THE DROID'S MOTION DELIVERABLE – 2

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***Abstract*—The main objective of this project is to design a robot that can stroll around a room. In this project, the robot is designed using a Java program, and is anticipated to print the pattern and trace its course in accordance with the user's instructions. Each of the function is tested separately using unit testing and has its own set of functional requirements.**

Repository URL : https://github.com/CURepo/COEN6761_DROID-s_Motion.git

I. INTRODUCTION

The project aims to develop a robot, using Java programming language that is capable of navigating within a room. The project is designed in such a way that, that robot can hold the pen in two positions, mainly – up and down. The conditions say that when the pen is in the up position, the robot can move around and does not trace any paths. While the pen in down position, the robot can trace its path. The instructions are given by the user and the robot can navigate accordingly. The robot is positioned at [0,0] with a floor size of N-by-N array, with the pen up, facing north. Section 2 depicts the picture of the use case diagram for the motion of the droid, along with an explanation, Section 3 lists out the various functional requirements, each with unique identifier. We have added the screenshots of all the functions in Section 4. Section 5 displays a table linking the unit test cases and its corresponding requirements with the screenshots. Section 6 tells us about the GUI interface that we have used to display our output using JavaFX. Finally, section 7, a table with the test case results and conclusions. The GitHub URL has been attached to view the unique development and test code.

II. USE CASE DIAGRAM

The droid's motion is depicted in the form of a use case diagram with all the constraints given. The functions like move pen up to walk without any traces, move pen down to trace the paths, turn left, turn right, depicting the path traced, terminating the program, and printing the current position, which includes the cell, the direction, and the pen status is mentioned.

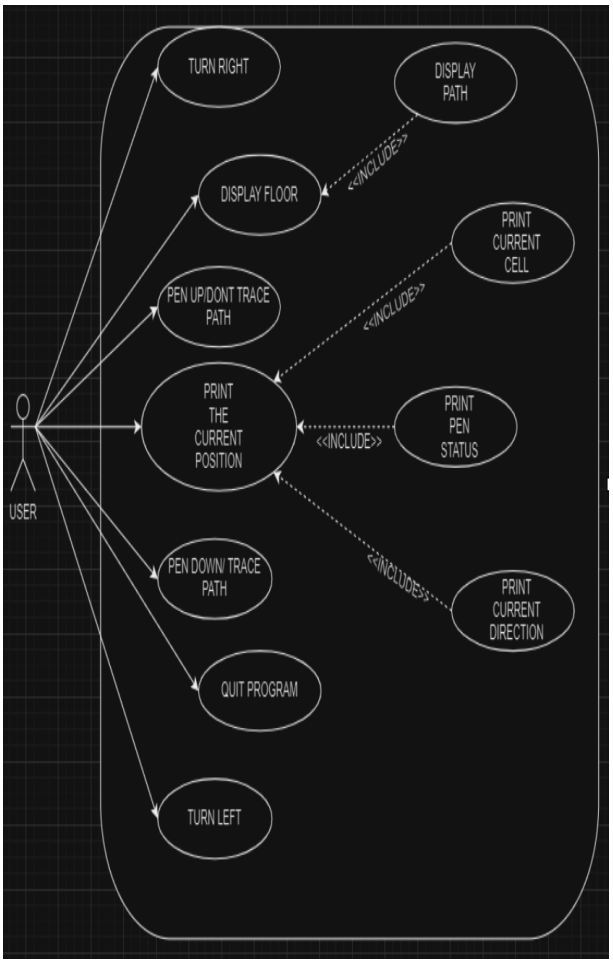

Fig. 1. **Use Case Diagram**

III. FUNCTIONAL REQUIREMENTS

Below is the table that shows the functional requirements of each step.

R	Functional Requirements
R1	User instruction to robot to move the pen down
R2	User instruction to robot to move the pen up
R3	User instruction to a west facing robot to turn right and face north
R4	User instruction to a south facing robot to turn right and face west
R5	User instruction to an east facing robot to turn right and face south
R6	User instruction to a north facing robot to turn right and face east
R7	User instruction to an east facing robot to turn left and face north
R8	User instruction to a south facing robot to turn left and face east
R9	User instruction to a west facing robot to turn left and face south
R10	User instruction to a north facing robot to turn left and face west
R11	User instruction to robot to trace n steps with pen down and facing north
R12	User instruction to robot to trace n steps with pen down and facing east
R13	User instruction to robot to trace n steps with pen down and facing south
R14	User instruction to robot to trace n steps with pen down and facing west
R15	User instruction to robot to not to trace n steps with pen up and facing north
R16	User instruction to robot to not to trace n steps with pen up and facing east
R17	User instruction to robot to not to trace n steps with pen up and facing south
R18	User instruction to robot to not to trace n steps with pen up and facing west
R19	Upon user request the robot is anticipated to trace its path
R20	Upon user request the robot is anticipated to print its current position
R21	Set initial position to x=0, y=0, while facing north and pen up
R22	With the command Q, user can quit the program

