

**An Augmented Reality Labyrinth Game Mobile Application**

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# **Introduction**

Augmented Reality (AR) is an enhanced version of real physical world that is achieved through the use of digital visual elements, sound or sensory stimuli delivered through technology. Augmented Reality is a growing trend among companies involved in mobile computing, business applications and mobile gaming in particular. The recent progress in camera and sensor technology in mobile devices have made development of mobile games powered through augmented reality more prevalent. This particular AR Project aims at developing the famous Labyrinth Maze game using AR technology for mobile devices. The Labyrinth is a game of physical skill consisting of a box with maze on top, and a steel ball. The object of the game is to try to tilt the playfield and guide the steel ball to the end of the maze. With the addition of Augmented Reality, the game will be able to convert a physical maze on paper from 2-D to 3-D and render a ball in the 3-D Maze for users to play the game. Users will then require to hover their phone over the maze and tilt their phone to get the ball rolling. This will allow users to engage more with the augmented game on their phone screens and help them with their patience and balance skills.

The Labyrinth Maze Game was designed to properly understand the AR Frameworks and their workings, and how AR can be used to design mobile games with augmented reality experience with minimal concepts and understanding.

* 1. **Project Scope**

In this particular AR Project will focus on rendering a 3-D model of the maze on top of the original maze and a ball at the starting point of the maze for users to navigate throughout the maze. The ball in the game will move on the plane of the maze through the gyroscope of the mobile device. The AR project is currently limited for rendering a particular maze design currently present in the application’s database and will not work for any other maze designs. The AR Project also currently works only for Android mobile devices.

# **Design & Implementation**

This section of the project report discusses the design and implementation of the proposed AR Labyrinth Maze Game and all its functionalities in detail. In this section, each and every component of the project is reviewed and described whether they were a part of the original enactment or not. This project section explains everything starting from the initial project design to its final implementation to help readers perceive every stage of the project development.

* 1. **Technology Used**

This sub-section briefly discusses all the technology and softwares utilized during the development of the AR Application and how did they contribute towards the final implementation. Following are all the softwares and technologies used for the project:

* + 1. **Unity Engine**

The Unity Software developed the Unity Engine which democratizes game development and enhances the interactive 2-D and 3-D content, making it more accessible. Unity Engine provides software-development platform tools to Augmented Reality developers and a unified workflow across devices. One of the core features of the AR Foundation framework is the ‘ARCore’. Its SDK was used to build the Labyrinth Maze AR Application to seamlessly blend the digital images to the physical world. ARCore allows the mobile device to sense the environment and interact with the information in the real world. Unity Software has also been used to deploy the implemented application on an Android mobile device.

* + 1. **Vuforia Engine**

Vuforia Engine is a software development kit (SDK) for developing Augmented Reality applications. Vuforia Engine supports AR application development for various devices such as Android, iOS, Lumin, and Universal Window Platform (UWP).

In this project, Vuforia Engine has been used to simply add advanced computer vision functionality to the Labyrinth Maze mobile application. This allows mobile devices to easily recognize images and objects (Maze in this case) and interact with spaces in the real world.

The Vuforia Engine SDK easily integrates with the Unity Software adding the support of ‘ARCamera’ to Unity. ARCamera is a Unity Game Object that includes the Vuforia behaviour to the software adding the support for augmented reality applications for both digital eyewear and handheld devices.

* + 1. **Blender**

Blender is an open source 3-D computer graphics software used for creating, modelling, simulation, rigging, rendering, motion tracking, game creation, etc. Blender software has been used to create a 3-D model of the Labyrinth Maze design of the project. Blender is capable of converting any image from 2-D to its corresponding 3-D Model.

The 3-D model of the Maze created in Blender is used in Unity Engine to augment the 3-D model over the 2-D image of the maze.

* 1. **Implementation**

This sub-section includes a brief description all the images, objects, logics, and functionalities implemented during the course of the project. These objects and functions play a vital role in the implementation and performance of the application.

* + 1. **Game Objects**

In the implemented project, there are four main game objects that render upon the image target. They are base plane, 3-D maze model, game ball, and teleportation holes.

**Base Plane**

The base plane object renders directly at the level of the image target. It acts as a plane of reference for all the other objects in the application. The base plane ensures that the ball, 3-D maze model, and the teleportation holes directly render at the certain level to prevent unexpected errors and provide a smooth working interface.

**3-D Maze Model**

This is the 3-D Model on the maze in the database developed using Blender. It renders directly at the level of the base plane and acts as a barrier to prevent free movement of the ball. Thus, allowing the ball game object to move only through the white passage between the black walls.

**Game Ball**

The Game Ball is one of the most important game objects of the AR Game. The ball Game Object has been defined as a Rigid Body. It enables the ball to move under the control of physics. A Rigid Body type of Game Object in Unity can receive forces and torque to make the objects move in a more realistic way. A Rigid Body can be influenced by gravity, act under added forces via scripting, etc. This enables the ball in the maze to move through tilting.

**Teleportation Holes**

Teleportation Holes have been added to the Maze design for additional fun and engagement. There are four total holes in the maze. Two of these holes are inputs whereas the other two are outputs to the corresponding input holes. Whenever the ball’s mesh overlaps with the holes’ mesh, the ball is teleported to the output hole. This feature has been implemented using the C# script in Unity.

# **Evaluation**

A mobile application has been developed as the end result of the project. The application has been evaluated based on the accuracy of ball movement and the rendering smoothness of the game objects on the image target.

* 1. **Results**

The APK was downloaded through the Unity Engine to run the application on an Android mobile device. The AR Labyrinth Maze game was tested using 3 different Android mobile devices. In all these cases, the objects were smoothly rendering on the image target. The ball in the game was also moving smoothly in all the devices following the rules of physics. However, when the image target was being tilted more than 90 degrees, the ball was falling off. To rectify this problem, a new transparent plane was inserted at the top on the 3-D maze model. This prevented the ball from falling off. Additionally, the teleportation holes in the maze were accurately performing their functions.

* 1. **Limitations**

Although the implemented AR Game fulfils all the requirements proposed at the beginning of the project, there are certain limitations to the game.

Firstly, the application requires the image target to be stable with minimal movements to properly render the game model on the maze. And secondly, proper lighting is required for the application to render the 3-D model on the maze properly. The application is also limited to a single maze design for the designed AR Game and would perform no actions for any other maze design.

* 1. **Future Work**

The implemented AR Project could be further extended in the future with many functionalities.

The first possibility would be to enable the project to model any maze design from 2-D to 3-D for users to be able to play the game with any maze design. The project could also implement a feature to capture the image of the maze which will then be converted to a 3-D model and can be played in future.

# **Conclusion**

There have been similar games developed in the past but many of them use Virtual Reality to render the game. This AR Game project is kind of unique but is currently limited by many factors and functionalities. The game might not be fun to play at this moment due to the limitations and the fact that the gam would require users to hold their mobile devices in one hand and tilt the maze from another hand to play the game but with the advancement of technology in Augmented Reality devices like digital eyewear, e.g. HoloLens will improve the game experience extensively.

Games powered through Augmented Reality could be very beneficial as they would improve interactions between games and humans as well as make these applications more intriguing and engaging.

# **Appendix**