WEST UNIVERSITY OF TIMIŞOARA
FACULTY OF MATHEMATICS AND COMPUTER SCIENCE
BACHELOR: Computer Science in English

BACHELOR THESIS

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GRADUATE:
Sorin-Ionuţ Rosalim

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Development of a Mobile Augmented Reality (MAR) application as an interactive tool

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Abstract

In today's world, technology is everywhere; we use it to communicate, to learn and to discover new things in order to improve our lives. This paper presents a novel approach to the problem of augmenting the real world with digital content for entertaining or didactic purposes. We propose a new method to access digital content using Quick Response (QR) codes, present a proof of concept of our approach, and discuss the potential of Augmented Reality (AR) as an interactive tool for learning and discovering new things. This thesis theme is the development of an Android mobile application called RealityEnhance. The application aims to augment the real world with digital content through the user's smartphone. RealityEnhance gives its users the power of an enhanced perception of their surroundings to discover and interact with digital content.

În lumea de astăzi, tehnologia este peste tot; o folosim pentru a comunica, pentru a învăța și pentru a descoperi lucruri noi pentru a ne îmbunătăți viața. Această lucrare prezintă o abordare nouă a problemei îmbunătăţirii lumii reale cu conținut digital în scopuri de divertisment sau didactice. Propunem o nouă metodă de accesare a conținutului digital folosind coduri QR, prezentăm o dovadă de concept a abordării noastre și discutăm potențialul realităţii augumentate ca instrument interactiv de învățare și descoperire de lucruri noi. Urmărim dezvoltarea unei aplicații mobile pentru Android numită RealityEnhance. Aplicația își propune să îmbunatăţească lumea reală cu conținut digital prin intermediul smartphone-ului utilizatorului. RealityEnhance oferă utilizatorilor săi puterea unei percepții îmbunătățite asupra mediului înconjurător pentru a descoperi și a interacționa cu conținut digital.1

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Chapter 1

Introduction

1.1 Project Theme

Augmented Reality is a technology combining the virtual and physical worlds, allowing digital content to be added on top of the physical world. AR relies on device sensors to detect the users' surroundings, position and orientation. QR codes are a type of barcode; they are predominantly used to store information such as text, links, and images and are easy to share.

By combining these two technologies, we can create a new way of accessing digital content and interact with newly accessed information in the real world. This technology gives users the power of enhanced perception while accessing digital content that can be used for entertainment or didactic purposes.

1.2 Theme Relevance

The topic of AR is relevant because it can be implemented and used in a multitude of domains. This technology is already used in the following domains:

- 3-dimensional (3D) printing - AR is used to visualise the 3D model of the object that will be printed.
- Architecture - ARis used to visualise the 3D model of a building or a house.
- Automotive - AR is used for navigation and to display map information.
- Publicity - AR is used to lunch novel marketing campaigns and interact with digital content.

Augmented reality is an interactive experience that recently became more accessible to the world with the help of the smartphone. Most smartphones have the necessary hardware to run AR applications. This AR applications give their users a new perspective on the digital content that they are accessing.

QR codes are two-dimensional matrix barcodes that are easily scanned by a smartphone camera. They were first used for tracking parts in vehicle manufacturing. Nowadays, they are used in a wide variety of domains, such as:

- Virtual stores - QR codes are used to display information about the products.
- Online payments - QR codes are used to store payment information.
- WI-FI access - QR codes are used to store WI-FI access information.
- Augmented reality - QR codes are used in some AR applications to determine the positions of objects in 3D space.

1.3 Project Aim

The AR topic was chosen because this technology has many applications in different fields. The immersive experiences of AR allow people to do interactive activities.

The goal is to develop a highly functional mobile application that utilises AR and allows users to scan QR codes and interact with 3D models.

The application will be developed for the Android platform using the Android Studio IDE and Google's ARCore SDK. Also, the Google Buckets service will be used to store the 3D models and the QR codes. It will have a simple and intuitive user interface and will provide a interactive function for some of the 3D models. The interactive function will be a simple animation or a different state of the 3D model that will be triggered by the user's touch input. It will provide users with a new way of accessing digital content and interacting with it, giving them the possibility to build, learn and discover the digital content that they are accessing. Also, the application will be tested on multiple Android devices to ensure compatibility and it will be published on the Google Play Store.