A. *USER STORIES AND EFFORT TRACKING*

We used https://monday.com, effort tracking and project management. The tool simplified our effort tracking through task allocation, time tracking, visual dashboards, automation, collaboration, and real-time updates. It enhances productivity and project success. We divided the user requirements into 5-implementation stories and 4-unit testing stories. Each user story was assigned to a team member. The validation and implementation stories were divided in such a way that every team member gets to work both in the development and validation part of the project. The link to our work is attached below:

https://ashakash85s-team.monday.com/boards/4814848928/

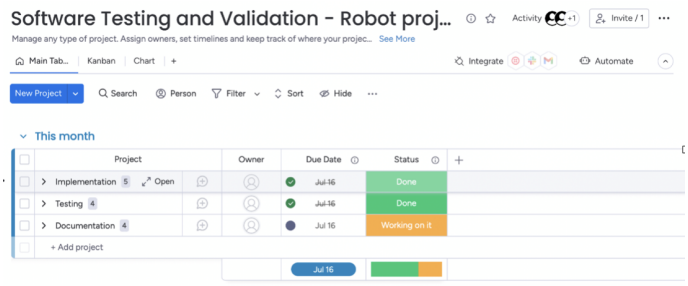

Fig. 2. **Effort Tracking of Project**

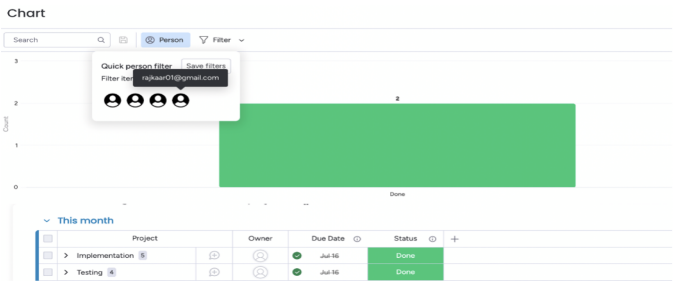

Fig. 3. **Project Progress Chart**

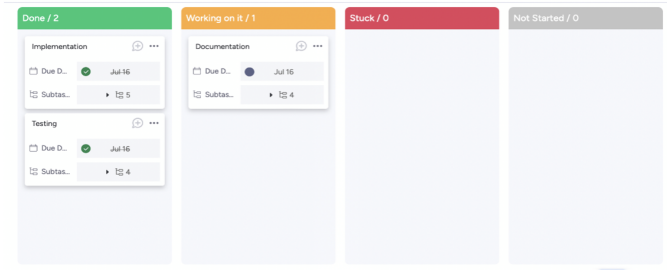

Fig. 4. **Kanban View of the Project**

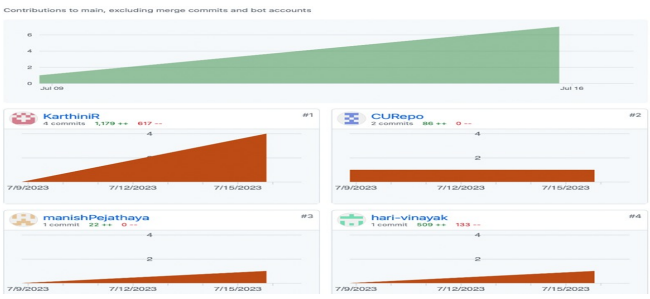

Fig. 5. **GitHub Contributors Work**

IV. SCREENSHOTS OF FUNCTIONS

The screenshots of functions are attached below for reference.

```
public void turnRight() {
    switch (direction) {
        case NORTH -> direction = Direction.EAST;
        case EAST -> direction = Direction.SOUTH;
        case SOUTH -> direction = Direction.WEST;
        case WEST -> direction = Direction.NORTH;
    }
}

public void turnLeft() {
    switch (direction) {
        case NORTH -> direction = Direction.WEST;
        case EAST -> direction = Direction.NORTH;
        case SOUTH -> direction = Direction.EAST;
        case WEST -> direction = Direction.SOUTH;
    }
}
```

Fig. 6. **Function for move right and move left**

```
public void move(int steps, Floor floor) {
    if (steps <= 0) {
        throw new IllegalArgumentException("Invalid number of steps: " + steps);
    }
    if (penDown) {
        for (int i = 0; i < steps; i++) {
            floor.markPosition(x, y);
            switch (direction) {
                case NORTH -> y++;
                case EAST -> x++;
                case SOUTH -> y--;
                case WEST -> x--;
            }
        }
    } else {
        switch (direction) {
            case NORTH -> y += steps;
            case EAST -> x += steps;
            case SOUTH -> y -= steps;
            case WEST -> x -= steps;
        }
    }
}
```

Fig. 7. **Function for robot movement**

```
public Robot() {
    x = 0;
    y = 0;
    penDown = false;
    direction = Direction.NORTH;
}
```

Fig. 8. **Function for initialization**

```
private void updatePositionLabel() {
    String penStatus = robot.isPenDown() ? "down" : "up";
    String positionText = "Position: " + robot.getX() + ", " + robot.getY() +
            "\nPen: " + penStatus + "\nFacing: " + robot.getDirection();
    positionLabel.setText(positionText);
}
}
```

