IE2034

Analog Electronics

1st Year, 1nd Semester

Project Report:
Advanced Naval Battle Simulation System

Submitted to

Sri Lanka Institute of Information Technology

As a partial response to the mandate for

BSc (Hons) in
Computer Systems Engineering

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11/04/2024

Contents

1. Introduction

Naval battle simulations are widely used to analyze combat strategies, ship positioning, and weapon effectiveness. This project implements an **Advanced Naval Battle Simulation System** using the C programming language. The system models escort ships and a battleship within a two-dimensional battlefield and simulates movement, firing mechanisms, and battle outcomes based on mathematical and logical rules.

The project focuses on applying structured programming concepts, file handling, and simulation logic to solve a realistic problem scenario.

2. Objectives

The main objectives of this project are:

- To simulate a naval battle using structured C programming.
- To represent ships and their attributes using structures.
- To read battle data from an external file.
- To calculate distances and firing ranges accurately.
- To simulate battleship movement and escort ship engagement.
- To visualize the battlefield using a two-dimensional grid.
- To determine battle outcomes and statistics.

3. System Overview

The simulation consists of two main entities:

3.1 Escort Ships

Escort ships are defensive units positioned across the battlefield. Each escort ship possesses the following attributes:

- A unique ID and type (A, B, C, D, or E)
- Position coordinates (x, y)
- Impact power
- Time interval between two firings
- Shooting angle range
- Shell velocity range
- Minimum and maximum firing range
- Gamma value affecting hit probability

3.2 Battleship

The battleship is the main attacking unit. It is defined by:

- A starting position
- Multiple travel points
- Shell velocity range
- Maximum firing range
- Gamma value
- A firing interval
- Possibility of gun jamming during movement

4. Data Input Handling

All simulation data is read from an external file named data.dat. This ensures flexibility, reusability, and the separation of data from program logic.

Data includes:

- Number of escort ships
- Escort ship parameters
- Battleship configuration
- Battleship movement coordinates

Standard C file handling functions such as fopen, fscanf, and fclose are utilized.

5. Program Structure

5.1 Header Files Used

- stdio.h: For standard input and output operations.
- math.h: For distance and angle calculations.
- stdlib.h: For general utilities.

5.2 Structures

Structures are used to represent ships efficiently, improving readability and data organization.

Example Structure for Escort Ships:

```c
typedef struct{

    int id_E;
    char typeNotation_E;
    int x_E;
    int y_E;
    int maxAngle_E;
    int minAngle_E;
    int maxVelocity_E;
    int minVelocity_E;
    int maxRange_E;
    int minRange_E;
    float impactPower_E;
    int isDestroy; // check to e is distroyed or not, if E destroy return value 0
    int fireTime_E;// E ship time taken to between tow gun firing
    int n; //number of firings
    float gama;
}escortship;
```

5. Key Functionalities

6.1 Distance Calculation

The Euclidean distance formula is used to calculate the distance between ships to determine if a target is within firing range:

$$Distance \ = \sqrt{\{(x_2 - x_1)^2 + (y_2 - y_1)^2\}}$$

6.2 Battleship Movement

The battleship moves through predefined travel points. At each point:

- Its firing capability is evaluated.
- Gun jamming may occur.
- The minimum attacking angle may be adjusted dynamically.

6.3 Firing and Hit Detection

Each firing event checks angle, range, and velocity constraints. Gamma values are used to influence hit probability. Successful hits reduce the escort ship count or the battleship's health.

6.4 Battle Outcome Evaluation

The simulation determines:

- Number of escort ships hit.
- Remaining battleship health.
- Total battle duration.
- Whether the battleship survives or sinks.

6. Sample Input and Sample Output

7.1 Sample Input Summary (Scenario 1)

- **Number of escort ships:** 12
- **Escort ship types:** C, E, B, D
- **Battleship type:** M
- **Battleship starting position:** (20, 16)
- **Battleship travel points:** (14, 14), (11, 20)

Example escort ship entry:

- Escort ship id: 0, type: C
- Impact power: 0.07
- Time between two firing: 17
- Minimum range: 400, maximum range: 800
- Gamma value: 0.11

7.2 Sample Output Summary (Scenario 1)

- **Status:** Gun jam occurred at second travel point.
- **Updated minimum attacking angle:** 27
- **Escort ships hit:** 11
- **Battle ended at time:** 52.04
- **Battleship remaining health:** 31
- **Battleship attacking order:** 3 (B), 6 (E), 9 (B), 0 (C), 5 (E), 8 (C), 10 (C), 11 (E), 2 (B), 1 (E), 4 (B)

7.3 Sample Output Summary (Scenario 2)

- **Number of escort ships:** 22
- **Battleship type:** U
- **Status:** Gun jam at second travel point.
- **Minimum attacking angle:** Updated to 0.
- **Escort ships hit:** 18
- **Outcome:** Battleship sunk at position (13, 12).
- **Battle ended at time:** 13.01

7. Two-Dimensional Battlefield Grid Representation

The simulation visualizes the battlefield using a two-dimensional grid.

Grid Symbols:

Symbol	Meaning
A, B, C, D, E	Escort ship types
#	Battleship starting position
*****	Battleship traveling point
-	Empty sea cell

Sample 2D Grid Output

```
-----------------------B------
------------------------------
------------------------------
----------------D----E--------
------------------------------
-------------------D----------
------------------------------
----C-------------------------
------------------------------
--------D------E--------------
----------E-E-----------------
----------D------------C------
--------------------*---------
------------------*--A--------
------------------------------
----------------------------E-
------------*#----------------
------------A*----------------
-------------------A----------
------------------------------
------------------------------
-C----------------------------
-----------------D------------
------------------------------
------D-----------------------
------------------------------
------------------------------
---------------D--------------
----------------D--E------B---
------------------------------
A,B,C,D,E represent Escort ship
'#' represent Battle ship starting position
'*' - Battle ship traveling point
```

8. Observations

- Escort ship density directly impacts battle duration.
- Higher gamma values increase hit probability.
- Battleship movement path influences combat effectiveness.
- Gun jamming significantly reduces attack capability.

9. Conclusion

The **Advanced Naval Battle Simulation System** successfully demonstrates the use of structured programming, file handling, mathematical computation, and logical decision-making in C. The system accurately models ship interactions, movement, and combat outcomes within a two-dimensional environment. This project provides a strong foundation for further extensions such as real-time visualization, probabilistic damage modeling, and multi-battleship coordination.