



STANFORD

EE 267

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**EE267: Virtual Reality Final  
Project - First Person  
Minesweeper**

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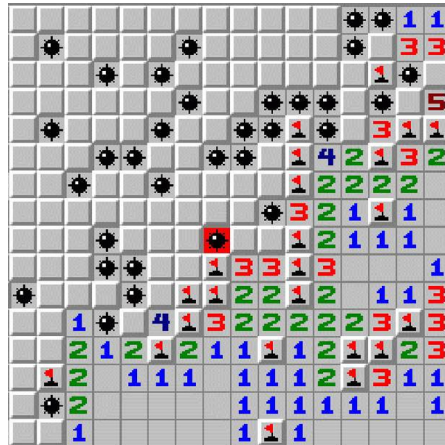


Figure 1: Traditional Minesweeper

## 1 Motivation

The games played in childhood remain close to our hearts. It is safe to say that many of our generation recall playing Microsoft **Minesweeper** [2] at some point during their youth. We developed a version of Minesweeper in a virtual environment with the same rules as the simple 2D game. The game is played with a head mounted display (HMD) which renders a virtual environment. In the environment, a grid of mines is placed, and the user controls a first-person point of view character using keyboard and mouse input.

2-Dimensional minesweeper has two basic functionalities - clicking on a tile to query the number of mines surrounding that tile (shown in Fig 1), and flagging that tile if the player thinks it contains a mine. One of the key improvements we wanted to make was improving the user experience when you lose a game.

In traditional minesweeper, losing is somewhat anticlimactic, and considering it happens so often, (to us, anyway - we aren't great at minesweeper), we thought that losing should be nearly as fun as winning. In VR Minesweeper, the player gets to experience the effect of an explosion occurring very close to their face.

## 2 Objectives

We create a gaming environment to play the game of Minesweeper with standard controls using the keyboard. Therefore the objective can be categorized as the follows:

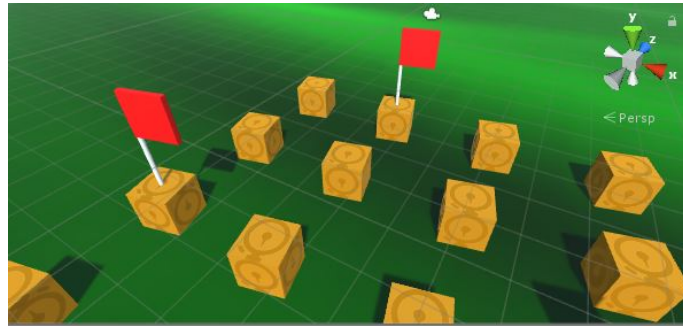
1. Implement a 1st person Minesweeper game
  - The game follows the basic principles of the Microsoft Minesweeper game. In the 2D version, the player can see the whole field at a time. In the 1st person implementation, the players can see what a person strolling down a minefield would see, and must walk up to each potential mine to query it, risking an explosion.
2. Extend to a Virtual Environment
  - Extension to the stereoscopic view is straightforward by creating the virtual environment in the Unity3D game engine, which has native support for XR applications in the newest release (2018.1). The physics engine is used to implement an explosion which blows the player backward if he/she trips the mine!

### 3 Methodology

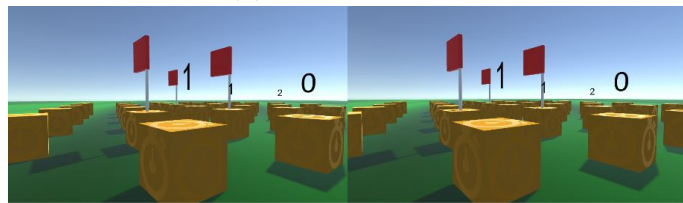
The most convenient way to develop virtual reality games was utilizing the development environment in Unity [3]. We use ViewMaster VR headset [4] and a Topfoision 6-inch 1080p LCD screen connected to a laptop computer to render the scene in stereoscopic mode.