Fig. 9. **Function for robot position**

V. UNIT TEST CASES WITH THEIR CORRESPONDING FUNCTIONAL REQUIREMENTS

R	Unit Test Cases (UTC)	Functional Requirements (F)
1	UTC1	R1
2	UTC2	R2
3	UTC3	R3
4	UTC4	R4
5	UTC5	R5
6	UTC6	R6
7	UTC7	R7
8	UTC8	R8
9	UTC9	R9
10	UTC10	R10
11	UTC11	R11
12	UTC12	R12
13	UTC13	R13
14	UTC14	R14
15	UTC15	R15
16	UTC16	R16
17	UTC17	R17
18	UTC18	R18
19	UTC19	R19
20	UTC20	R20
21	UTC21	R21
22	UTC22	R22

Below are the screenshots of all the unit test cases that passed successfully.

```
@Test
public void testMovePenDown() {
    robot.setPenDown(true);
    Assertions.assertTrue(robot.isPenDown());
}
```

Fig. 10. **UTC1 for Functional Requirement R1 – to move pen down**

```
@Test
public void testMovePenUp() {
    robot.setPenDown(false);
    Assertions.assertFalse(robot.isPenDown());
}
```

Fig. 11. **UTC2 for Functional Requirement 2 – to move pen up**

```java
@Test
public void testTurnRightFromWest() {
    robot.setDirection(Direction.WEST);
    robot.turnRight();
    Assertions.assertEquals(Direction.NORTH, robot.getDirection());
}
```

Fig. 12. **UTC3 for Functional Requirement 3**

```java
@Test
public void testTurnRightFromSouth() {
    robot.setDirection(Direction.SOUTH);
    robot.turnRight();
    Assertions.assertEquals(Direction.WEST, robot.getDirection());
}
```

Fig. 13. **UTC4 for Functional Requirement 4**

```java
@Test
public void testTurnRightFromEast() {
    robot.setDirection(Direction.EAST);
    robot.turnRight();
    Assertions.assertEquals(Direction.SOUTH, robot.getDirection());
}
```

Fig. 14. **UTC5 for Functional Requirement 5**

```java
@Test
public void testTurnRightFromNorth() {
    robot.setDirection(Direction.NORTH);
    robot.turnRight();
    Assertions.assertEquals(Direction.EAST, robot.getDirection());
}
```

Fig. 15. **UTC6 for Functional Requirement 6**

```java
@Test
public void testTurnLeftFromEast() {
    robot.setDirection(Direction.EAST);
    robot.turnLeft();
    Assertions.assertEquals(Direction.NORTH, robot.getDirection());
}
```

Fig. 16. **UTC7 for Functional Requirement 7**

```java
@Test
public void testTurnLeftFromSouth() {
    robot.setDirection(Direction.SOUTH);
    robot.turnLeft();
    Assertions.assertEquals(Direction.EAST, robot.getDirection());
}
```

Fig. 17. **UTC8 for Functional Requirement 8**

```java
@Test
public void testTurnLeftFromWest() {
    robot.setDirection(Direction.WEST);
    robot.turnLeft();
    Assertions.assertEquals(Direction.SOUTH, robot.getDirection());
}
```

Fig. 18. **UTC9 for Functional Requirement 9**

```java
@Test
public void testTurnLeftFromNorth() {
    robot.setDirection(Direction.NORTH);
    robot.turnLeft();
    Assertions.assertEquals(Direction.WEST, robot.getDirection());
}
```

Fig. 19. **UTC10 for Functional Requirement 10**

```java
@Test
public void testMoveNorthWithPenDown() {
    // Arrange
    robot.setPenDown(true);
    int steps = 3;

    // Act
    for (int i = 0; i < steps; i++) {
        robot.move(1, floor);
    }

    // Assert
    int[][] expectedFloorArray = new int[][] {
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {1, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {1, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {1, 0, 0, 0, 0, 0, 0, 0, 0, 0}
    };

    int[][] actualFloorArray = floor.getFloorArray();
    Assertions.assertArrayEquals(expectedFloorArray, actualFloorArray);
}
```

Fig. 20. **UTC11 for Functional Requirement 11**

```java
@Test
public void testMoveEastWithPenDown() {
    robot.setDirection(Direction.EAST);
    robot.setPenDown(true);

    int steps = 3;
    for (int i = 0; i < steps; i++) {
        robot.move(1, floor);
    }

    int[][] expectedFloorArray = new int[][]{
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {1, 1, 1, 0, 0, 0, 0, 0, 0, 0},
    };

    int[][] actualFloorArray = floor.getFloorArray();
    Assertions.assertArrayEquals(expectedFloorArray, actualFloorArray);
}
```

Fig. 21. **UTC12 for Functional Requirement 12**

```java
@Test
public void testMoveSouthWithPenDown() {
    robot.setDirection(Direction.SOUTH);
    robot.setPenDown(true);

    int steps = 3;
    int initialX = robot.getX();
    int initialY = robot.getY();

    for (int i = 0; i < steps; i++) {
        robot.move(1, floor);
    }

    int[][] expectedFloorArray = new int[][]{
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {1, 0, 0, 0, 0, 0, 0, 0, 0, 0},
    };

    int[][] actualFloorArray = floor.getFloorArray();
    Assertions.assertArrayEquals(expectedFloorArray, actualFloorArray);
}
```

