

**MULTI-MARKER TABLETOP AUGMENTED REALITY FOR
ANAMORPHIC ILLUSIONS
USER MANUAL**

A Thesis Proposal
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by

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Chapter 1

Introduction

This application is a mobile marker-based augmented reality (AR) anamorphic puzzle game. It uses the concept of anamorphic illusions to produce levels that can be solved by moving the camera physically. It also implements the ability to track multiple AR markers, allowing players to customize their play area.

1.1 System Requirements

1.1.1 System Summary

The application works stably for low-end mobile devices. The application requires installation to the mobile device, and needs the prescribed markers to enable gameplay.

1.1.2 System Configuration

The application operates on a mobile device with Android OS 6.0 or newer. The application was developed with Unity, Vuforia and C. For smooth gameplay, it is recommended that the mobile device running the application runs Android OS 8 or newer at least 4GB of RAM, at least 512MB of free storage space, and a rear camera with a resolution of at least 8MP.

1.1.3 User Access Levels

Everyone can use the application. The application does not contain sensitive content.

1.1.4 Contingencies

When the application registers an AR marker for the first time, the puzzle may be distorted in an unsolvable state. The provided refresh button on the right of the screen will allow the application to register the marker again. After extended usage, the application may also become unresponsive. In this event, it is recommended that the application be forced to close through the mobile device's application manager.

1.2 Installation

1.2.1 Where to Download the Application

The application APK installer is available and can be downloaded from the public Google Drive link:

<https://drive.google.com/file/d/1a8SvaJIMOKkWCw5iGp4qtlfQbK-LDMFD/view?usp=sharing>.

1.2.2 Installing the Application

Running the APK file in your mobile device will open a confirmation screen. Confirm and wait for the installation to finish. It may be necessary to enable "Allow installation of from unknown sources" in your device's privacy or security settings to proceed with the installation.

1.2.3 Running the Application

After installation, the application can be ran by tapping on the Unity logo thumbnail with the name "THS-ST3 Anamorphosis" in your device's home screen or applications gallery. When the application is first run, it will ask for permission to access your device's camera. This is a necessary permission required to enable gameplay. It is recommended to select "allow all the time" for this permission.

1.3 Physical Components

The application uses 4 AR markers to allow players to view the sculptures in the game level. These 4 markers show a pebble design, asphalt design, wood chips design, and grass design. These marker designs are required cannot be substituted for.

1.3.1 Asset Download

The 4 AR marker images are available and can be downloaded as PNG or as a collated PDF from the public Google Drive link:

<https://drive.google.com/drive/folders/1Fs21pRTjLs5-4XAQPKDOB3DL7kl0gNBz?usp=sharing>.

1.3.2 Printing

The markers are recommended to be printed on paper with dimensions at least 19cm long and 10.7cm wide. The prints are required to be in color. The player may print the markers on board paper or paste the paper markers on more rigid material for easier manipulation.

Chapter 2

Getting Started

2.1 Interface

The system has a total of nine functional buttons, all spread across three different screens, the main menu, level selection, and game proper. These buttons are the main start and exit buttons, level buttons, help button, exit button, refresh button, box toggle button, play again button, and the exit level button.

2.1.1 Main Menu

The main start and exit buttons as well as the help button are present in the main menu screen. In the main menu, the user has the option to either start, exit, or check out the instructions of the application. Clicking on the help button at the top right corner of the screen will prompt a help panel to pop up with the instructions as well as the mechanics of the game to guide the user on how the game works. This can be seen in Figure 2.1. Once the user is ready to play, they can simply click on the start button and it will redirect them to the level selection page.



Figure 2.1: (left) Main menu with start, exit, and help button. (right) Help panel showing the instructions for the game.

2.1.2 Level Selection

The game has 10 levels available to play, each one with a different anamorphic model that the user will have to solve. In the selection screen, each level is displayed as the complete model that will be present in that specific level so that the user will have an idea of what it is they are trying to solve for in each level. Clicking on any of these buttons will lead the user to the level that they selected.



Figure 2.2: Level selection screen showing a preview of each puzzle that can be solved.

2.1.3 Gameplay Proper

Upon entering a level, the user is presented with a screen that shows their camera along with four interactive buttons. The refresh button allows the user to recalibrate the camera in the instance that the virtual object is not positioned where it is supposed to be. The box toggle button at the bottom right corner of the screen simply toggles the bounding box on and off, allowing the user to hide the box if they want to see the play area more clearly and turn it back on if they want to see the bounds of the anamorphic model.