Our game has the following attributes:

1. A world field (like a golf course) on which there is a placement of a grid of blocks, a certain number of which are mines.
2. The player can left click a box to check it for mines, and right click it to flag it as a mine. The player controls a camera which can walk, turn its head, run, and jump. The player's avatar has a Rigidbody collider and has physical attributes attached to it, such as mass and walking speed.
3. A series of 2D arrays store properties about each block, such as whether it's a mine, how many adjacent mines there are, and whether or not it is currently flagged.
4. The blocks either display the corresponding number of adjacent mines when queried, or explode. Each box may also render a 3D flag.
5. The victory condition is implemented with a simple comparison between the isFlagged array and the isMine array. The loss condition is thrown if the player clicks on a mine.



(a) Game top view



(b) Left and right camera view

Figure 2: 1st Person Minesweeper Gameplay; Flags and blocks exposed

### 3.1 Challenges

While developing the game in Unity we also faced couple of challenges

- Realizing a targeting reticule on screen was a problem. A pointer close to the eye which exists in world space causes us headaches. A solution suggested by a visitor on demo day is to create an object at infinity, but render it so that it appears on top of all objects. We could also just make the boxes light up, but these features were not implemented.
- Integrating the stereo display with the Google Cardboard SDK was a challenge. In order to use the Cardboard protocol, which has native support in Unity 2018.1, the app must be exported for iOS or Android. However, compatibility with the ViewMaster HMD constructed in class requires a Linux, OSX, or Windows build. Our solution was to create a Unity build using the Vive "Mock HMD" option meant to test stereo rendering on a computer before porting to a true HMD. The output of this mode was sufficient for our purposes.

## 4 Rules of the Game

To win the game, you must correctly identify each mine. The steps are as follows:

- Begin the game and walk to one of the many blocks displayed on the screen.
- To interrogate a block, click left. If it's not a mine, it will display the number of mines adjacent to the block. Correspondingly, right click to flag the block if you think it's a mine.
- Expose the blocks one by one. Keep in mind the number shown on top of the blocks is equal to the number of neighboring blocks which have mines underneath.
- Once you have successfully identified and flagged all blocks containing mines, you win the game! Enjoy the fireworks.

## 5 Related Work

The gaming industry is rapidly moving towards Virtual Reality, as a result there are quite a lot of games similar to VR Minesweeper.

- Virtual Reality Chess:

Some open source implementations are present for VR Chess, with a few examples being ChessUltra and ImmersionChess. Most of the games have incorporated haptic feedback and hand movement tracking to incorporate physical resemblance of playing chess.

- Virtual Reality Fruit Ninja:

VR Fruit Ninja has gained great popularity recently, and is available on Steam FruitNinja, Oculus and PlayStation [1]. This game also has a hand tracking mechanism to mimic the sword that cuts the fruit.

## 6 Milestones

The project milestones are listed below:

- Week 1
  - Gain familiarity with Unity programming and scripting with simple objects.
  - Set up basic functionalities like block placement on a grid, work out the mathematics for mine placement.
- Week 2
  - Implement 1st person game controls.
  - Work out ray-tracing for clicking blocks, render into HMD mode.
- Week 3
  - Finish the game.
  - Circulate the game among friends and gather feedback.
  - User experience improvement and fine tuning. Present on the Demo Day.

## References

- [1] Fruit ninja on ps4. <https://www.playstation.com/en-us/games/fruit-ninja-vr-ps4/>. Accessed: 2018-06-06.
- [2] Microsoft minesweeper. <https://www.microsoft.com/en-us/p/microsoft-minesweeper/9wzdncrfhwcn>. Accessed: 2018-06-06.
- [3] Unity 3d game engine. <https://unity3d.com/>. Accessed: 2018-06-06.
- [4] View-master deluxe vr. <http://www.view-master.com/en-us>. Accessed: 2018-06-06.