Fig. 22. **UTC13 for Functional Requirement 13**

```java
@Test
public void testMoveWestWithPenDown() {
    robot.setDirection(Direction.WEST);
    robot.setPenDown(true);

    int steps = 3;
    int initialX = robot.getX();
    int initialY = robot.getY();

    for (int i = 0; i < steps; i++) {
        robot.move(1, floor);
    }

    int[][] expectedFloorArray = new int[][]{
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {1, 0, 0, 0, 0, 0, 0, 0, 0, 0},
    };

    int[][] actualFloorArray = floor.getFloorArray();
    Assertions.assertArrayEquals(expectedFloorArray, actualFloorArray);
}
```

Fig. 23. **UTC14 for Functional Requirement 14**

```java
@Test
public void testMoveNorthWithPenUp() {
    robot.setDirection(Direction.NORTH);
    robot.setPenDown(false);

    int steps = 3;
    for (int i = 0; i < steps; i++) {
        robot.move(1, floor);
    }

    int[][] expectedFloorArray = new int[][]{
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
    };

    int[][] actualFloorArray = floor.getFloorArray();
    Assertions.assertArrayEquals(expectedFloorArray, actualFloorArray);
}
```

Fig. 24. **UTC15 for Functional Requirement 15**

```java
@Test
public void testMoveEastWithPenUp() {
    robot.setDirection(Direction.EAST);
    robot.setPenDown(false);

    int steps = 3;
    for (int i = 0; i < steps; i++) {
        robot.move(1, floor);
    }

    int[][] expectedFloorArray = new int[][]{
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
    };

    int[][] actualFloorArray = floor.getFloorArray();
    Assertions.assertArrayEquals(expectedFloorArray, actualFloorArray);
}
```

Fig. 25. **UTC16 for Functional Requirement 16**

```java
@Test
public void testMoveSouthWithPenUp() {
    robot.setDirection(Direction.SOUTH);
    robot.setPenDown(false);

    int steps = 3;
    for (int i = 0; i < steps; i++) {
        robot.move(1, floor);
    }

    int[][] expectedFloorArray = new int[][]{
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
    };

    int[][] actualFloorArray = floor.getFloorArray();
    Assertions.assertArrayEquals(expectedFloorArray, actualFloorArray);
}
```

Fig. 26. **UTC17 for Functional Requirement 17**

```java
@Test
public void testMoveWestWithPenUp() {
    robot.setDirection(Direction.WEST);
    robot.setPenDown(false);

    int steps = 3;
    for (int i = 0; i < steps; i++) {
        robot.move(1, floor);
    }

    int[][] expectedFloorArray = new int[][]{
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
            {0, 0, 0, 0, 0, 0, 0, 0, 0, 0},
    };

    int[][] actualFloorArray = floor.getFloorArray();
    Assertions.assertArrayEquals(expectedFloorArray, actualFloorArray);
}
```

Fig. 27. **UTC18 for Functional Requirement 18**

Fig. 28. **UTC19 for Functional Requirement 19**

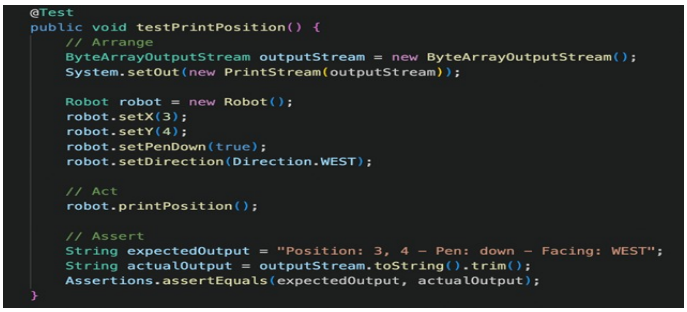

Fig. 29. **UTC20 for Functional Requirement 20**

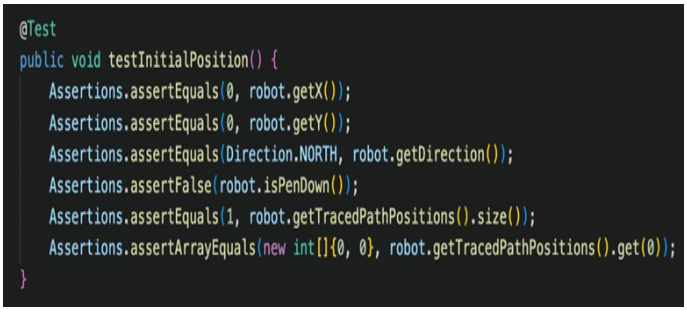

Fig. 30. **UTC21 for Functional Requirement 21**

Fig. 31. **UTC22 for Functional Requirement 22**

VI. UNIT TEST CASE TABLE

The table below conveys the unit test case results for the corresponding functional requirements.

