ENSE 375:
Howitzer Firing Simulator

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https://gitlab.com/sharoika/ense-375/

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01
Introduction

Introduction

Project: A howitzer company is asking for a simulator to teach its soldiers about kinematics and dynamics.

What is needed?

We need to simulate Barrel pose (position and orientation), radius and mass of the projectile, drag coefficient, and various other forces.

02
Problem Definition

Problem Definition

What is the problem you are trying to solve?

Write a program that simulates a Howitzer in the programming language of Java using Eclipse IDE.

We want an ACCURATE solution which soldiers are able to use with various inputs to simulate battle conditions based on wind, gravity, earth rotation and so on.

https://www.dvidshub.net/image/213352/indian-and-us-soldiers-find-similarity-classroom

03
Design Requirements

M777 Howitzer

https://en.wikipedia.org/wiki/M777_howitzer#/media/File:M777_howitzer_rear.jpg

Length: 10.7m (combat), 9.5m (travel)
Barrel Length: 5.08m
Shell diameter: 155mm
Shell Height: 60cm
Shell weight: 43.2kg
Firing range: M107: 24.7km

```
Shell Information After Landing:
Position X:3058.501349018851 Y:24836.99131336721 Z:0.0
Velocity X:0.0 Y:0.0 Z:0.0
```

Design Requirements

Functions?

Objectives?

Constraints (if any)?

https://www.ntaskmanager.com/blog/objective-vs-outcome/

Design Requirements

Functions

Ability to request from the user:

Howitzer Input: such as vertical angle and horizontal angle.

Shell Input: such as weight, diameter, height, and if able to self-propell.

External Force Input: such as wind speed, wind direction, and wind angle.

By default, the user will be using solution 3, with all 5 forces, in order to change solution used, SOLUTIONSELECTOR in the main function must be changed to desired solution

Design Requirements

Objectives

The Howitzer simulation should model behaviour as realistic as possible within an error of 5%; with significant user input.

The program's physic logic should simulate in a 3D plane, with 3 dimensions of measure.

Have the ability to input different values for the variables to get different results.

This is a differential equation problem, therefore to get an accurate simulation, there should be a form of differential calculus being used, for our solution we decided to use a modified version of euler’s equation

Design Requirements

Constraints

Economic Factors
- Cost of project
- Cost of use

Social Factors
- Time is a constraint, scope of project should be kept accomplishable

Reliability
- Project will have continuous development over a short term, therefor not making it viable long term

Sustainability and Environmental Factors
- Project must strive to use sustainable alternatives where possible

Societal Impacts
- Project should have minimal societal impact, other than to train soldiers or other required parties about the howitzer cannon

04
Solutions

Hypotheses

Solutions:

Solution 1:

- Created a Simulator that calculated position while also taking into account gravity, acceleration, drag force, and the coriolis effect

- Solution was moderately accurate due to using Euler's approximation and the addition of drag force

https://www.biography.com/scientist/leonhard-euler

Solution 1

Hypotheses

Solutions:

Solution 2:

- Same as Solution 1 with gravity, acceleration, coriolis + Wind velocity taken into account

- Solution was very accurate due to the addition of wind which added a layer of environmental factors

https://easydrawingguides.com/how-to-draw-the-wind/

Solution 2

Hypotheses

Solutions:

Solution 3:

- Same as Solution 2 + Enabled Self Propelled Shell calculations

- Solution had same accuracy but allowed the addition of a completely different force which made the simulator more realistic as self propelled shells are pretty common

https://www.newsweek.com/how-american-m777-howitzers-turning-tide-ukraine-war-russia-1705184

Solution 3

Testing

Unit Tests:

Boundary Value Analysis:

- Testing the allowable inputs, we used robustness testing as we had 6 inputs so 7 tests per input