1.4 Author's contribution

My contribution is applying my knowledge and experience to develop a mobile application that uses the Google ARCore SDK module, a QR code scanner and the Google Buckets service.

By integrating these technologies together, I have created a new way of accessing digital content and interacting with it. The application will give users the power of an enhanced perception of their surroundings to discover and interact with digital content through their smartphone.

The application is able to load the interaction module specific for each 3D model. The interaction module will be a simple animation or a different state of the 3D model. For example, if the 3D model is a LEGO car, the interaction module will be a simple guide for assembling the LEGO car. If the model is related to a geometrical shape, related to the school geometry curriculum, the interaction module will display a different perspective of the 3D model, for example, if the 3D model is a cube, the interaction module will display only the cube's edges.

Chapter 2

Related Work

2.1 Related writings

Deeper Learning With QR Codes and Augmented Reality: A Scannable Solution for Your Classroom

In the realm of education, the integration of technology has revolutionized teaching and learning processes. This article explores the immense potential of AR, and QR codes in the context of education. Drawing inspiration from Monica Burns' book "Deeper Learning With QR Codes and Augmented Reality: A Scannable Solution for Your Classroom", we delve into how AR and QR codes can enhance learning experiences and engage students in interactive educational content.

AR offers a unique opportunity to create immersive and interactive learning environments. By overlaying digital content onto real-world objects, AR provides students with a dynamic and engaging platform for exploration. As Monica Burns highlights, AR can be likened to a "window to interactive learning" [Bur16]. Students can unlock a wealth of three-dimensional models, virtual objects, and multimedia resources through trigger images, such as posters or activity sheets. By scanning these triggers using smartphones or tablets, students are transported into a world where knowledge comes to life.

Educators worldwide have embraced AR as a powerful tool for instructional design. Teachers can seamlessly integrate AR into their lessons by leveraging AR apps and printing corresponding trigger images. For instance, using an Augmented Reality (AR), students can explore the intricacies of the human body by scanning large posters of anatomical models. As Burns emphasizes, using AR captivates students' attention and provides a unique opportunity to interact with and deepen their understanding of content [Bur16].

Unleashing digital resources alongside AR, QR codes have become an efficient way to connect physical and digital resources. By scanning these codes using mobile devices, students gain instant access to a wealth of online content. With a simple scan, QR codes can link students to websites, videos, interactive quizzes, and other digital resources, expanding their learning beyond the confines of traditional materials.

QR codes have become a versatile tool in the classroom, empowering teachers to deliver digital content seamlessly. Educators can create QR codes to supplement lessons, provide additional resources, or foster independent research. Students can

embark on self-directed learning journeys by incorporating QR codes into lesson plans, exploring personalized content, and engaging in collaborative projects. The ease of use and immediate access to digital resources make QR codes invaluable in modern classrooms.

Integrating AR and QR codes in education holds tremendous potential for transforming learning experiences. Educators can foster engagement, deepen understanding, and inspire lifelong learners by immersing students in interactive virtual worlds and providing access to vast digital resources. As we embrace Monica Burns' notion of "tasks before apps," we must approach these technologies with clear pedagogical objectives [Bur16]. By strategically integrating AR and QR codes, we can create meaningful and impactful learning experiences that prepare students for success in a technology-driven world.

2.2 Related apps

Snapchat

Regarding AR applications, Snapchat [Inc11] stands out as a platform that pioneer the use of AR and revolutionises how we create, explore, and play with the digital content. By harnessing the power of their AR module and, Snap AR [Incb] enables users worldwide to scan their surroundings and discover valuable information. With just a tap on the Camera screen, the AR Bar unfolds.

What sets Snapchat AR apart is its commitment to accessibility. The introduction of the Web Lens Builder and Lens Studio tools has democratised the creation of AR Lenses, making it easier for aspiring creators to bring their visions to life. Moreover, Snapchat has embraced the incorporation of real-world physics and real-time data integrations, elevating the realism and immersion of their AR experiences to new heights.

Snapchat AR has a wide range of special Lenses, each offering a distinct and captivating visual experience. From playful animations to informative overlays, the creative possibilities are endless. It also has a diverse collection of filters that can be applied onto the user's face. These filters can be used to enhance the user's appearance or transform them into a variety of characters. The filters are updated regularly, ensuring that users have access to a wide range of options.

