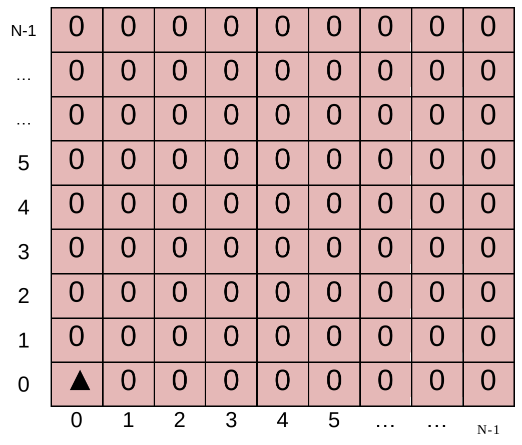
Concordia University
Department of Electrical and Computer Engineering
COEN 488 – Software Testing and Validation (Winter 2022)
Project (Lab Work): Robot Motion

The objective of the project is to test the practical use of the software testing techniques covered in the course. The project will be performed over supervised lab sessions. There will be deliverables (see the Project Milestones section), including a final demonstration of all the artifacts developed during the project. The demo will be performed during the lab sessions.

NOTE: The marks associated with each aspect of the project will be communicated to you by the TA. Also, the TA reserves the right to make some modifications to the deadline and deliverables depending on how the labs progress.

1. Project Description

Imagine a robot that walks around a room under the control of a Java program. The robot holds a pen in one of two positions, up or down. While the pen is down, the robot traces out shapes as it moves; while the pen is up, the robot moves about freely without writing anything. The room will be represented by an N by N array called floor that is initialized to zeros. Initially the robot is at position [0, 0] of the floor, its pen is up, and is facing north (as shown in the below figure).



The robot moves around the floor (i.e. the array) as it receives commands from the user. The set of robot commands your program must process are as follows:

Command	**Meaning**
[U|u]	Pen up
[D|d]	Pen down
[R|r]	Turn right
[L|l]	Turn left
[M s|m s]	Move forward s spaces (s is a non-negative integer)
[P|p]	Print the N by N array and display the indices

[C|c]	Print current position of the pen and whether it is up or down and its facing direction
[Q|q]	Stop the program
[I n|i n]	Initialize the system: The values of the array floor are zeros and the robot is back to [0, 0], pen up and facing north. n size of the array, an integer greater than zero

* By default, input of command [M s|m s] and [I n|i n] should follow the format of command character following by zero or one space and then an integer greater than zero.

** You can override this default requirement on input. Please note the new overriding requirements must be clearly specified in your project deliverables (please refer 3. project milestone task 1)

2. Project Teams

Projects will be executed by teams. Each team will **contain two or three members**. The team will select a coordinator who will be the person who communicates with the professor concerning the project. The scrum development method is recommend for the project.

The coordinator submits to Moodle link by 5pm **Week 2 Friday**, the SID and Name of each team member in a simple text file.

For those have difficulties in finding a group to join, please also submit to Moodle link by 5pm **Week 2 Friday**. The Lab TA will assign students who do not have a group yet to a group the TA decides.

At the end of the project, each team member will be asked to evaluate the contribution of each of the team members to the project.

3. Project Milestones

In this project, one will proceed following an iterative and incremental process. One will be doing development and testing work.

- Task 1: Development and Verification (**Deadline: Week 5 – Friday 11:59pm**)

Write a Java program that simulates the robot capabilities to move through the floor. The program must keep track of the current position of the robot at all times and whether the pen is up or down. As the robot moves with the pen down, set the appropriate elements of the array floor to 1 (no matter how many time it has been traced). When the 6 command (i.e. print) is given, wherever there is a 1 in the array, display an asterisk; wherever there is a zero, display a blank.

Here is only a command line example of how the execution of the program should look like. The program can have a graphic user interface as well.

```
>Enter command: I 10
```

(This should initialize the system as a 10 x 10 array. The values of the array floor are all set to zeros and the robot is back to [0, 0], pen up and facing north.)

```
>Enter command: C
>Position: 0, 0 - Pen: up - Facing: north
```

