



INDIAN INSTITUTE OF TECHNOLOGY, BOMBAY

RESEARCH & DEVELOPMENT PROJECT
CS - 490

Capture The Flag - An AR Game

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1 Introduction

Augmented Reality can be utilised for wide range of activities, including education, advertising, gaming and what not. Augmenting virtual 3D models on real life objects provides the user a new dimension. This is particularly useful when a user wants to have a better understanding of the spatial nature of either the virtual or the real world. Several Augmented Reality Games and applications are being tested and used worldwide.

This project focuses the attention to Augmented Reality Games. In a traditional Map based game (including Age of Empires, League of Legends) the characters move in a virtual world, of which, we have a very limited control. In these games we are only free to decide one of the available maps. We do not have the freedom to choose, for example, the position of a particular hill or a forest. This Augmented Reality Based Game tries to address this issue by enabling user to create and play in whatever map the user wants. This is a Multiplayer game where one of the player has the freedom to decide the map and the location of each and every game object. And correspondingly, the opponent will try to complete the level using another set of available game objects.

2 Literature Survey

There are several AR based game built to address very specific requirements. In [1], the authors used an Augmented Reality based game to access upper motor dysfunction. On similar lines, [2] built an AR game for defense training purposes.

Some other applications of Augmented Reality are also available. One such application is discussed in [3] where AR is used to display information from mobile phones. This effectively increases the visible area of the screen. For our application of developing an AR Game, a survey of current games in AR was also done extensively. Some of the relevant games which already exists in AR are pointed below with a brief description of the same.

- WallaMe: This is an AR based game where hidden messages and emojis can be put on Geographical Locations and would pop up to the recipient if he scans that wall.
- ARrrrrgh: An environment dependent game. The room is converted to a level and the player has to shoot at the incoming birds.
- Sharks in the Park: Simple AR app for kids. You have to go near schools of fish to get points and run away from sharks to avoid death. Geo-AR used. Everyone can see the same set of fishes and sharks.
- Nightenfell: Based on Shared AR. Team up and shoot comets and protect your territory.

3 Project Description

3.1 Softwares and Packages

- **Unity 2018.3.2f1 Personal** for Game Development, Level Design, Physics Engine etc.
- **Vuforia Engine 8.1.7**, an Augmented Reality SDK, used for Image Targets Detection, Board area formation, and Game Objects placement.
- **Android 8.1.0** for testing and deploying.

3.2 Image Target Management

Printed version of QR Codes are used as Image Targets for most of the Game Objects, except in one case where a printed photo of a Time Bomb is used as Image Target.

QR Codes are generated using an online tool. The QR Codes are then printed and then a photo of the printed Image Marker is taken (with the same device which is used to play the game). The captured image is then uploaded in blueVuforia Target Manager. All the Image Targets had a lot of feature points and were rated “Easily Augmentable” as per Vuforia Ratings. The Vuforia Database is then downloaded and imported in Unity and then can be used directly. The ready to print Image Target can be downloaded from here.

3.3 Game Description

The objective of the game is to capture a flag put anywhere on the map. This is a **2-player game** where one person designs the map and the other player has to reach the destination starting from a place decided by the level designer. This task is to be completed within one minute. The other person can use mobile joystick to move the player. In the game scene, we have a **Staircase** for climbing in case the Destination is in different plane than the Origin. Also, there is a **Time Bomb** which explodes at a random time instant. If the player is within a radius to the Bomb, he dies and the game ends.

3.4 Game Components - Level Design Mode

Level Design scene is easy to learn and use. A Level Design scene is split into 5x5 grid (can be easily extended to more grids). It has the following features.