Despite its notable contributions, Snapchat AR does have its limitations. A consistent internet connection is imperative to browse for new lens and filters, which may prove challenging in certain circumstances. Additionally, while Snapchat AR offers a compelling experience, it needs to improve in terms of functionality when compared to more specialised AR applications.

Pokemon Go

In mobile gaming, Pokemon Go has become a global sensation by leveraging the power of AR. The game's AR+[Inca] mode takes the concept of AR to new heights by seamlessly merging the Pokemon universe with the player's real-world surroundings. Through this innovative approach, Pokemon come alive and appear anchored to the user's environment, providing exciting opportunities for a interactive gameplay experience.

In AR+ mode, Pokemon Go brings an added layer of realism to the gameplay experience. Players can approach, walk toward, or even move around these digital creatures by fixing Pokemon to specific points in the real world. The Pokemon in AR+ mode possess an uncanny awareness of the player's proximity and movement, requiring strategic and cautious approaches to maximise successful encounters.

In contrast, the AR mode in Pokemon Go detaches Pokemon from the real-world environment, lacking the anchor points and awareness of the player's location and movement found in AR+ mode. The enhanced AR features in Pokemon offer players a captivating and dynamic experience. As they explore their surroundings, Pokemon seemingly inhabit their world, creating magical moments for excellent throws and captivating photos. The fusion of AR with the beloved Pokemon franchise has captivated millions of players worldwide.

Like Snapchat AR, Pokemon Go relies on a consistent internet connection to enable the AR features. This requirement may pose challenges in situations where a stable connection is unavailable. Additionally, the GPS needs to be enabled to play Pokemon Go, which may drain the battery life of mobile devices. Despite these limitations, Pokemon Go has become a global phenomenon, demonstrating the power of AR in mobile gaming.

Chapter 3

Application description

3.1 Architecture

The application will be developed using the Android Studio IDE. The application will be developed using the Java programming language. The application will use the Google ARCore framework[Goo]. The application will use the Firebase cloud database to store the models. The application will use the QR code reader to import the models. The application will use the Google Vision API to recognize the QR code. As shown in Figure 3.1, the architecture of the application consists of...

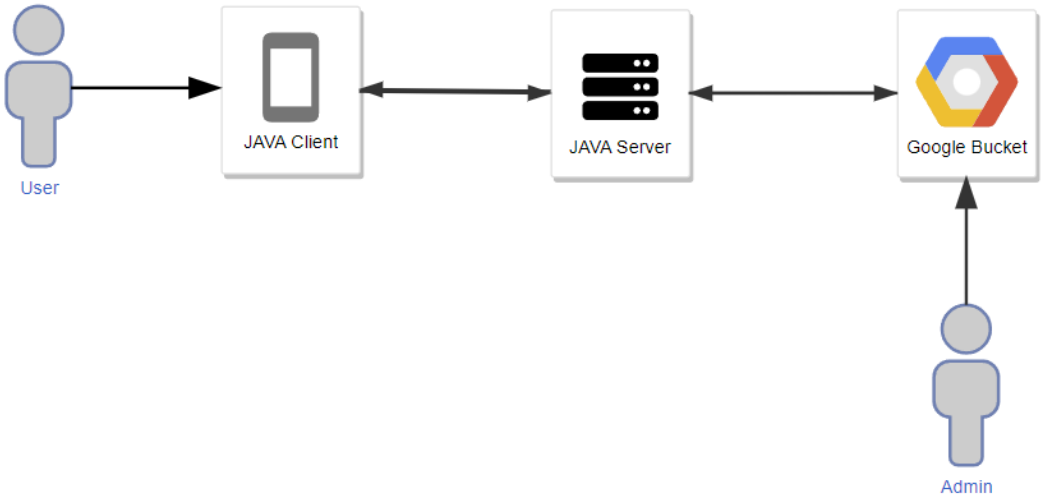

Figure 3.1: Architecture

- **Android Version 7.0+** - to use the application on the phone
- **Android Studio** - IDE for Android development
- **Firebase** - Cloud DataBase for where the models will be retrieved
- **Java** - Programming language

- **Google ARCore** - AR framework

3.2 Diagrams

Class Diagram

As shown in Figure 3.2, the class diagram of the application consists of the following main classes: MainActivity, QRActivity and LibraryActivity.

The MainActivity class is the main class of the application. It is the first class called when the application is started, and it is responsible for the AR mode. It contains methods dedicated to interacting with the 3D models (moving the model, rotating the model, scaling the model).

