

# Maze VR: Immersive Applications

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## ABSTRACT

With the advancement of virtual reality technology (software and hardware), the user experience has become increasingly immersive. This level of immersion can even allow users to develop real world skills in a virtual environment. A virtual maze offers a controlled setting with diverse implementations, facilitates problem-solving and exercises a user's spatial awareness. virtual reality as an instrument of education is not a new concept, however, this paper will explore how a user's enjoyment of their experience elevates their overall learning.

**Index Terms:** Virtual Reality—Maze—Problem solving—Spatial awareness;

## 1 INTRODUCTION

### 1.1 Objectives/Goals

The objective of the virtual reality maze is to take advantage of the ability to interact with the maze and the high level of immersion that virtual reality gives in order to allow users to have the experience of being inside a maze within their own homes. Users can experience different scenarios virtually, which removes most physical limitations and thus potentially increases the level of engagement.

The virtual reality maze introduces traps and objectives that would hinder the user's progress. Users are forced to problem-solve in order to avoid traps and fulfill the objectives that are required to complete the maze. Each maze within the game has a different theme along with unique traps that would provide challenges that users would find entertaining as well as intellectually engaging. Upon completing the objectives and completing the maze, users should leave with a mentality for thinking outside the box, enjoyment and satisfaction for having completed the maze.

### 1.2 Rationale

A virtual reality maze was chosen not only for its simplicity but also for its potential to have added layers of complexity. The mazes are versatile in which each maze can be different with unique themes and objectives. For example, although a simple maze has the objective of reaching the exit, more complexity was added by including challenges that would make the maze more difficult to complete.

## 2 RELATED WORK

There has been research done about the use of virtual reality maze games and the dissemination of scientific knowledge. A maze can have puzzle signs or hints that can keep the user entertained as well as promote scientific knowledge. [3] In addition, virtual reality environments can be used to help with children's social interaction, cooperation and education remotely. Mazes can be especially useful in teaching how simple steps towards manageable tasks can lead to the achievement of more complex ones. [2]

Another study also showed how important virtual reality environments are when it comes to testing warning signs. Users can be studied in order to see what warning sign can capture the most attention. The immersion of virtual reality can help test the decision making of individuals without putting them in real risk if the decision ends up being incorrect. [1]

## 3 METHODOLOGY

### 3.1 Input Device

The virtual reality maze is developed for the Oculus Rift headset, and in terms of interaction, the touch controllers can be used to interact with objects within the maze. As stated before the path to the objectives and the exit of the maze will have traps that would reset the player to the spawn point within the maze. This is where the tracking for the Oculus headset and touch controllers comes in which would allow users to trigger the traps without risking being killed in the game and respawning at the spawn point.

### 3.2 Interaction

The Virtual Reality Maze has objects that can be interacted with by users which would include traps that are hidden within the maze as well as objects that are used to complete objectives in the maze. These traps would "kill" the user and send them to a spawn point at the start of the maze, users can trigger the traps without risking themselves by interacting with the triggering mechanisms. Interacting with the objects would allow the user to complete the separate objectives that would each remove a "gate" that would prevent players from completing the maze unless they complete the objectives first. At the end area, the user can choose to move on to other mazes by clicking on their names.

A list of traps that the user might encounter:

- Enemy avatar
  - Fire Dragon
  - Ice Elemental
  - Armed Vigilante
  - Wizard
  - Skeleton
- Interactable traps
  - Button for explosion
  - Slider for ceiling to hide lava rain
  - Trip wire for fire arrows
  - Trip wire for pistol shots
  - Trip wire for dynamite explosion
  - Trip wire for Fire Dragon
  - Trip wire for Ice Elemental
  - Armed Vigilante's field of view
  - Wizard's field of view
  - Skeleton's field of view
  - Cacti trap
  - Spike trap
  - Lava trap

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### 3.3 Western Themed Maze - Brajan Halili

The default version of Maze Generator, which was an asset taken from the Unity Asset Store, was used for the basic structure of the maze. The structure was then radically changed to fit the spatial needs of the traps that were implemented. The texture picked for the walls was bricks and the texture picked for the ground was sand. The night sky was taken from a website and incorporated into Unity's skybox. Fog was also incorporated and the lighting inside the maze was done by using lamp posts so that the player can be immersed in the scenery. There are sewer area, a house close to the armed vigilante, a water well, rocks, crates and barrels that serve as some decor. A treasure chest was put on the way to the detonator, which will be explained later, as an attempt to lure the user since the tile in front of the treasure is a cacti trap.

