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Object-Oriented Programming Methodology 7.5 p
5DV133

OU2 Robots and Labyrinths

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1 Problem Description

Aim of this laboration was to implement a number of class that allow to simulate robots in a labyrinth. The assignment suggested three base classes *Maze*, *Position* and *Robot* [1]. Further, it was defined that two specializations of the *Robot* class had to be implemented: One robot that always follows with his 'right hand' along the wall until he finds the goal of the maze. And another one that can remember positions where he has been and hence look for new unexplored positions until he finds the exit.

The classes were to be tested in a *main* program. More specific, the two specialized robot classes should be evaluated in a competition against each other. The maze shall be provided as text file in the command line arguments.

2 Usage Instructions

Find below the command line instruction to compile and run the program.

```
javac JavaApp.java
java JavaApp maze1.txt
```

A typical output of running the program from the command line looks as follows:

```
Right Hand Rule Robot has reached goal in 26 moves
Memory Robot has reached goal in 59 moves
The Right Hand Rule Robot wins
```

3 System Description

3.1 UML class diagram for the Maze project

For the UML class diagram 1 few changes were needed from the one given in the assignment [1]. In the *Maze* class diagram, the private properties *rows* and *columns* were added. To emphasize that the *toString()* method was adapted/overridden for the class *Maze* it was also shown in the class diagram. This was also true for the *Position* class. For validity checking of *mazeData* a private method *hasGoalPosition* was further added. The *Position* class diagram is identical with the one in the assignment so is the one from *Robot* class. The *MemoryRobot* has two additional properties *backtrack* and *positionHistor*, a stack and a hash map respectively. The *RightHandRuleRobot* has an additional property *direction* which is further described in the algorithm part. The *RightHandRuleRobot* has a number of additional private methods that are used for translating between the robots direction and the geographical directions north, east, south and west *moveDirection*, *wallDirection* and *movableDirection*.

3.2 Class Responsibilty and Collaborations

Class responsibilty and collaboration (CRC) charts are for the main classes are shown in table 1, 2 and 3. They are however in the opinion of the author not very helpfull as they are not a result of the design process. As such they are a bit artificial, modelled after the finished program. I don't see much of a use in this 'reverse engineering'. Please enlight me if you have a convincing argument on this.