The QRActivity class is responsible for the QR code reader. It has a method called when a QR code is scanned and verifies if it is valid. It will check if the model is already imported. If the model is already imported, it will load it from the local storage; it will also request the Google Bucket Storage.

Lastly, the LibraryActivity class is responsible for the list of models and the loading of the models.

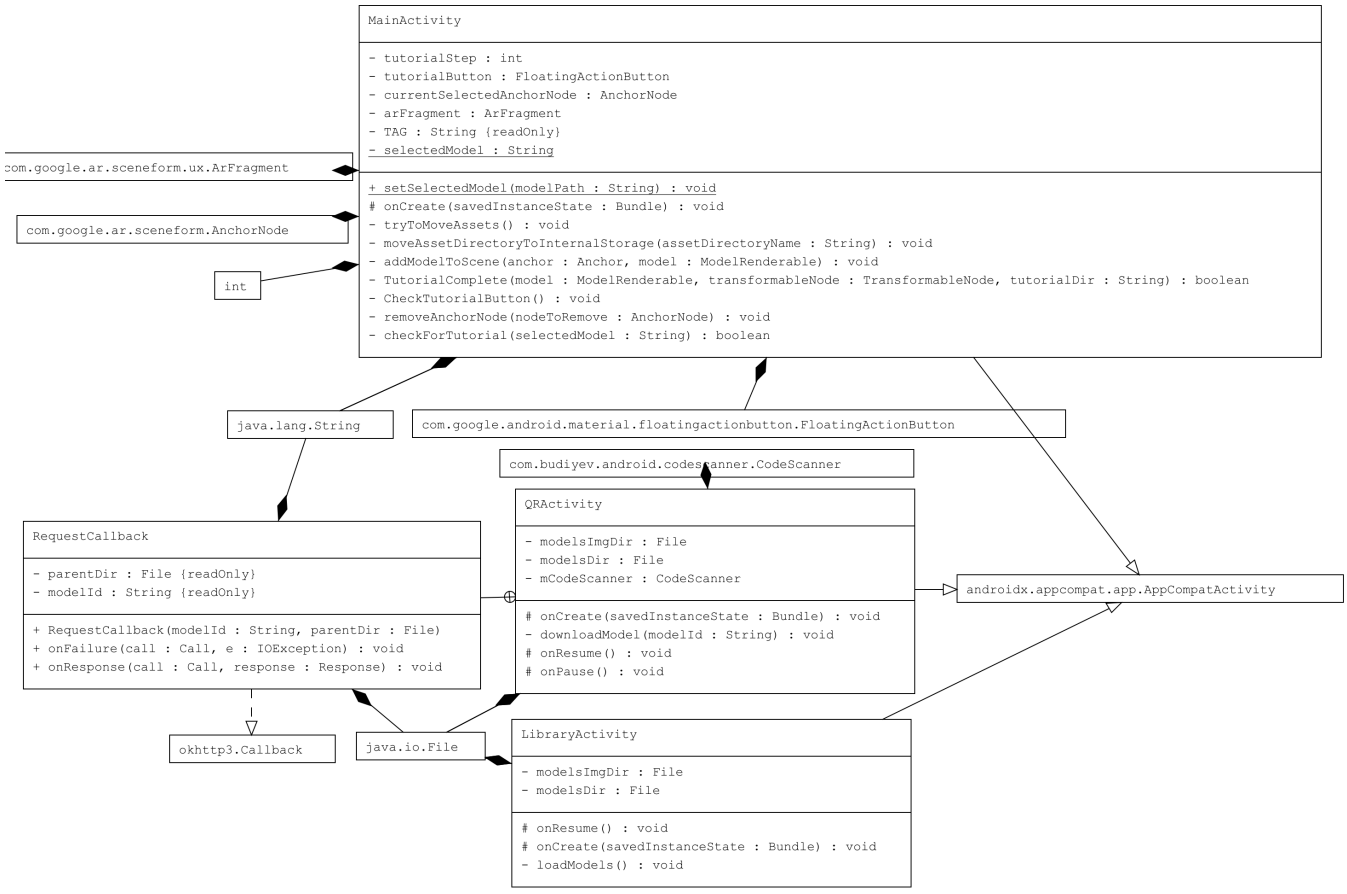

Figure 3.2: Class Diagram

Use Case Diagram

By looking at the Use Case Diagram in Figure 3.3, we can see what the user is able to do inside the application. RealityEnhance allows the users to scan a QR code load or to import a new model. It also gives users the power to interact with the 3D models in the AR mode. The users can also browse a library of already imported models.