R	Unit Test Cases (UTC)	Functional Requirements (F)	Unit Test Case Results
1	UTC1	R1	Pass
2	UTC2	R2	Pass
3	UTC3	R3	Pass
4	UTC4	R4	Pass
5	UTC5	R5	Pass
6	UTC6	R6	Pass
7	UTC7	R7	Pass
8	UTC8	R8	Pass
9	UTC9	R9	Pass
10	UTC10	R10	Pass
11	UTC11	R11	Pass
12	UTC12	R12	Pass
13	UTC13	R13	Pass
14	UTC14	R14	Pass
15	UTC15	R15	Pass
16	UTC16	R16	Pass
17	UTC17	R17	Pass
18	UTC18	R18	Pass
19	UTC19	R19	Pass
20	UTC20	R20	Pass
21	UTC21	R21	Pass
22	UTC22	R22	Pass

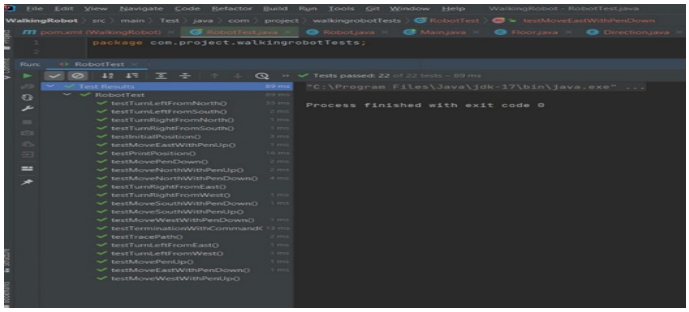

Fig. 32. **Test cases that are run successfully without any errors**

VII. GUI INTERFACE AND JAVAFX

JavaFX is a Java framework for generating visually appealing graphical user interfaces (GUIs). It has cross-platform compatibility, rich UI controls, CSS style, media support, animation capabilities, layout management, and seamless connection with the Java environment. It is open-source and has a vibrant developer community. JavaFX supports the responsive design technique, which allows developers to construct user interfaces that adapt and adjust to multiple screen sizes and resolutions. This ensures that JavaFX applications deliver a consistent and optimal user experience across a wide range

of platforms, including desktops, laptops, tablets, and mobile phones.

Please refer to the README file in our GitHub repository to view the complete guidance on running our code using JavaFX. https://github.com/CURepo/COEN6761_DROID-s_Motion.git

VIII. OUTPUT OF THE GUI

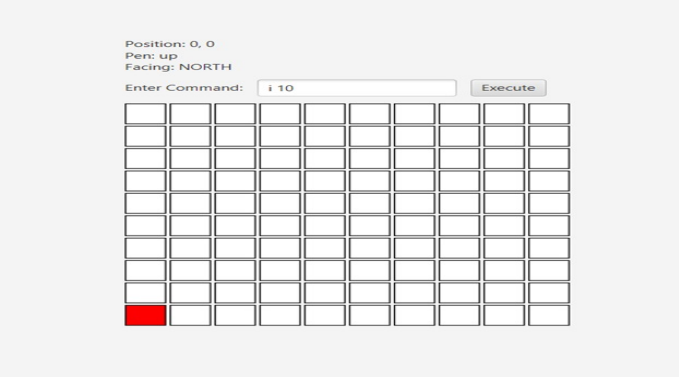

Fig. 33. **Robot Simulator – I10 is the command to initialize the system into a 10-by-10 array. The red square indicates the robot. The robot is now at [0, 0], pen up, pointed north, and the values on the array floor have all been set to zeros**

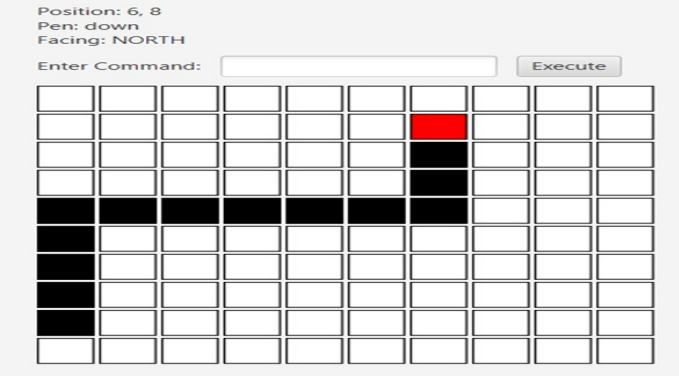

Fig. 34. **Trace of the robot when the pen is facing down**

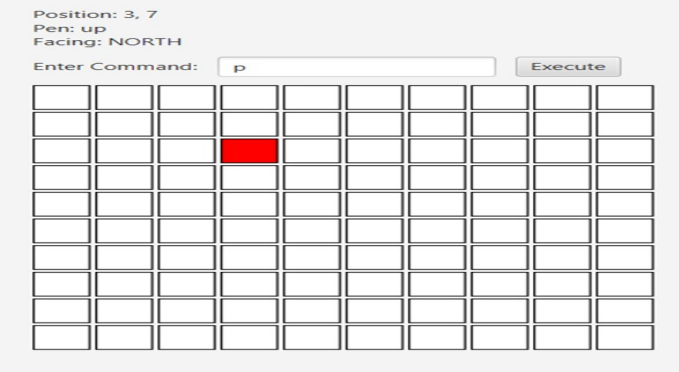

Fig. 35. **No Trace of the robot is found because the pen is facing up**

IX. COVERAGE TESTING

Test coverage is a statistic used in software testing to evaluate the level of testing completed by a set of tests. Data about the program's execution is acquired during test suite execution to determine which branches the conditional statements have taken. There are five sorts of test coverages, and the examples below use our algorithm to calculate the predetermined numbers required for releasing.

