Project Document

1. **Personal information:**

    - Project name: Fortress Fury
    - Topic: Tower Defense
    - Last name: Nguyen
    - First name: Vu Minh
    - Student number: 101676647
    - Degree program: Digital Systems and Design
    - Year of study: 1

2. **General description:**

    - Tower defense is a game where you have to place gun towers or use abilities to stop the attack of the enemy troops and protect the headquarter. Enemies will follow a specific path to the headquarter, and player has to place gun towers along the path to defense. The player can also use special ability to defense. The game progress can be saved to be continued playing later, and after the game end, the records will be saved for leaderboard statistics.
    - Difficulty: Demanding/Challenging

3. User interface:

a. Lobby Scene:

Figure 1: Lobby Scene

- **Click *Play*** to be diverted to *Tutorial Scene*.
- **Click *Continue*** to continue playing existing game (the button will not be visible if there are no existing game). Player will be diverted to *Game Scene*.
- **Click *Leaderboard*** to be diverted to *Leaderboard Scene*.

b. Tutorial Scene:

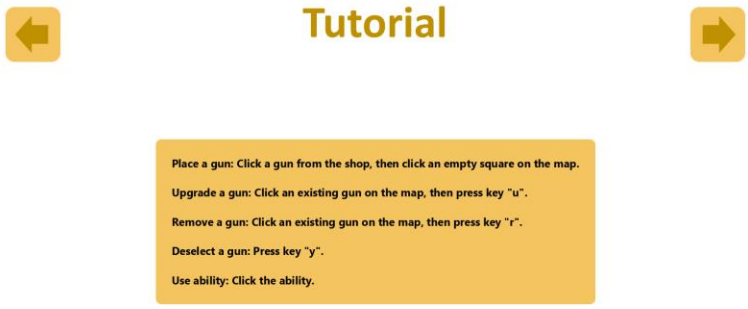


Figure 2: *Tutorial Scene*

- **Click *Back arrow*** to be diverted to *Lobby Scene.*
- **Click *Next arrow*** to be diverted to *Map Selection Scene*

c. Map Selection Scene:

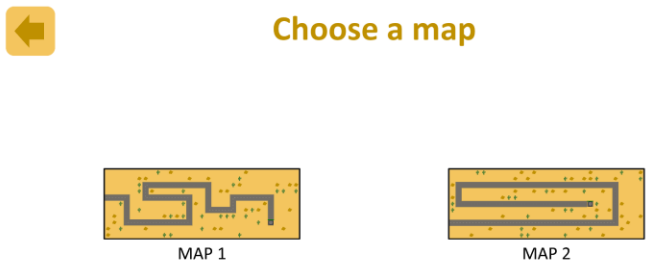


Figure 3: Map Selection Scene

- **Click either map** to be diverted *Game Scene* with chosen map.
- **Click *Back arrow*** to be diverted to *Lobby Scene*.

d. Game Scene:

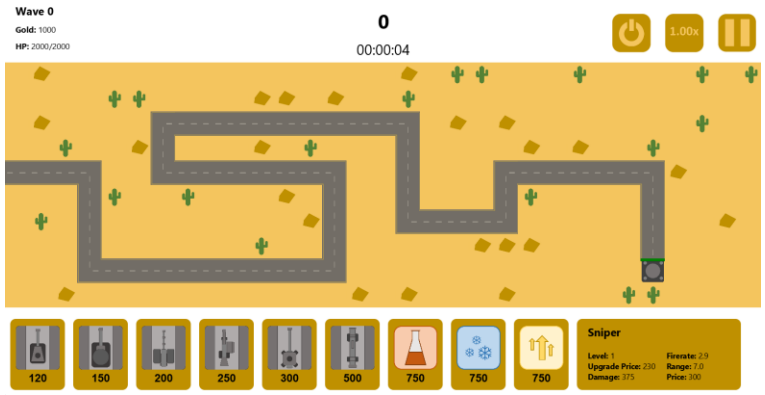


Figure 4 Game Scene

i. Top:

- On the left are basic statistics.
- In the middle are *score* and *timer*.
- On the right are 3 buttons:
    - **Click *quit*** to quit the game, save the game and be diverted back to *Lobby Scene*.