The ability to interact with the 3D models is a very important feature of the application. It allows the users to see the models from different angles and to change the size, orientation and position using familiar gestures. It also gives users the possibility to remove a selected model that is already placed in the AR scene.

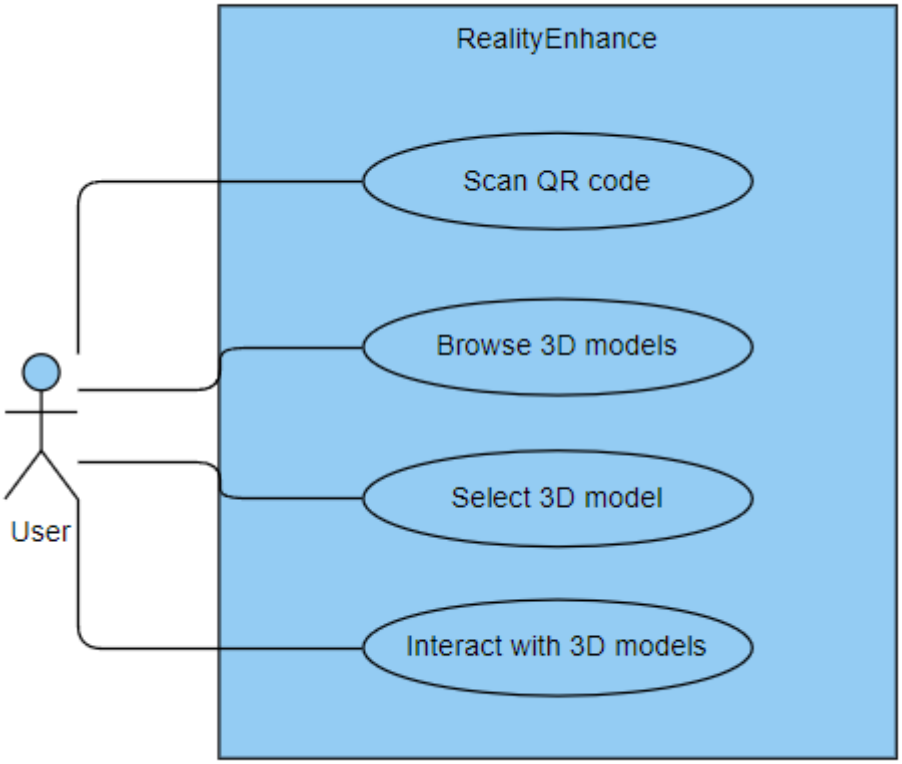

Figure 3.3: Use Case Diagram

Sequence Diagram

The Sequence Diagram in Figure 3.4 shows the interaction between the user and the application. The user starts the application and is presented with a prompt that will request permission to use the camera. After that, the AR module will begin to scan the user's surroundings in order to map the environment. For importing a new model, RealityEnhance uses a QR code scanner that will check if the code is valid.