(This is output by the program to indicate the position of the robot and the whether the pen is up or down)

```
> Enter command: D
```
(Now user orders the robot pen down)
```
> Enter command: C
> Position: 0, 0 – Pen: down - Facing: north
```

```
> Enter command: M 4
```
(The user orders the robot move 4 cells forward, the new position of the robot is now 0, 4)
```
> Enter command: C
> Position: 0, 4 – Pen: down – Facing: north
```

```
>Enter command: R
```
(The user orders the robot turn right)
```
> Enter command: C
Position: 0, 4 - Pen: down – Facing: east
```

```
>Enter command: M 3
```
(The user orders the robot move 3 cells forward)
```
> Enter command: C
Position: 3, 4 - Pen: down – Facing: east
```
(The new position is now [3, 4] since the robot turned right)

```
>Enter command: P
```
(The user wants to display the floor. You don't need to print any background color of the array)

```
9
...
...
5
4    *   *   *   *
3    *
2    *
1    *
0    *
     0   1   2   3   4   5   …   …   9
```

```
>Enter command: Q
```
(End of program)

Deliverables and Milestones:

- A working application (the project can be downloaded, compiled, and run in any Java platform)
- The source code is available in the github repository to share.

- Demo to TA
- Unit test code should be included in the source code.
- A detailed report in PDF that includes
    - Github URL
    - Requirements. Each requirement is a one or two-line statement that describes a specific function of the system. Each requirement should have a unique identifier i.e. R1, R2.
    - Screen-shots of each function to fulfill the requirements.
    - A table mapping requirements and unit test cases.
    - Test cases execution results (fail or pass).

- Task 2: Code Analysis and Software Release (**Deadline: Week 7 – Friday 11:59pm**)

This task aims to use Java code coverage tools to find what parts of the code are covered by tests and what parts are not. The results can help to decide if unexecuted parts should stay or remove. Choose a code analysis tool to produce the measurement for the following metrics:

a) Function coverage: how many of defined functions have been called;
b) Statement coverage: the number of statements that have been successfully executed in the program;
c) Path coverage: how many paths of the control structures in the program (if statements or loops) have been executed;
d) Condition coverage: how many Boolean expressions have been validated inside your program;
e) Line coverage: how many lines of the program have been executed.

Deliverables and Milestones:

- Demo to TA
- Update the task 1 report in PDF that includes two new sections for code analysis and software releasing.
    - Github URL
    - Predefined the code coverage threshold values for releasing
    - Code coverage results for (a) to (e), with screenshots from the code analysis tool.
    - Discussion of the code coverage results in term of the threshold values and decision making for releasing.
- Submit the updated report in a single PDF file.

Task 3: Black-box and White-box Testing (**Deadline: Week 11 – Friday 11:59pm**)

Before the spring break, the TA will send each team the github link for the application and the report developed by another team and each team will be required to test the application using various techniques including black-box and white-box testing techniques or any other technique appropriate. Apply white-box testing techniques as follows:

a) statement coverage (show percentage covered > 50%)
b) decision coverage (show percentage covered > 50%)
c) condition coverage (show percentage covered > 50%)
d) multiple condition coverage (show percentage covered > 50%)
e) Select one function and apply mutation testing
f) Select one function and apply data flow testing

The evaluation will be based on the ability to perform the testing and apply various testing techniques.

Deliverables and Milestones:

- Demo to TA
- A test report that includes
    - A test plan
    - A list of test cases developed using black-box testing techniques
    - A list of test cases developed for (f) to (k).
    - For each of the test cases, show the test result (the result is more than just printing the program output. Please refer to the section 4. Other Considerations).

By Monday Week 12, the TA will send each team the external test report produced by other teams.

<u>Task 4: Regression Testing (**Deadline: Week 13 – Friday 11:59pm**)</u>

- Add in one new function development to the current application.

  [H|h]   Replay all the commands entered by the user as a history

- Carry out regression test according to the newly added function
- Review the test report performed by another team and develop any further changes and perform regress test on any changes introduced. If no changes, please present the details and explain why.

Deliverables and Milestones:

- Update the test report with a new section as regression test to document the regression test cases, and the test results.
- Submit the updated report in a single PDF file.

  A public class demo session will be held on the **last lecture session**. The demonstration order of individual groups will be decided randomly. Each group will be given 10 minutes. The demo follows this template

1) Development process and testing method
2) Code coverage results
3) Explain the testing techniques applied in White-box testing a) to f) and regression test, and show test execution. Each team member presents 1 item.
4) Q&A by individuals.

4. Other Considerations

- Use Java as a programming language.
- The requirements should be precise and concise.
- The report on test results should be well documented to provide good feedback to the development team. It is important to include the requirements being tested as well as the code coverage achieved by the testing technique.
- Delays of submission will result in no test done by other teams and mark deduction to the project on Task 3.
- Start working on the project right away. The TA will assist during the lab sessions.