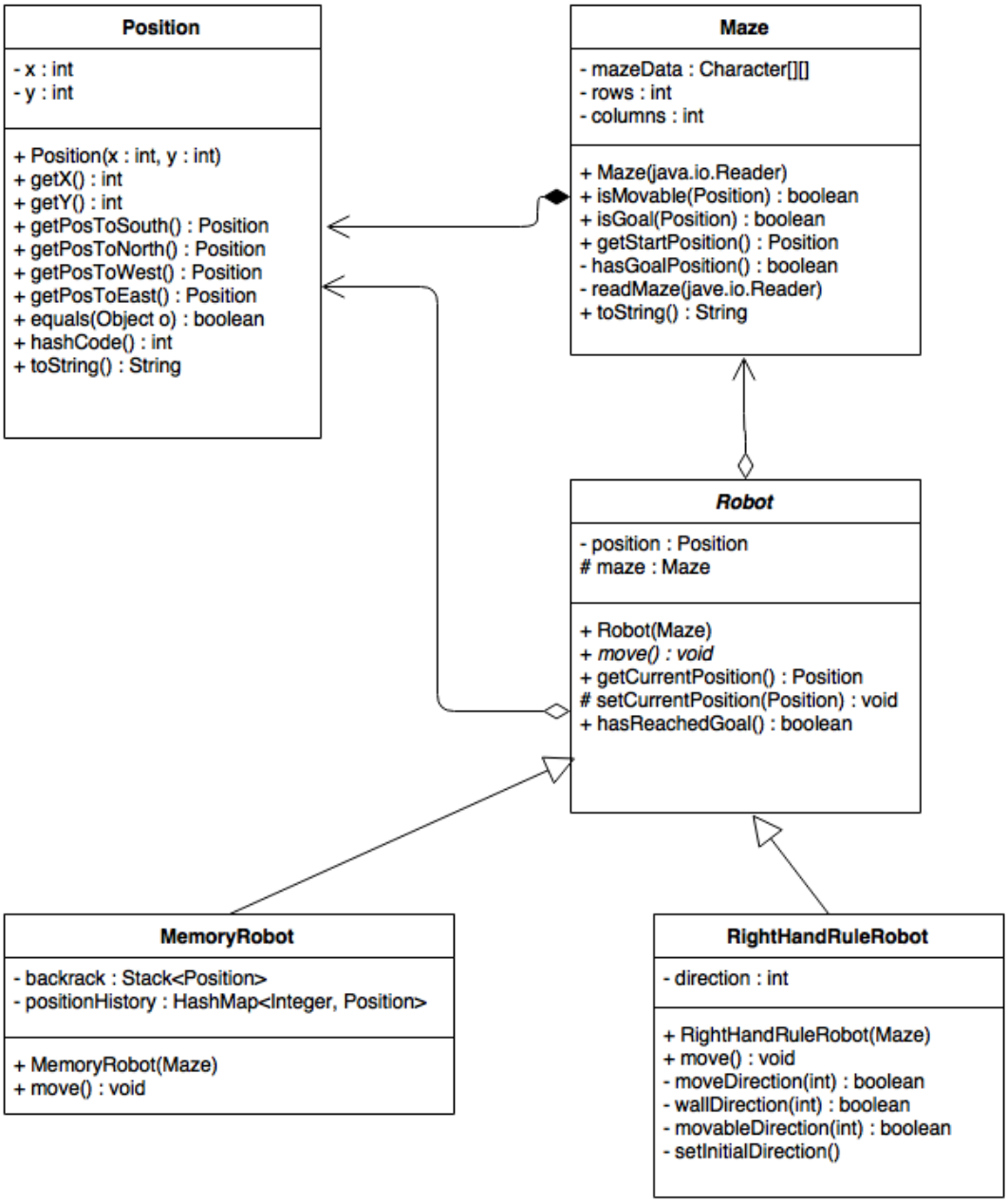

Figure 1: This is the UML class diagram

Table 1 *'Class Responsibility and Collaborator' table for the class 'Maze'*

Class: Maze	
Responsibilities	**Collaborators**
contains the data for the maze	Position
	Robot
can find the start position	
can identify 'free' position	
can identify 'goal' position	

Table 2 *'Class Responsibility and Collaborator' table for class 'Position'*

Class: Position	
Responsibilities	**Collaborators**
knows x/y coordinates	Maze
	Robot
can inform about it's X/Y coordinates	
can give the neighbouring coordinates	
can compare for equality with another Position	
can produce an identifier unique for it's coordinates	

Table 3 *'Class Responsibilty and Collaborators' table for Class 'Robot'*

Class: Robot	
Responsibilities	**Collaborators**
knows his position in the labyrinth	Maze
	Position
can move to another position	
can inform about his current position	
can find out if he reached the goal	

3.3 Specific Implementation details

The two most non-trivial problem solution details were somehow related to the robot moving algorithms and are as such described later.

Implementation of the data import did not feel very intuitive the way it was implemented now. However, this was partly given by the assignment specifications which demanded the constructor of *Maze* to take in a *java.io.Reader* object. As such, the file handling has to be put in the main class. This is maybe the way it has to be done, but it just didn't felt so generic. I would have prefered to either directly read the file, or alternatively take in a String. Now it's something in between and as user I would feel confused as where to look for information about valid in data.