- **Click *speedup*** to switch among 5 speed levels (0.5, 0.75, 1, 1.5, 2).
- **Click *pause*** to pause/resume the game.

ii. Bottom:

- On the left are 3 abilities player can use: Poison, freeze, and rage.
- In the middle are the information of the selected gun tower.
- On the right are gun towers that player can buy. **Click a gun tower** to select it, and the information of the selected gun will be display on the center bottom.
- **Press "y"** to deselect a gun.

iii. Middle:

- After selecting a gun from the bottom right, **click an empty square** to place in at that square. The action will fail if the player's gold are not sufficient.
- **Click an existing gun** to select in. The information of the selected gun will be display on the center bottom.
- **Press "u"** to upgrade selected gun.
- **Press "r"** to remove selected gun.
- **Press "y"** to deselect a gun.

iv. When game is over:

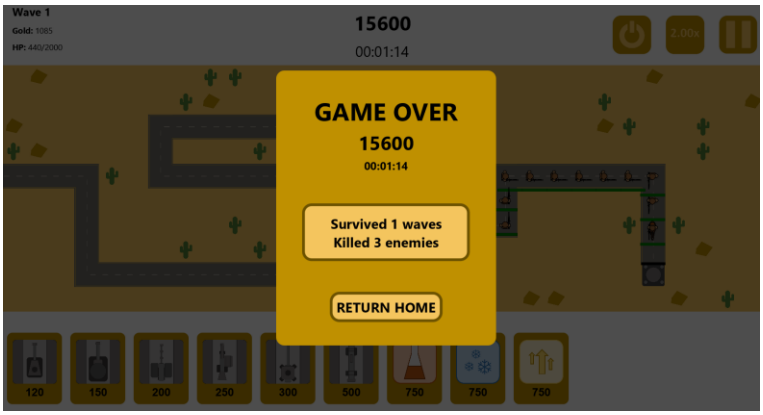


Figure 5: Game Scene when game over

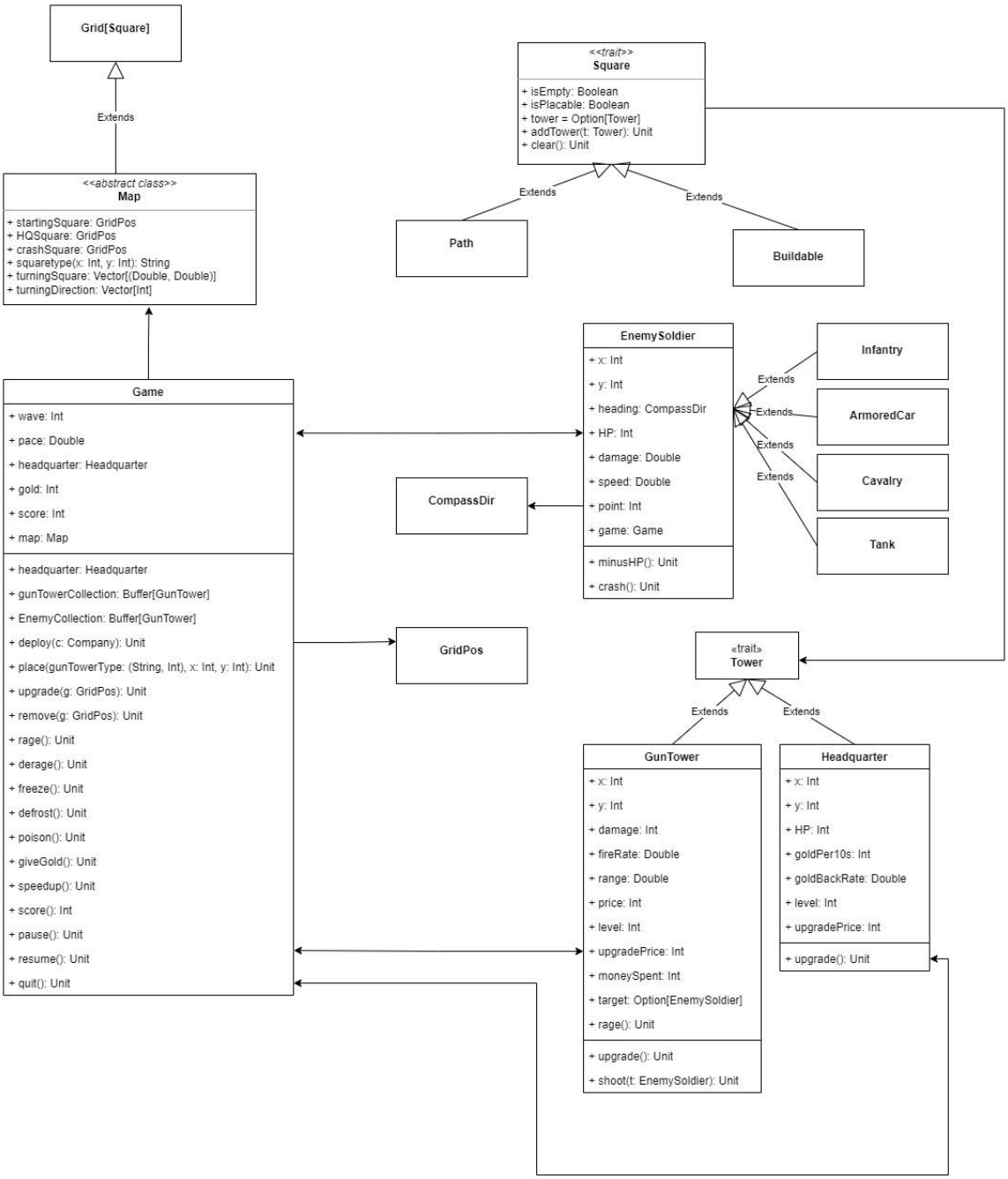
- **Click *Return home*** to be diverted to Lobby Scene.