The cacti trap included a 1x1x2 area under the map which could be accessed by stepping on the tile. The tile was made to resemble the sand texture in order to trick the user into failing to notice it. However, the color of the texture was a bit greener, so that the user could distinguish and not step into the trap if they are careful. The trap had a box collider on top of the cacti so that it was able to respawn the user to the designated area if the user fell into it. The trap also played a stab sound to inform the user that they were stabbed by cacti.

The tripwire with pistol shots trap had an invisible trip that was deliberately placed where the light source could cast shadows so that its shadow could project to the ground and help the user notice it. All pistol shot traps were evadable after the triggering, however some had to be triggered in order to progress in the maze. The pistols all played a gun sound independently and were set to not fire at the same time. If any of the bullets hit the user, they would be respawned in the designated area. After the trap was triggered, the wire was destroyed as an object, but the pistols stay as static objects afterwards. The pistols only had one bullet, which was placed inside the gun barrel and would move with some velocity when the trip wire is stepped on. Then, the bullets were made to be destroyed in order to not go infinitely in one direction and take computing resources.

The tripwire with a dynamite explosion included the same trigger mechanics as the previous trigger mentioned. It also included two particle effects: the fuse lighting up and the dynamite explosion. Both particle effects include sounds and trigger one after the other. When the explosion effect starts, the crate and dynamite get destroyed. Just like the pistol trap, some dynamite traps need to be triggered in order to progress, but they are easily evadable by the user as the user can hear the sound and back off in time. The traps then destroy a wall, leaving a few bricks around and opening the way for the player to get to the detonator.

The detonator is on the bottom left corner of the game, it has a capsule collider that can be pushed down. Once enough force is applied and it reaches a certain point, then a huge explosion triggers, something that the user can hear and see from afar, which will open the end area and also create a lot of bricks around. The user then can go to the end area or can choose to explore more. If they choose to explore more, they can interact with the armed vigilante that aims and shoots at the user if they are in his field of vision [Figure 1]. There is sound to indicate the shot and if the bullet hits the user, they respawn at the designated area.

### 3.4 Fire Themed Maze - Calvin Wang

The Maze Generator was not used in this scene because a more traditional square design is preferred for the maze. The floors and walls are default cube objects from Unity that have been scaled relative to the average human height. In order to create the illusion of a fire filled environment, a lava rock texture from the asset store was used. The sky is a sunset skybox from the asset store, and due to its reddish color, obscures certain details in the scene from the



Figure 1: The avatar preparing to shoot in the Western themed maze.

user. It elevates the difficulty and also adds to the level of immersion by providing a frame of reference for the user. Buttons were added to allow the user to interact with the doors. In addition, foot step sounds were added to allow the user to know that they are moving.

The first observation that the user must make in order to progress is discovering a decoy wall that is in actuality a proximity door. This decoy wall is intentionally made a darker shade than the other walls, and once the user gets within a certain range, will open and allow the user to progress. There is another section of decoy doors in the end that reveal the final gate. In order to open these doors however, the user must discover three tiles that are a darker shade than the floor, and step on all of them. Each time a tile is pressed a high pitch ding sound, reminiscent of a phone notification, is heard.

There are multiple doors within this scene, most of which are related to traps that the user can trigger. One such door is the lava floor door that is triggered by a button. It is intentionally situated next to two other doors in order to evoke a desire to make a decision from the user. When faced with options, humans often either rush in with their instinct, or take the time to analyze the situation. If enough attention is paid, the user will notice a certain bubbling sound that increases in volume the closer the user gets to the lava floor door. This bubbling sound represents the lava that is flowing below, and is the signal for the user to avoid opening the door. There is another trap door that is triggered with the button press, and this one will cause an explosion to occur. Both the button press and the explosion use spatial audio to further immerse the user.

Other than buttons, there are also two trap doors that are triggered by trip wires. One of them is a fire arrow trap while the other is a dragon fire trap [Figure 2]. For both of these traps, the trap wire is made intentionally thin yet distinctly white so that upon closer inspection, the wire is noticeable. Also, there are tiles hidden within the vicinity of each trap that when stepped upon, will disable the trap and notify the user with a scissor snipping sound. Due to the lighting of the scene, the shadows of the wall face a certain direction, and therefore the tiles were intentionally placed in the shadows to elevate the difficulty.