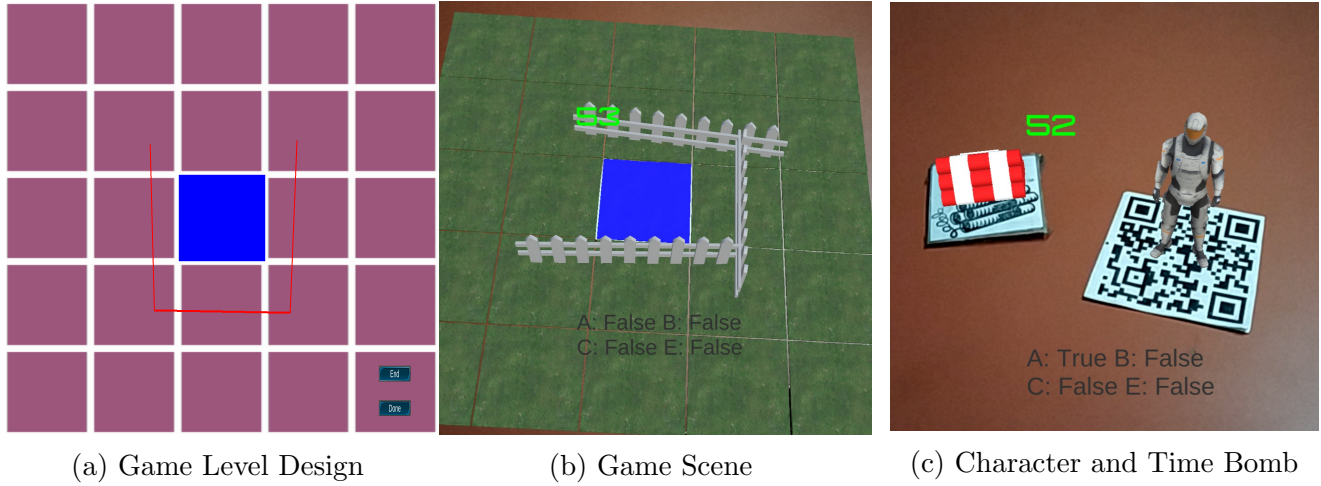


Figure 1: (a) shows the designed game level. (b) is the corresponding scene constructed from the design chosen in the Game Design Scene. (c) shows the character 3D model and the Time Bomb model

3.4.1 River Block Placement

Out of the 25 grids available, the level designer can choose at max 10 of these grids to represent water block. A water block can be selected by simply clicking on the grid while the “Draw Wall” button is not active. 1a shows an example selection of water blocks.

3.4.2 Drawing Walls

Upon activating the “Draw Wall”, the level designer can create walls which will correspond to a fence in the Game Play where the soldier cannot pass. Upon clicking on the screen, a Red Line appears between two successive clicks representing a wall. This can be deactivated by pressing “End”. 1a shows an example scene with river blocks and walls marked. To proceed to the Player Scene “Done” button needs to be clicked.

3.5 Game Components - Player Mode

3.5.1 Setting up the Scene

All the Level design parameters needs to be imported properly in this scene. This is done using *PlayerPrefs* package in Unity. This stores a variable while going from one scene to another. Hence, the position of River Blocks, and their count, along with Wall Positions and number of Walls is stored and then fetched while in the new Scene. There is a center image target which corresponds to the middle grid in the Level Design scene. All the rivers and walls are made relative to this reference

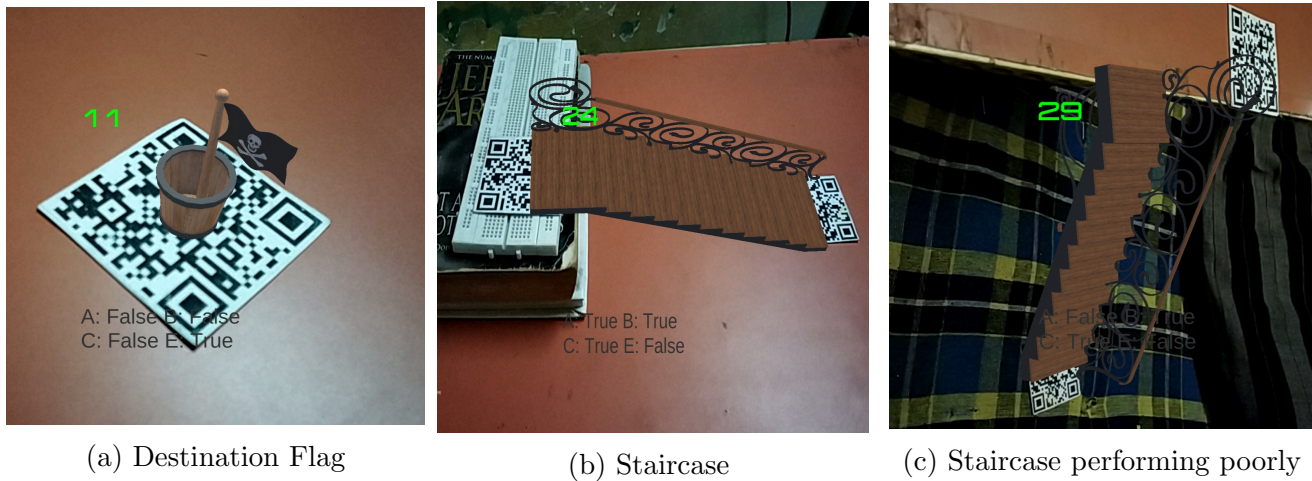


Figure 2: (a) shows the destination 3D model. (b) is the staircase where the height difference is perfectly handled by the staircase. while in (c) it is incorrectly oriented. This is separately discussed in Challenges section

image target. By default, all the non-river blocks are covered with green grass. The blocks with river is represented by a similar dark blue rectangular patch.