e. Leaderboard Scene:

Figure 6: Leaderboard Scene

- **Click *Back arrow*** to be diverted to *Lobby Scene*.

4. Program structure:



```
        ├── main
        │   ├── resources
        │   │   ├── image
        │   │   │   ├── ....
        │   │   ├── record.txt
        │   │   └── savedGame.txt
        │   └── scala
        │       ├── app
        │       │   ├── scenes
        │       │   │   ├── GameScene.scala
        │       │   │   ├── LeaderboardScene.scala
        │       │   │   ├── LobbyScene.scala
        │       │   │   ├── TutorialScene.scala
        │       │   │   └── MapSelectionScene.scala
        │       │   └── FortressFuryApp.scala
        │       └── logic
        │           ├── grid
        │           │   ├── CompassDir.scala
        │           │   ├── Grid.scala
        │           │   └── GridPos.scala
        │           ├── EnemySoldier.scala
        │           ├── Game.scala
        │           ├── Map.scala
        │           ├── Square.scala
        │           └── Tower.scala
```

Figure 7: Class structure

- All classes and sub-classes in package *logic* are used to support class *Game*. An instance of class *Game* is created in class *GameScene*, and class *GameScene* will control the flow of the game.

- All classes in package *app* are used to describe the user interface.

- Other solutions:

    - Implement *Ability* as a trait with 3 sub-classes: This is unnecessary since 3 sub-classes can be implemented as 3 methods in class *Game*.

    - Implement *GameOver* as a scene: This is unnecessary since it can be done by adding a pane on top of *GameScene* when the game is over (see Figure 5).

5 . Algorithms:

- **Pythagoras theorem ($c^2 = a^2 + b^2$):** This is used to check if an enemy soldier is in the range of a gun tower.

- **2-argument arctangent (θ = atan2(x,y)):** This is used to calculate the angle of the line crossing the gun and its target.

- **Linear relationship:** Initially, the enemies and the square they are on are not aligned. The further the coordinate from (0, 0), the greater the misalignment. I find the misalignment of each coordinate and use Linear regression calculator to find the slope.

- **Find the target of a gun tower:** Iterate over enemies in the order of their deployment and return the first enemy that is in the range of a gun tower. In this way, the gun will prioritize shooting the enemy that is closer to the headquarter.

6. **Data structure:**

- **Buffer:** I used this to store enemies and gun towers on the map since they need to be mutated frequently.

- **Vector:** I used this to store constant information (pace, gunInfo, etc.) since they do not need to be mutated.

- **Seq[Seq[…]]:** I used this to store information from .txt files. This is the most viable solution since the .txt files are in TSV (tab-separated values) format (see Figure 8, 9)

7. **Files:**

- There are 2 files in the project: *savedGame.txt* and *record.txt.*

- They are .txt file, but both of the are formatted in TVS format: Data in 1 line are separated by *tab character* ("\t") and lines are seperated by *new line character* ("\n")

a. ***savedGame.txt*:**

- **Line 1** includes 2 datas: the number of gun towers (n) and the number of enemies on the map (m).

- **Line 2** includes 8 datas: score, gold, wave, time, nextDeployTime, cannotDeployUntil, enemyKilled, and mapType.

- **Next n+1 lines** each includes 4 datas (name, x, y, level) of 1 headquarter and n gun towers.
- **Next m lines** each includes 3 datas (name, stepTaken, HPpercentage) of m enemy.
- **The last line** includes information about undeployed enemies.
- **Example:**

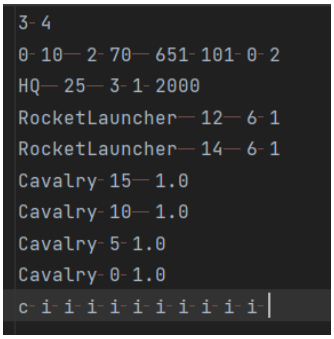


Figure 8: savedGame.txt

b. record.txt:

- Each line includes 6 datas: date, mapType, score, survivedTime, survivedWave, enemyKilled
- **Example**:

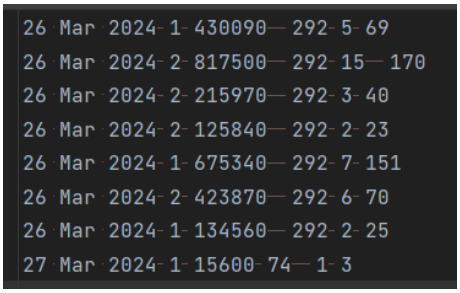


Figure 9: record.txt

8. Testing:

- **Using test file:**

- *giveGold(), deploy(enemy), enemy.advance(), place(gun), gun.shoot()*

- **Using user interface:**
  - *pause(), resume(), speedup()*
  - The rotation and shooting effect of gun towers, the turning of enemies
  - *save()* and *load()* methods

9. Known bugs and missing features:

- When changing the scene, there is a glitch, which makes panes unaligned. This can be fixed by slightly adjust the window size.
- On Mac devices, the enemies are off the center of the path (but the scene changing glitch does not occur).
- Potential crash.

10. 3 best sides and 3 weaknesses:

- **3 best sides:**
  - Clearly structured, user-friendly user interface.
  - Has many interesting features: speed up, quit, save game, etc.
  - Relatively clean code, with comments to divide it into different sections.
- **3 weaknesses:**
  - Potential performance issues.
  - Require keyboard to play the game (most tower defense game does not require)
  - No usernames to identify whose record it is.

11. Deviations from the plan, realized process and schedule:

Week	Plan	Actual progress	Progress evaluation
11.2 – 24.2	Finish basic class implementation.	Initialize classes.	Behind schedule
25.2 – 9.3	Finish complex methods and finalize enemy soldiers' and guntowers' attributes.	GUI: worked on the basic of *GameScene*. Logic: finished *Map*, *Towers*, a part of *Game*.	GUI is far beyond schedule, but logic is behind schedule.
10.3 – 23.3	Start working on UI.	GUI: had *LobbyScene* and the basic of *GameScene* done. Logic: finished the basic of all classes.	On schedule
24.3 – 6.4	Keep working on UI and test the functions via UI.	GUI: finished other scenes. Logic: finish some I/O functions.	On schedule
7.4 – 17.4	Finish UI and finalize documents.	GUI: Reformat the layout of all scene.	On schedule

- I decided to start UI earlier than in the plan, because it made testing functions easier.

- The biggest difference is I worked with logic and GUI concurrently, instead of finishing logic then move to GUI.

- The order of implementation of the project is to implement small classes first (*Towers, EnemySoldiers*) first, the implement bigger one (*Game, Game Scene*). After finising the core features, I moved on to other scenes and minor features (*saveGame, LobbyScene, LeaderboardScene*).

- During the process, I got to know many new features of the language Scala. It is also the first time I got to use the I/O features (apart from A+ exercises). Besides, when trying to make the layout and color of the scenes harmonious, I learned something about arranging and coloring in a design.

12. Final evaluation:

- **Good and weak aspects:** The game layout is familiar, users can easily navigate through different scenes. There is a *TutorialScene* to help players to use the *GameScene*. However, there are no usernames to identify whose record it is, but for an offline game, it is not necessary. Last but not least, for a tower defense game, it would be smoother to navigate through the game using only mouse.

- **Shortcoming and explanation:** The program has potential performance issues. This is due to the method *updateTimerText()* in GameScene being called once every 0.2 second in normal speed or 0.1 second in x2 speed.

- **Shortcoming and explanation:** The movements of the enemies are always on track on Window devices, but are off track on Mac devices. This is due to there are 2 layer of pane, one is *GridPane* for the squares on the map, the other is a *StackPane* for the enemies. On Window devices, these 2 panes align perfectly, but on Mac, there is a slight unalignment, leading to the unalignment of the enemies.

- **Possible future improvement:**

    - Make the game keyboardless

    - Find another way to implement enemies movement

    - Have enemies or guns to operate on their own, instead of using *foreach* to control each of them.

- **Different choices of solution/data structure/class structure:** I think the general structure of my solution is relatively good. The program is easy to make changes or extensions. By adding a few more lines, you can add/remove guns, enemies, map, etc.

- If I started the project again from the beginning, I would research the tower defense game pattern and the scalafx documentation from A+ more carefully. This would lead to fewer refactoring.

13. References:

- How to write a file: https://alvinalexander.com/scala/how-to-write-text-files-in-scala-printwriter-filewriter/
- How to use Thread: https://alvinalexander.com/scala/how-to-create-java-thread-runnable-in-scala/
- How to update UI in a thread: https://stackoverflow.com/questions/32640697/updating-ui-from-a-background-thread-in-scalafx