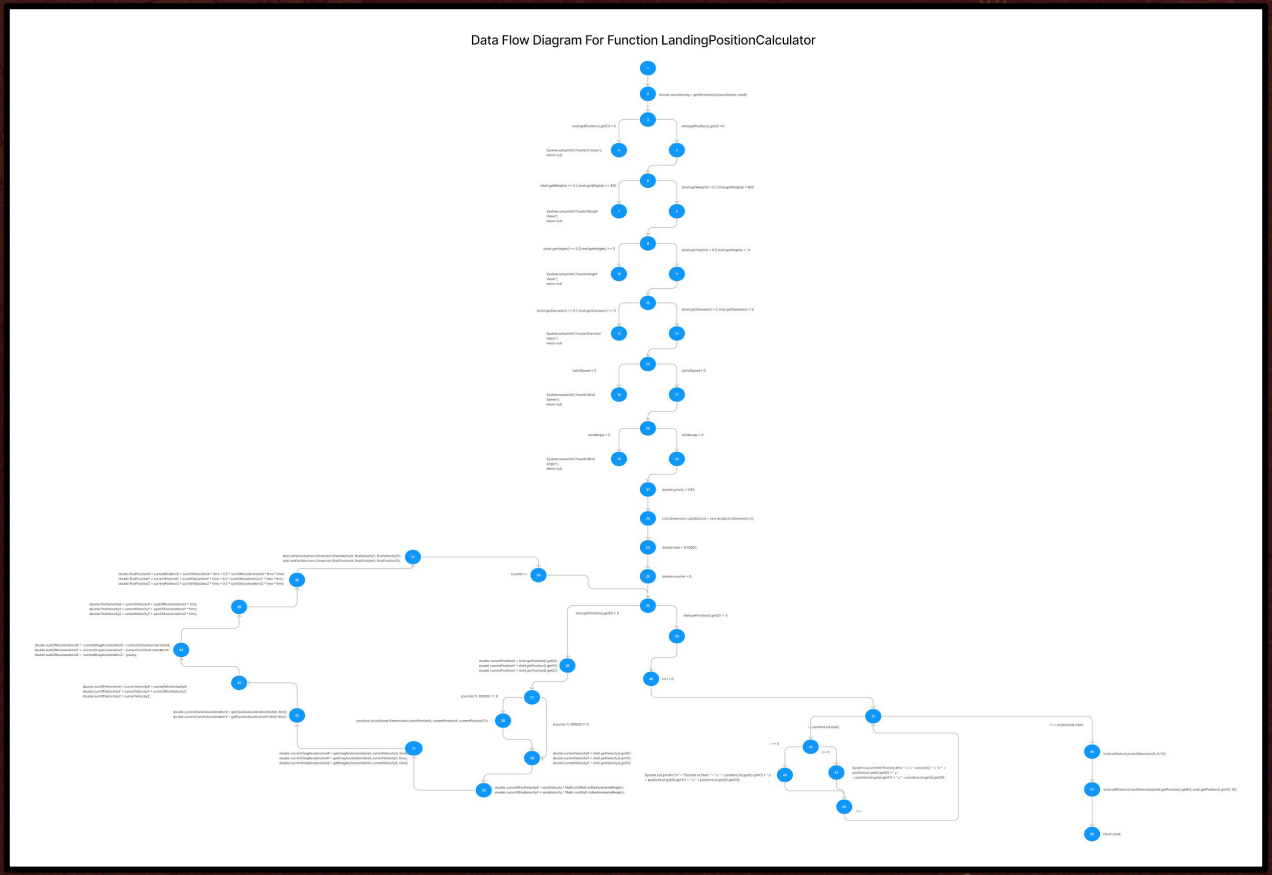
Equivalence Class Testing:

Equivalnce class test requiremnts table						
	Classes					
	Z Position	Weight	Height	Diameter	Wind Speed	Wind Angle
Test Requirement 1	-10	-10	-10	-10	-10	-1
Test Requirement 2	0	0	0.5	0.5	0	1
Test Requirement 3	0	500	10	10	0	1

Path Testing:

- Testing to make sure every path in the function was covered
- Utilized graph and ecl emma