X. SOFTWARE USAGE

JaCoCo (Java Code Coverage) is a popular and commonly used code coverage tool for Java applications. It is an open-source library created by the EclEmma team. The primary goal of JaCoCo is to determine how much of your Java code is run during testing. Line coverage, branch coverage, method coverage, and class coverage are among the code coverage metrics provided by JaCoCo. Instead of relying on Code coverage tools in-built with Intelli-J, we have used a new plug-in which provides much better coverage reports.

```
    private final List<int[]> tracedPathPositions;

    public Robot() {
        x = 0;
        y = 0;
        penDown = false;
        direction = Direction.NORTH;
        tracedPathPositions = new ArrayList<>();
        tracedPathPositions.add(new int[]{x, y}); // Add initial position to traced path
    }

    public void move(int steps, Floor floor) {
        if (steps <= 0) {
            throw new IllegalArgumentException("Invalid number of steps: " + steps);
        }

        for (int i = 0; i < steps; i++) {
            int nextX = x;
            int nextY = y;

            switch (direction) {
                case NORTH -> nextY++;
                case EAST -> nextX++;
                case SOUTH -> nextY--;
                case WEST -> nextX--;
            }

            if (floor.isValidPosition(nextX, nextY)) {
                x = nextX;
                y = nextY;

                if (penDown) {
                    if (i == 0) {
                        floor.markPosition(x, y);  // Mark initial position
                        tracedPathPositions.add(new int[]{x, y});
                    } else {
                        floor.markPosition(x, y);
                        tracedPathPositions.add(new int[]{x, y});
                    }
                }
            }
        }
    }
```

Fig. 36. **Code Coverage from Jacoco Software**

Green – It indicates all branches in loop has been executed.
Yellow – It indicates only code is partially executed.
Red – It indicates branches in the code is not executed.

XI. UNIT TEST CASES FOR CODE COVERAGE

```
@Test
public void testInitializeFloorGrid() {
    Platform.runLater(() -> {
        try {
            main.initializeFloorGrid( size: 10);
        } catch (Exception e) {
            fail(e);
        }
    });

    WaitForAsyncUtils.waitForFxEvents();
    try {
        sleep( millis: 2000);
    } catch (InterruptedException e) {
        e.printStackTrace();
    }

    FxAssert.verifyThat( nodeQuery: "#floorGrid", Node::isVisible);
}
```

Fig. 37. **UTC1 TestInitializeFloorGrid**

```
@Test
public void testExecuteCommandI() {
    main.executeCommand( testInput: "I 10",  isTesting: true);
    try {
        sleep( millis: 2000);
    } catch (InterruptedException e) {
        e.printStackTrace();
    }
    FxAssert.verifyThat(positionLabel, LabeledMatchers.hasText("Position: 0, 0\nPen: up\nFacing: NORTH"));
}
```

Fig. 38. **UTC2 TestExecuteCommandI**

```
@Test
public void testExecuteCommandU() {
    main.executeCommand( testInput: "I 10",  isTesting: true);
    try {
        sleep( millis: 2000);
    } catch (InterruptedException e) {
        e.printStackTrace();
    }
    main.executeCommand( testInput: "U",  isTesting: true);
    try {
        sleep( millis: 2000);
    } catch (InterruptedException e) {
        e.printStackTrace();
    }
    FxAssert.verifyThat(positionLabel, LabeledMatchers.hasText("Position: 0, 0\nPen: up\nFacing: NORTH"));
}
```

Fig. 39. **UTC3 TestExecuteCommandU**

```
@Test
public void testExecuteCommandD() {
    main.executeCommand( testInput: "I 10",  isTesting: true);
    try {
        sleep( millis: 2000);
    } catch (InterruptedException e) {
        e.printStackTrace();
    }
    main.executeCommand( testInput: "D",  isTesting: true);
    try {
        sleep( millis: 2000);
    } catch (InterruptedException e) {
        e.printStackTrace();
    }
    FxAssert.verifyThat(positionLabel, LabeledMatchers.hasText("Position: 0, 0\nPen: down\nFacing: NORTH"));
}
```

Fig. 40. **UTC4 TestExecuteCommandD**

We have used JavaFX for GUI implementation. Due to which the coverage of the Main.java class was less. In order to achieve better coverage for the Main class, we have included 7 more Unit test case.These unit testcases are for

```
@Test
public void testExecuteCommandR() {
    main.executeCommand( testInput: "I 10",  isTesting: true);
    try {
        sleep( millis: 2000);
    } catch (InterruptedException e) {
        e.printStackTrace();
    }
    main.executeCommand( testInput: "R",  isTesting: true);
    try {
        sleep( millis: 2000);
    } catch (InterruptedException e) {
        e.printStackTrace();
    }
    FxAssert.verifyThat(positionLabel, LabeledMatchers.hasText("Position: 0, 0\nPen: up\nFacing: EAST"));
}
```