3.4 Move Algorithms of the Robots

Right Hand Rule Robot

The right hand rule robot needed a number of help methods besides the specified *move()* method. This was mainly a consequence for giving the robot a memory for the direction of movement. This was seen as a measure to model the behaviour of the robot as close as possible how a physical implementation would work: If a robot has a *right hand*, it also has a direction and all operations should relate to the direction of the robot. The private methods *moveDirection()*, *wallDirection* and *movableDirection* are used to lookup geographic directions from robot directions. The actual translation is done in the *move()* method using addition and subtraction followed by a modulo operator on a direction value that is initialized by the *setInitialDirection()* method.

Try...catch statements are used to handle *ArrayIndexOutOfBounds* exceptions when the robot is at the edge of the maze. The edge is interpreted as a wall.

Memory Robot

The memory robot needs just the specified *move()* method. It uses a *stack* (*java.util.Stack*) for implementing the back tracking and a hash table (*java.util.HashMap*) for the memory of already visited places. For this work, the *hashCode()* method of the *Position* Class had to be implemented with an override. It was chosen to concatenate the X and Y position with an arbitrary unlikely-to-appear number ('9999' was chosen here).

The *move()* method of the memory robot can be roughly separated in two parts. In the first part, the robot checks in every four directions the possibility to move based on the condition *isMovable* from the *Position* class and whether the *hashCode* of the potential new position is already stored in the *positionHistory* hash map. In the current version, a fixed sequence of direction is implemented (North, East, South, West). As soon as a viable directin is found, the robot makes the move. This includes pushing the current position on the *backtrack* stack, storing the hash code of the current position to the *positionHistory* hash map and finally, changing location to the new position. After making the move, the method is left with a return statement without reaching the second part. Each of the direction checking code blocks is enclosed in a *try...catch* statement that handles the *ArrayIndexOutOfBounds* exception when the robot is at the edge of the maze. Hence positions 'beyond' the maze are interpreted as wall.

The second part of the *move()* method in the memory robot is concerned with the backtracking. It consists just of reading the stack for the last position, and then popping the top of the stack. As mentioned above, this second part is just reached when no direction offered a viable move.

4 Known Limits

The robots are implemented such that they accept the border of the maze as a wall. Hence a valid maze without any wall can be created.

In the current version, the *Memory Robot* will not detect when there is no solution to the maze. This could be implemented by checking for the start position after back tracking.

5 Testing

5.1 JUnit tests

As requested, JUnit tests were implemented for the classes *Maze* and *Position*. The test were implemented post development of the main code.

Maze

The JUnit test for maze verify whether a correct Maze can be loaded. Then each a test to check for exceptions when a maze without start or goal position, or a maze with uneven row length is attempted to load.

Position

JUnit tests to check whether a *Position* object can be instantiated and to verify that the *equals()* method works were implemented. Further, it is checked whether different positions yield different hash codes.

5.2 Run tests and Robot tests

The robot testing was implemented in a small main program. A static variable *ROUNDS* determine how many rounds the competition shall last. This mode was decided as it would be more difficult to detect adhoc whether a maze can be 'solved' in general or by a specific robot particularly. So, limiting to a fixed number of rounds was a mean to prevent infinite looping. A typical situation where an infinite loop could occur is when a robot starts within a compartment that has no connection to the compartment with the *Goal* position.

Move counters for each robot are used. In each round, it is first checked whether either of the robots has reached the *Goal*. Then the move counter is advanced by one and the the *move()* method of each robot is called. After the predefined number of rounds are over, it is evaluate whether the robots reached the goal and if so, which one reached it first.

For testing purposes, *toString()* methods for *Position* and *Maze* were implemented. They were used during development to verify the correctness of the algorithms.

The text files *maze1.txt* and *maze2.txt* work with both robots, while *maze3.txt* results in an exception for the right hand rule robot as the starting position is not at a wall. The other provided maze text files are used for the JUnit testing and produce exceptions.

References

[1] Umeå University, 5dv133 obligatorisk uppgift 2. `http://www8.cs.umu.se/kurser/5DV133/VT16/uppgifter/ou2/`, 2016. accessed: 2016-04-24.