Figure 2.3: (left) Game proper screen with one marker in the scene, showcasing the dragon level. (right) Help panel showing the instructions for the game within the game proper.

2.1.4 Endgame Screen

Upon solving the puzzle, the model becomes whole and turns into gold to show that the puzzle has been completed. At the time of completion, the timer at the top of the screen stops as well, and

fireworks go off in the background, indicating that the puzzle has successfully been solved. After a 3-second delay, a win pop-up will appear, congratulating the user as well as showing the total time it took for them to solve the puzzle. The win pop-up has two buttons, allowing the user to either play again or exit the level. Clicking on the play again button resets the level and sets the timer back to 0 while clicking on exit level redirects the user to the level selection screen.



Figure 2.4: Results panel showing the total time it took to solve the puzzle.

2.2 Gameplay Rules

This application involves solving 3D anamorphic puzzles by moving the physical camera around the broken sculpture tracked on the AR marker. The sculptures are broken into slices, then each slice is distorted to look like how it was originally when viewed only from a single position. The player physically moves the camera around to find this position where the broken sculpture looks whole and complete. Upon finding this position, the puzzle is considered solved. The time elapsed is tracked, but there is no time limit to the puzzle so players can play the game at their own pace.

Chapter 3

Modules

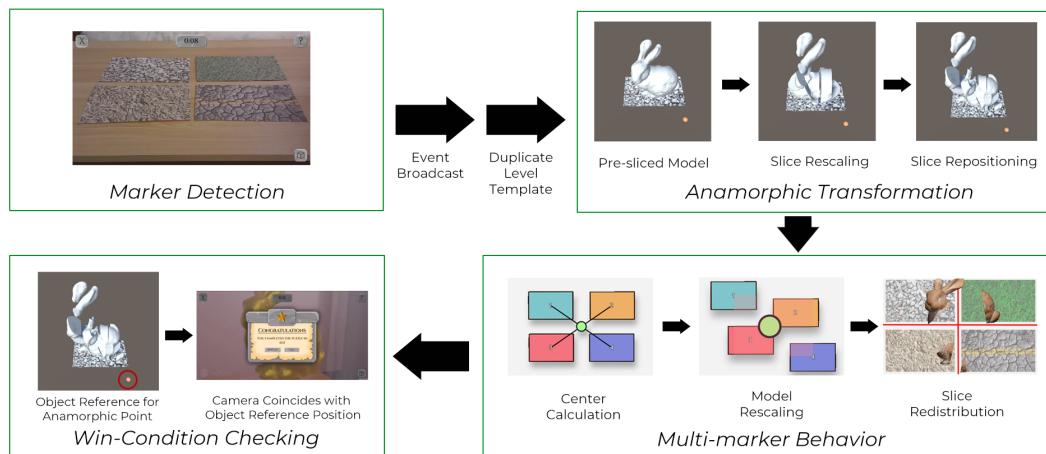


Figure 3.1: System framework for implementing the multi-marker augmented reality application for solving anamorphic puzzles

The application tracks a variable number of markers and renders a corresponding game puzzle using anamorphic illusions. The application performs this through four primary modules: Marker Detection, Anamorphic Transformation, Multi-marker Behavior and Win-Condition Checking.

3.1 Marker Detection

In Marker Detection, the application counts how many markers are visible to the camera, determines what specific markers these are, and determines their positions relative to one another. These information are necessary parameters for the other modules, and are broadcast to them through the event system.

3.2 Anamorphic Transformation

In Anamorphic Transformation, pre-sliced models undergo transformations in scale and position to achieve an anamorphic effect. These transformations are referenced from a constant point, which serves as basis for the win condition. Transformations are also random and dynamic so that repeated playthroughs of the same level don't look the same.

3.3 Multi-Marker Behavior

In Multi-marker Behavior, the anamorphic sliced model produced by the previous module is positioned and scaled depending on the number and position of the markers. Slices are then distributed and parented to the appropriate markers.

3.4 Win Condition Checking

In Win-Condition Checking, the application constantly checks whether the camera coincides with the solution point from which anamorphic transformation was referenced, provided a margin of error. When it is, an event is broadcast telling the other modules that the puzzle has been solved, completing a cycle of the application's the gameplay loop.