Fig. 41. **UTC5 TestExecuteCommandR**

```
@Test
public void testExecuteCommandL() {
    main.executeCommand( testInput: "I 10",  isTesting: true);
    try {
        sleep( millis: 2000);
    } catch (InterruptedException e) {
        e.printStackTrace();
    }
    main.executeCommand( testInput: "L",  isTesting: true);
    try {
        sleep( millis: 2000);
    } catch (InterruptedException e) {
        e.printStackTrace();
    }
    FxAssert.verifyThat(positionLabel, LabeledMatchers.hasText("Position: 0, 0\nPen: up\nFacing: WEST"));
}
```

Fig. 42. **UTC6 TestExecuteCommandL**

```
@Test
public void testExecuteCommandM() {
    main.executeCommand( testInput: "I 10",  isTesting: true);
    main.executeCommand( testInput: "M 5",  isTesting: true);
    try {
        sleep( millis: 2000);
    } catch (InterruptedException e) {
        e.printStackTrace();
    }
    FxAssert.verifyThat(positionLabel, LabeledMatchers.hasText("Position: 0, 5\nPen: up\nFacing: NORTH"));
}
```

Fig. 43. **UTC7 TestExecuteCommandM**

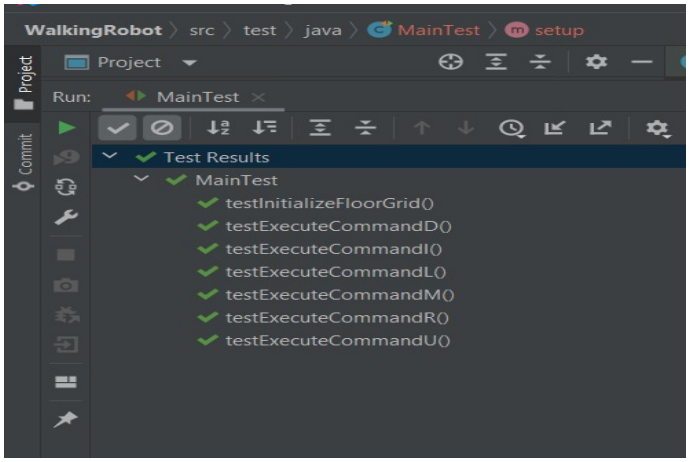

Fig. 44. **GUI UTC Results**

GUI UTC's	Results
UTC1 GUI TestInitializeFloorGrid	Pass
UTC2 GUI TestExecuteCommandI	Pass
UTC3 GUI TestExecuteCommandU	Pass
UTC4 GUI TestExecuteCommandD	Pass
UTC5 GUI TestExecuteCommandR	Pass
UTC6 GUI TestExecuteCommandL	Pass
UTC7 GUI TestExecuteCommandM	Pass

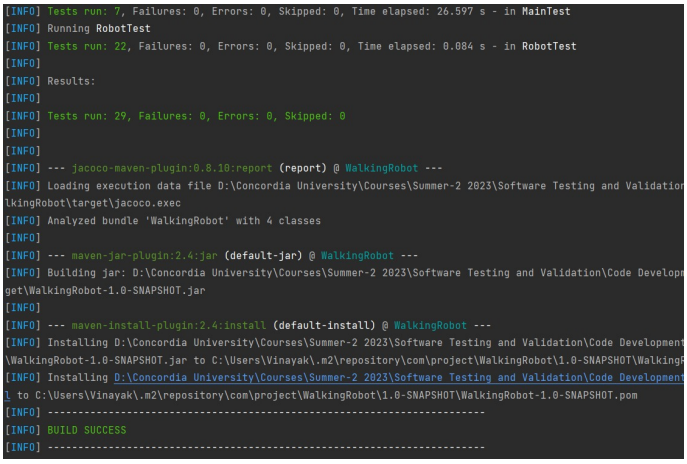

Fig. 45. **Overall UTC Results**

the GUI only, the functionality of these cases have already been covered in the 22 functional requirements.We have used TestFx framework to interact with JavaFx framework to test the GUI functionality of the walking robot. By doing this we achieved better coverage of the code, which is explained in detail in the below section.

XII. LINE COVERAGE

A metric known as line coverage counts the lines of code that have been run during the testing process. In general, it is stated as a proportion of the overall lines of code used in the software program. Line coverage can be calculated by,

Line Coverage Percentage = (Number of lines covered / Total Number of lines) * 100 = (25 /37) * 100 = 67.5%

XIII. STATEMENT COVERAGE

It is an illustration of a white box testing strategy that makes certain that each source code statement is executed at least once. Every path, line, and statement found in the source code is included. When creating test box cases, it is utilised to calculate how many statements have been performed overall out of all the statements in the code. Statement Coverage is calculated by,

Statement Coverage Percentage = (Number of Statements Executed/Total Number of Statements) *100 = (4/4) * 100 = 100%

XIV. FUNCTION COVERAGE

Function coverage is a term for a metric that assesses the functions utilised during software testing. This metric is calculated by dividing the total number of functions in the software under test by the number of functions that a test suite performs. It does not provide each function a unique value, unlike branch coverage or statement coverage. Only the use of each function by the tests that were running is checked. Functional Coverage can be calculated by,

Considering Robot.java class and the Move() function,

Functional Coverage Percentage = (Number of functions called)/ (Total Number of functions) *100 = (1/13) * 100 = 7.7%

XV. CONDITION COVERAGE

The variables included in the conditional statement are examined and assessed in condition coverage. It makes sure that conditional statement values for both true and false are covered. Additionally, it helps by giving the control flow an appropriate coverage. Expressions with logical operands are the only ones considered in this coverage.