Data Flow Testing



Testing

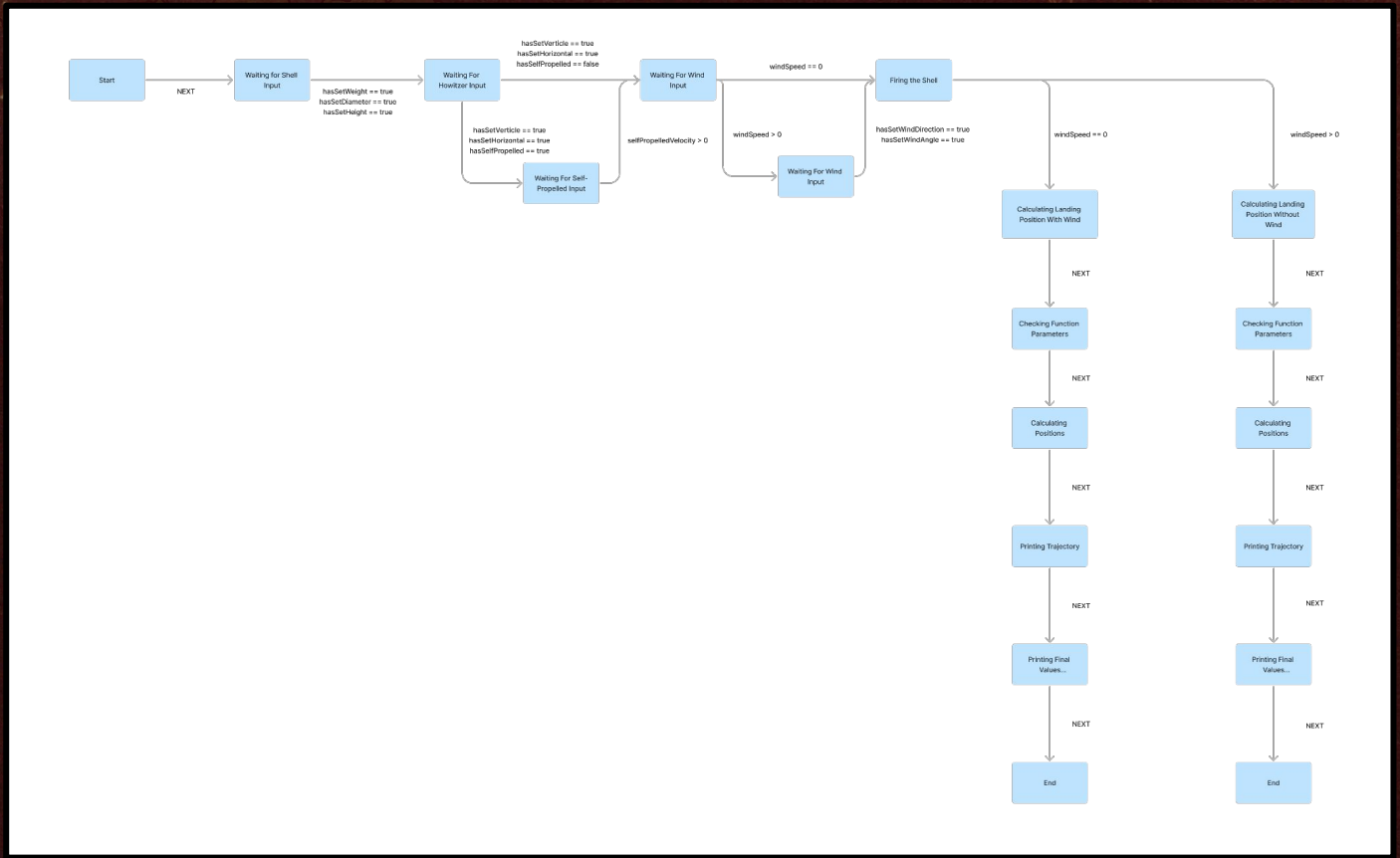
Decision Table Testing:

	Conditions						Actions
Case	Wind Angle	Wind Speed	Z Value	Weight	Height	Diameter	Expected Output
1	Invalid	Valid	Valid	Valid	Valid	Valid	Null
2	Valid	Invalid	Valid	Valid	Valid	Valid	Null
3	Valid	Valid	Invalid	Valid	Valid	Valid	Null
4	Invalid	Valid	Valid	Invalid	Valid	Valid	Null
5	Valid	Valid	Valid	Valid	Invalid	Valid	Null
6	Valid	Valid	Valid	Valid	Valid	Invalid	Null
7	Valid	Valid	Valid	Valid	Valid	Valid	Valid returned shell

Integration Testing:

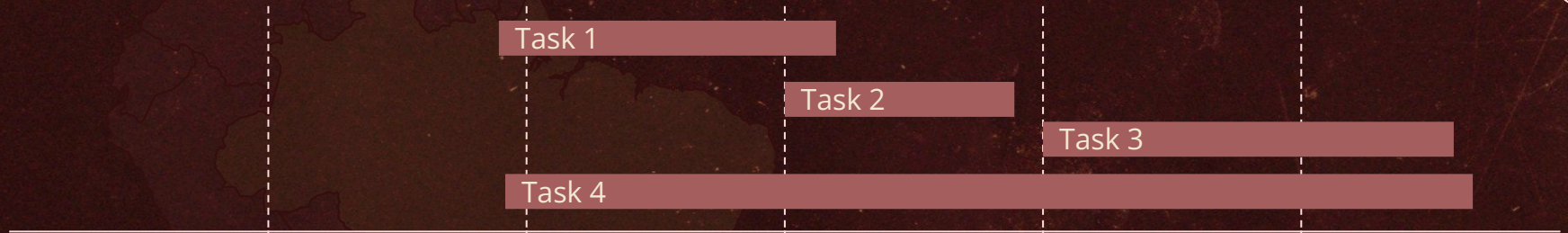
- Tested within the Force Simulator Class using test stubs and test drivers to check call sites

System Testing - FSM (Finite State Machine)



05
Project Management

Gantt Chart



May	May	June	June	July	July

Task	Description	Date	Status
Task 1	Start Project	May 29 - June 15	Completed
Task 2	Integrate solution 1, 2, and 3	June 15 - June 25	Completed
Task 3	Testing Phase	July 1- July 20	Completed
Task 4	Documentation	May 29 - July 23	Completed

06
Conclusion and Future Scope

Conclusion & Future Scope

Conclusion

In conclusion, we learned a lot about the development from start to finish about a program, from planning, developing, testing, documenting, overall giving us a better understanding of how a real world application is developed, especially with the weekly meetings, which taught to plan out appropriately instead of procrastinating

Future Scope

01

GUI

Adding a GUI for inputting values

02

3D Visualization

Showing the cannon firing, and also the shell in the air, while landing

Thanks!

Any Questions?