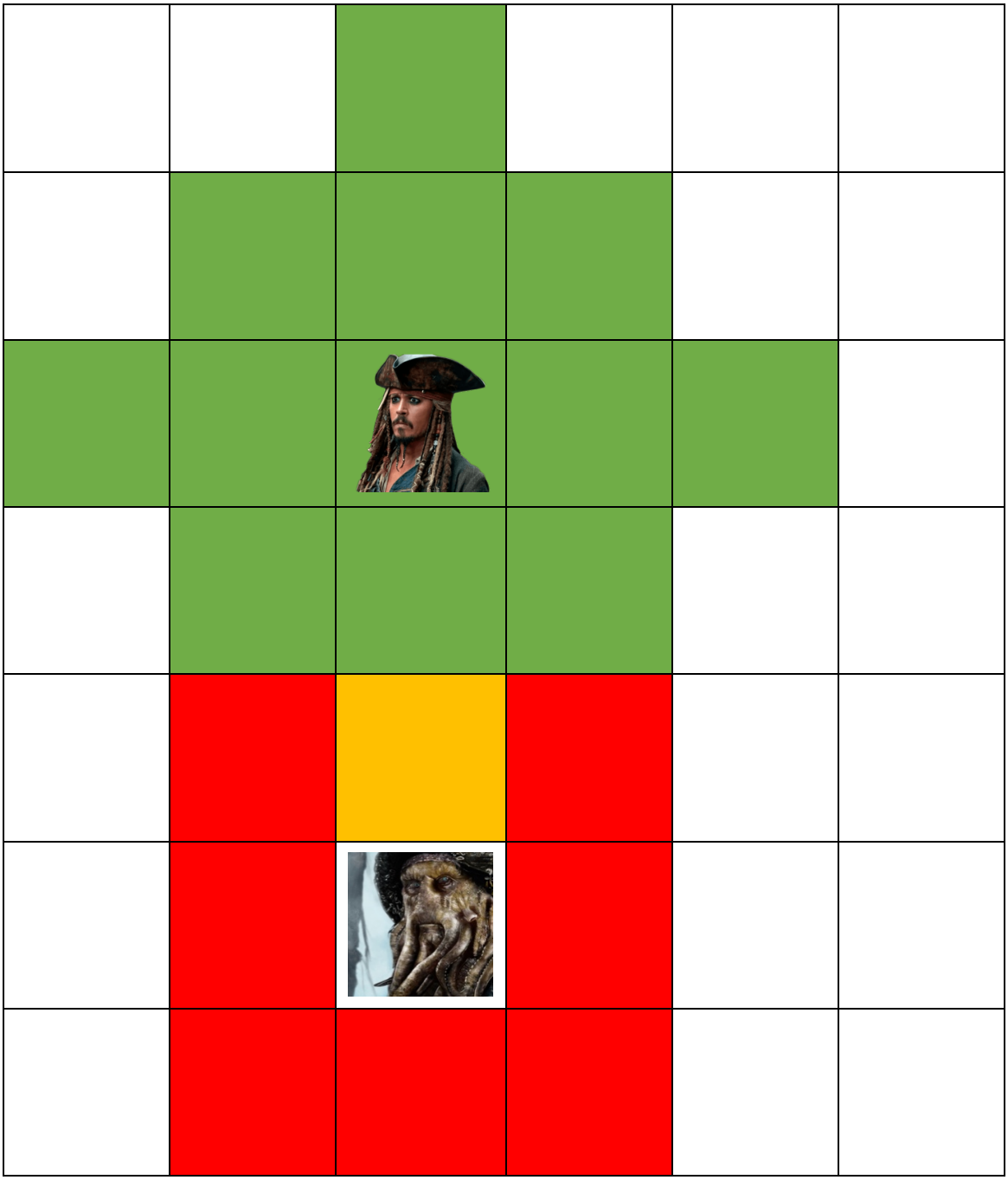

Figure 7b. Jack Sparrow's Perception Zones (variant 2)

While perceiving the danger zone of enemies, Jack Sparrow can't understand whose zone it is. But perception of the enemy's cell allows to understand who is the enemy.

Inputs

The algorithms input is a 9*9 square lattice. The map has a Jack Sparrow, Davy Jones, the Kraken, the Rock, the Dead Man's Chest and Tortuga island. The input file would be a sequence of positions for each agent in the abovementioned order followed by the Actor's perception scenario (1 or 2). Possible positions are including [0,0] [0,1] [0,2]....[8,6] [8,7] [8,8].

It should be possible:

1. to generate the map and manually insert perception scenario from console
2. to insert the positions of agents and perception scenario from the *input.txt*.

Map generation should guarantee valid inputs, manual typing may lead to errors. Any incorrect inputs violating conditions of the assignment should lead to the error message and request for valid data. Input should be written in 2 strings. For example,

[0,0] [4,7] [3,2] [6,4] [8,7] [0,6]

1

describes the positions of all agents in the first figure:

- [0,0] – Jack Sparrow
- [4,7] – Davy Jones
- [3,2] – Kraken
- [6,4] – Rock
- [8,7] – Dead Man's Chest
- [0,6] – Tortuga

and defines that the first scenario of Actor's perception is chosen. Assume that the *input.txt* file will end with a new line and should be located in the root with the **.java* file

Outputs

The output comprises of next lines in the same order:

1. Outcome - **Win** or **Lose**
   if Win case, then
   1. The shortest path length till the Dead Man's Chest
   2. The shortest path sequence, e.g. **[0,0] [1,1] [1,2]...[8,7]**
   3. The path highlighted on the 2D map
   4. Time taken by the algorithm to reach the Dead Man's Chest, e.g. **100 ms** (in ms)

There should be 2 output files for each input – one for each algorithm (*outputBacktracking.txt* and *outputAStar.txt*). In case of having Lose case, only first line should be provided in the output file (Lose). The output files should end with a new line and should be located in the root with the **.java* file.

Statistical Analysis

Comparison of algorithms through statistical analysis based upon 1000 test maps generated. The statistics should provide the mean, mode median and standard deviation for execution time, number of wins and number of loses. Also, the percentage of wins and loses should be provided Statistical analysis is required for both variants (described above). For each map, comparison would be:

1. Backtracking (variant 1) compared to A* (variant 1)
2. Backtracking (variant 2) compared to A* (variant 2)
3. Backtracking (variant 1) compared to Backtracking (variant 2)
4. A* (variant 1) compared to A* (variant 2)