3.5.2 Starting Point

A specific Image Target corresponds to the starting position of the character in focus. As soon as this image target gets detected, a character gets augmented and can be controlled using the Mobile Joystick. There are three animations possible in the character - Idle, Walk and Die. These three animations are used in different part of the game play.

3.5.3 Time Bomb

A time bomb is bind to an Image Target. The bomb explodes randomly between 10s and 20s from the start of the game. The explosion creates a loud noise. If the character happens to be within a certain radius of the bomb, the character dies and the Game is lost.

3.5.4 Staircase

There are two image targets which handles staircase. First is the staircase base and the other is staircase top. The staircase appears if both the image targets are present in the scene. The height of the staircase is proportional to the relative height of the top marker with respect to the base marker. The height is determined by fitting a straight line in the observed values of staircase 3D model's



(a) Correctly oriented 3D Model (b) Incorrectly oriented 3D Model (c) Multiple targets detect in one

Figure 3: (a) shows the expected orientation of the character while (b) is the erroneous orientation that is observed. In (c) we can see that the AR Camera has detected the shown image target to be both Start and the Destination.

height and the relative height between the two markers. This produces a satisfactory link between the staircase model height and the relative position between image target.

3.5.5 River Blocks and Walls

River Block and Wall positions are fetched from the Level Design scene. In this scene, it is ensured that the character is not allowed to pass through the Walls and the River Blocks. Hence the character is neither allowed to walk through river nor through walls.

3.5.6 Destination

The destination image target block has a flag which needs to be captured, as the part of the game. Once the character reaches the destination image target, a pop up button appears which reads “Capture”. Upon clicking the button, it takes a couple of seconds to capture the flag. Upon successfully completing this, a Game Won screen appears. If the player goes far off which capturing the flag, the game continues and the player needs to start the process all over again.

3.6 Challenges during Development

3.6.1 Ambiguous QR Codes

In Vuforia, an image target’s feature point is detected based on the edges in the image. The QR Code typically has a lot of them. Although in Vuforia’s target manager two image targets (say A

and B) were highly augmentable, it is observed that B gets detected while A is shown to the camera and vice versa. Sometimes both A and B got detected when only one of the two QR Code is shown to the Camera.

3.6.2 Staircase Height Issue

In the preceding section about staircase, it is mentioned that the relation between 3D staircase model's height and the relative distance between the base and the top is calculated using Linear Fitting. This, however does not always produce good results. This irregularity is also due to the camera position and orientation. Hence moving to other methods of fitting would also not produce accurate results.

3.6.3 Bad orientation of 3D Models

Sometimes it is observed that the 3D model does not behave as expected when the image target is tilted or moved. This is a known issue in the Vuforia package.

4 User Results

Lastly, the complete game is tested on users to analyze the performance of the game. For this analysis **16** students (13 boys, 3 girls) from IIT Bombay were asked to play this game in groups of two. Then they were asked to fill a questionnaire in a Google Form ([link](#)).

Students were asked to answer a question with a number from 1 to 5, which respectively signifies Strongly Disagree, Disagree, Neutral, Agree and Strongly Agree.

First set of question contains general questions about the game play while the second set of questions is about the game design. The mean and standard deviation of the ratings are tabulated below.

General Questions	Mean Score	Standard Deviation
This AR Game is easy to learn.	4.9375	0.25
The User Interface is good.	4.625	0.62
All the Game Elements are clear and easy to understand.	4.75	0.45
The interaction of game elements and AR elements is good.	4.625	0.96
The movement of the game element is comfortable with the help of mobile joystick.	4.375	0.96
The game caused stress in my eyes.	1.25	0.45
The performance is good and there is no delay in the rendering of game elements.	4.875	0.341
The current game is better than a non-AR game of the same game concept.	4.56	0.63
The relative size of Image Markers, 3D Models and Device is comfortable to use.	4.5	0.82
The current prototype of capable of replacing traditional Video Games.	3.875	1.024

Level Design Questions	Mean Score	Standard Deviation
The Level Design scene is easy to learn and design.	4.875	0.341
The two components - River Block and Staircase adds the desired complexity to the game.	4.562	0.89
The game design components translate nicely to the scene in Game Play mode.	4.81	0.543
The current grid size of 5x5 is enough.	3.56	1.093

References

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