The room that holds a button to open one of the final doors that lead to the gate, uses lava rain to prevent the user from reaching it. However, there is a box with a hidden mechanism that the user can interact with. This hidden mechanism is a different shade from the box and when pressed, will eject the lid that hides a slider. This slider can be grabbed by the user, and its position correlates with a ceiling. By moving the slider, the user is able to cover the room with a ceiling, thus preventing the lava rain from reaching the user when trying to push the button.

The last interaction lies in the inventory system. In order to complete the maze, the user must find a key and hold it in their hands when unlocking the final gate. Although this inventory system reduces the level of immersion, it is a convenient and necessary tool that will improve user sentiment. Rather than holding a key while trying to traverse the maze, it will reduce the strain on the users' hands and attention by allowing them to store the key virtually.



Figure 2: The avatar breathing fire in the fire themed maze.

### 3.5 Ice Themed Maze - Kenthony Garcia

To create the ice maze a map generator asset was used from the Unity Asset Store and the objects within the asset were used to create the maze from scratch. The snow texture was used what also included a ice texture, the snow was used for the floor tiles and the ice was used for the walls in the maze. The exit doors texture is a water texture that closely resembles ice. To open the exit door the user requires a torch to melt the final door. Both pathways in the maze lead to the door but have different challenges for the user to face. The maze was designed to be very claustrophobic and have narrow passage ways to make the maze more difficult for users which would cause them to become disorientated. Once the maze was complete, traps were implemented to make the maze more challenging for users and to set them back to the start so that they are required to go through the maze again.

One trap implemented was a ice spike trap that would require the player to press a button that resembles similar buttons that would open the doors in the maze. The spikes were set individually in a 9x8 placement totalling 72 spikes which has a plane sitting above the spikes that would be triggered if a player would fall into the plane causing them to respawn at a checkpoint in the middle of the maze. The trap has a noticeable tell to allow the user to notice that the floor under the button is not the same as other floors in the maze. If a user were to notice the flooring and interpret the difference in floor tile would allow them to avoid this trap in the maze allowing them to save time and disorientation from being respawned and the checkpoint.

Another trap implemented was an ice elemental that would send out 4 ice spikes towards a spot in the maze where the user would have to cross to get to a button that would open the door. This path would be the more risky and challenging for the user as they would need to dodge the ice spikes that would hit them and send them to the start of the maze. The spikes are sent out in randomly generated paths that would make it extremely difficult for the user to get through but with really good timing a user can press the button that opens a door that leads to a torch that would allow the user to exit the maze and into a room where there is a ui that would

allow them to change mazes. Although this path requires the user to commit to pushing through this path and to try and get by the ice elemental by timing the ice spikes to get to another button that would allow the user to proceed to the door with the torch.

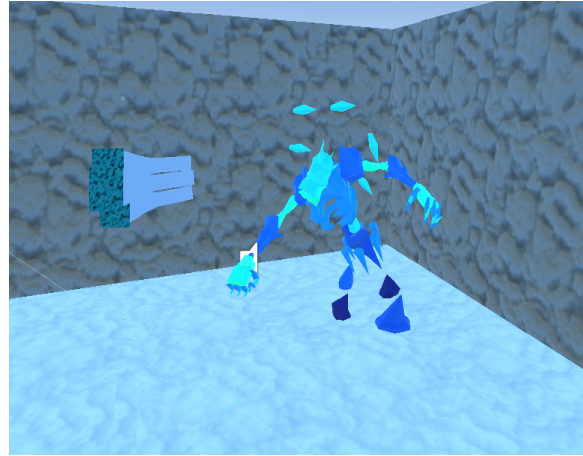


Figure 3: The Ice Elemental shooting ice particles in the ice themed maze.

### 3.6 Haunted Themed Maze - Sheikh Fuad

To create the Haunted maze, the map generator asset wasn't used instead an asset from the Unity Asset store was used which included individual wall and floor panels with the texture resembling a dungeon. The design of the maze was created from scratch by editing each section individually and putting it together section by section after it was completed. The maze has two separate sections dedicated for the starting point and the ending point which includes the menu to switch between scenes. There are multiple paths to reach the end of the maze, but each path requires to overcome different challenges. The maze was designed to mislead and disorient the user by having multiple paths with dead ends and traps. When the user interacts with a trap or fails to overcome the challenge, the user must start the maze from the beginning which makes it even more challenging to complete the maze.