Condition Coverage Percentage = (Number of Executed Operands / Total Number of Executed Operands) *100 = (4/4)*100 = 100%

XVI. PATH COVERAGE

Path coverage involves testing each line of code. To ensure that all lines of code are covered, path coverage testing specifies that testers review each individual line of code that contributes to a module and, for full coverage, review all possible instances. Path Coverage can be calculated by,

Considering Figure 36, there are 5 possible paths,

P1 -> When steps <= 0 - True —> Throw exception

P2 -> When steps <= 0 - False —> isValidPosition —> True —> exit

P3 -> When steps <= 0 - False —> isValidPosition —> False —> penDown —> False —> Exit

P4 -> When steps <= 0 - False —> isValidPosition —> False —> penDown —> True —> i == 0 —> False —> execute statements in else block—> exit.

P5 -> When steps <= 0 - False —> isValidPosition —> False —> penDown —> True —> i == 0 —> True —> execute statements in if block (initial condition) —> exit.

Path Coverage Percentage = (Number of path covered / Total Number of possible paths) *100 = (1/5) *100 = 20%

XVII. CODE COVERAGE RESULTS

The following are results of code coverage attached below.

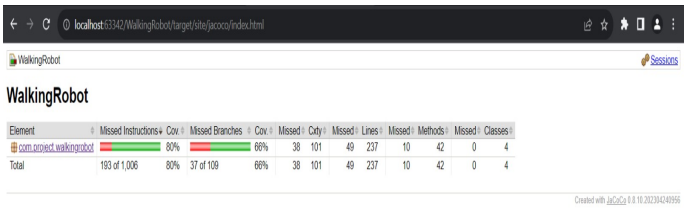

Fig. 46. **Main source code Package**

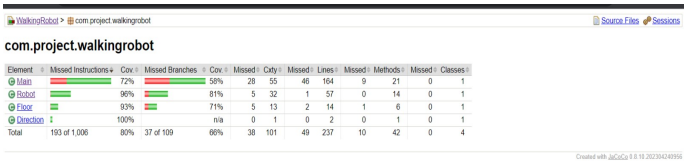

Fig. 47. **Coverage Classes in the Package**

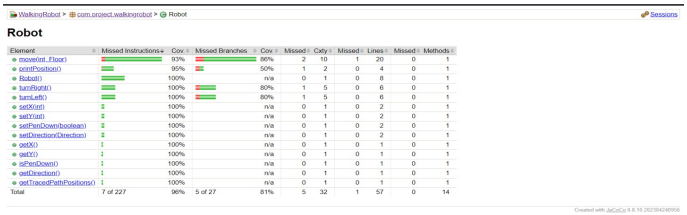

Fig. 48. **The Class Robot that contains all the main functionalities of the robot**

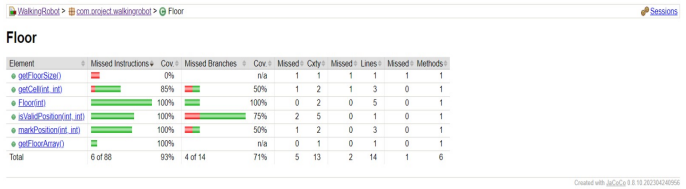

Fig. 49. **Class Floor**

Fig. 50. **Class Direction**

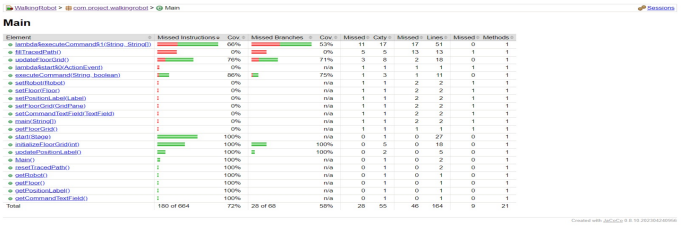

Fig. 51. **Class Main**

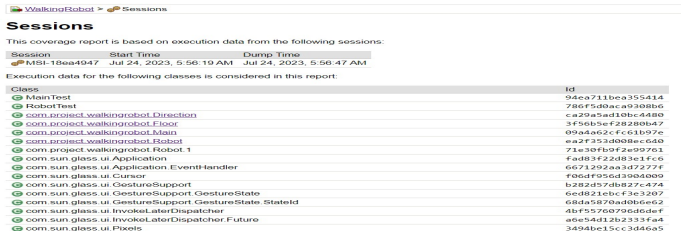

Fig. 52. **Sessions**

XVIII. CONCLUSION

In this report, we have done unit testing for 22 functional requirements and the output runs out successfully without any errors. Our works have been recorded in GitHub and our project time tracking is done using https://monday.com, a useful app that records the progress of our work.

For deliverable-2, we have introduced 7 new test cases to increase the coverage. These testcases correspond to GUI testing does not affect the functional requirements. We used JaCoCo code coverage and analysis plugin to check the code coverage. Overall code coverage was around 80% and branch coverage was 67%. We have achieved more than the acceptable code coverage threshold. All the screenshots of the new UTCs and coverage reports are attached in the report.