The maze includes multiple spike traps in multiple locations throughout the maze. Each trap is set under the map of the maze which is triggered when the user steps on the floor tile directly above the trap. The floor tile of each trap has the same design as the floors of the entire maze except the walls of the traps are set to stick out the side of the floor panel to give the user a slight chance to avoid the trap. The bottom of the trap has six metal balls with spike and a box collider. The box collider was implemented with a respawn script and an audio effect of the impact when the user falls in the trap and respawns back to the starting point.

Within the maze there are three Wizard's placed in three different locations of the maze which is one of the challenges the user needs to overcome. Each Wizard is placed within a section of the maze which has a box collider on trigger to indicate the user's presence. When the user enters that section, the Wizard will continuously attack if the user is within that section and if the user is impacted by the attack, the user respawns back to the starting point. The Wizard's attack is an effect-based attack which includes the usage of the particle system which creates an explosion of magic. The user needs to get out of that section quickly to overcome the challenge.

There are also three skeleton warriors equipped with battle axes in three different locations of the maze which is another one of the challenges the user needs to overcome. The set up of each section of the skeleton warrior follows the same methods used for the Wizard

except the warrior uses battle axes to attack and the user respawns back to the starting point when the user gets hit by one of the axes.



Figure 4: A wizard preparing to attack the user in the haunted themed maze.

#### 4 ANALYSIS

Due to lack of time and access to equipment, we were unable to get peers to review the mazes. We could not include other senses like touch or smell because we could not access other equipment that makes integration of those senses possible.

Some bugs that were encountered during the creation of the Western themed maze were gun sound issues with the pistol trap. If all audio sources played at the same time, there would only be one sound instead of five so a delay on each sound was created in order to remedy this. The avatar had issues looking at the player since the LookAt() function did not seem to center correctly. An offset was needed to help with it. The bullet from the avatar's gun also had issues hitting the user since there was a formula needed to calculate the direction of the velocity for the bullet.

Bugs encountered for the Fire maze would include the XR Direct Interactable from Unity, audio issues, and texture issues. It was difficult to implement the XR Direct Interactable in grabbing the slider because Unity does not allow the controller objects to have both the Direct and the Ray Interactor, which was already being used to interact with the main menu and inventory system. Ultimately, both the Ray and the Direct Interactors were implemented by allowing each controller to be responsible for a different interactor. The biggest audio issue was the lack of synchronization between the fire breathing sound and the fire breathing action of the dragon. After trial and error, the disharmonious feeling from the sound not matching the motion is reduced to a minimum. Due to the way the walls were set up, the textures were not proportioned properly on the edges, causing huge distortions. In order to fix this, The corners were all replaced with pillars that had the proper texture proportions.

Bugs encountered for the Ice maze would be the audio file not being played, upon activating the trip wire for the Ice elemental which would be the sound of icicles breaking or when the final door is being melted. Another bug encountered would be how the torch is being held by the user as it would prevent the user from moving forward if the torch was too close to the player. Also the torch would fall through the floor tiles in random locations which could be due to a small gap between the tiles that allows the torch to fall through. To remedy this bug the inventory was created to place the torch within it so that it would allow the user to move freely and allowing both of their hands to be free to interact with the maze.

In the implementation of the traps, bugs that were experienced was setting up the collision of the player and the attack of the characters. When the character attacked, the player did not collide with weapon properly to activate the respawn. To active the respawn, the player needed to be really close to the weapon itself rather than the motion of the attack. This bug was addressed by adjusting the box collider of the weapon used by the character by making it longer than the default size.

#### 5 DISCUSSION

The mazes gave the tester a lot of motion sickness. This probably had to do with the low polygon textures that were used. More realistic textures as well as more realistic sounds could probably help alleviate the sickness during play time.

Although our tester felt less nauseous with the Continuous Turn Provider, this may not be the case for all users. Giving the user the option to choose between Snap Turn Provider and Continuous Turn Provider is preferable since some users feel more comfortable in one of them more than the other. The mazes implemented spatial audio for many interactions, however more ambient sounds would be beneficial for increasing immersion. There were also lots of traps that needed to be triggered or deactivated, but more complex traps with multiple phases could be implemented to test problem solving skills even more. Despite all of these possible improvements, the mazes themselves were well designed to test the directional skills of the user.

#### ACKNOWLEDGMENTS

The authors wish to thank their families and Professor Wole. The project can be found on github<sup>1</sup>, and the demo can be found on YouTube<sup>2</sup>

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<sup>1</sup><https://github.com/KenthonyGarcia/VR-Maze>

<sup>2</sup><https://youtu.be/aEnxZzfUeLU>