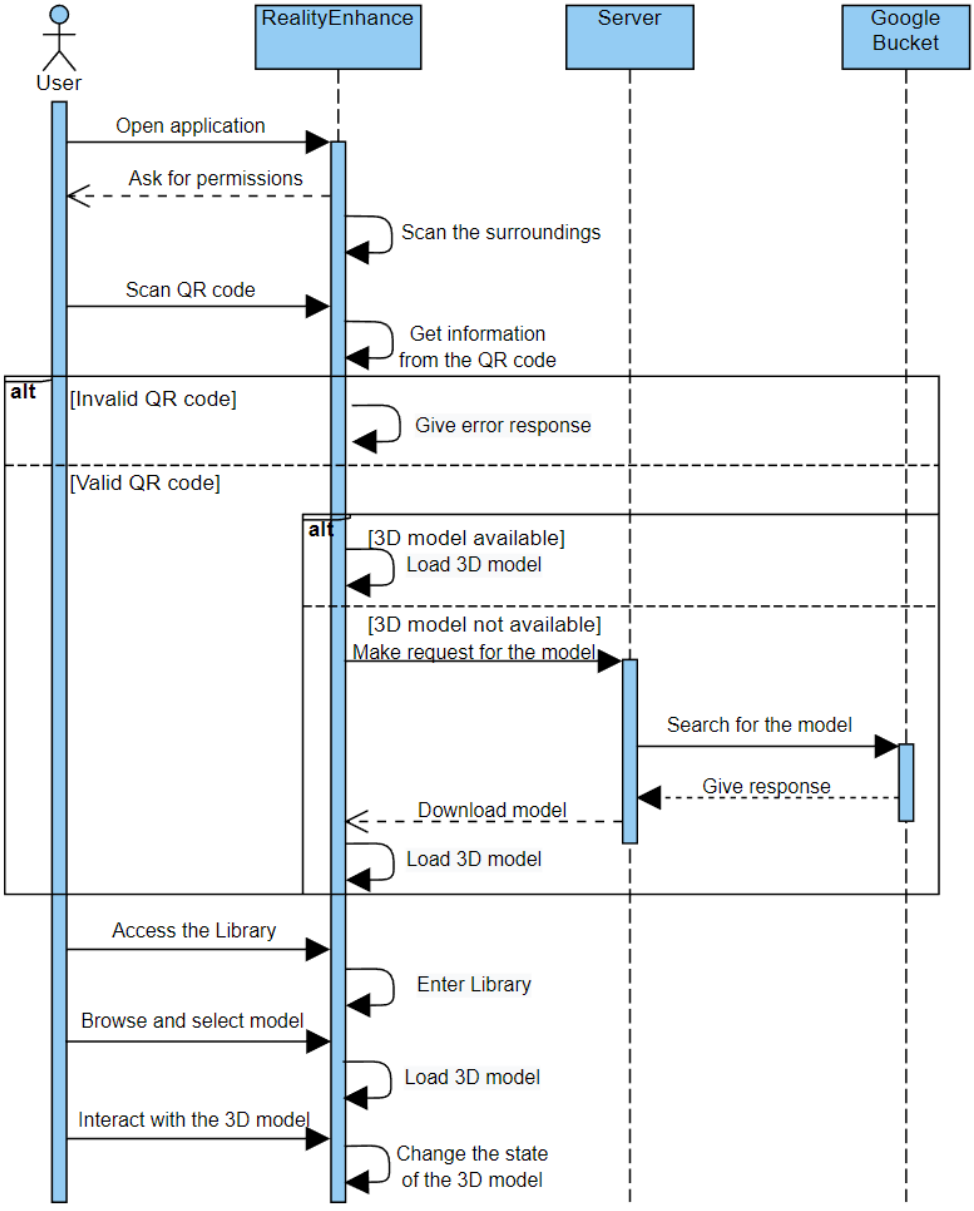

Figure 3.4: Sequence diagram

If the code fails the validation process, the user will be notified and will be prompted to scan another code. If the code is valid, the application will check if the model is already in the local storage, and it will load it. If the model is not in the local storage, the application will make a request to Google Bucket Storage

to retrieve all the information about the model (model file, textures, model image, model guide/interactive guide). After the request is completed, a response will be sent back with all the information about the model. The model will then be saved in the local storage and loaded in the AR scene.

The user can also browse the Library of already imported models. It also has access to the QR scanner interface and can search for the desired model that is wanted to be loaded in the AR scene.

The interaction between the user and the model bridges the virtual-physical gap and helps build a sense of immersion.

3.3 Implementation

Implementation details...

3.4 Deployment

Deployment details...

Chapter 4

Aplication features

4.1 Import model

4.2 See model in AR

4.3 Interact with model

4.4 Library of models

4.5 Delete model

4.6 Load model from library

Chapter 5

User Manual

5.1 Requirements

The application can be used in different area of application. The main requirement is to have a smartphone with a camera and a QR code reader. The application is available for Android and iOS. The application is available for free on the Google Play Store and the Apple App Store. The application is available in English and Romnian. The users will be able to import any model in the application using the QR code.

5.2 Graphical overview of RealityEnhance

We will now go through some of the application's graphical user interfaces. The following should summarise the fundamental flows present in the program and accommodate the user concerning the interface.

5.2.1 Application starting page

The first thing any user will see when they launch the app on their phone is the loading page. This page is a simple loading screen displayed while the app is loading. In the loading phase, the app will check if the user can run the app on their phone and if the phone has the necessary sensors to run it. If the user can run the app, the app will load the main page. If the user cannot run the app, the app will display a message that the user cannot run the app on their phone.

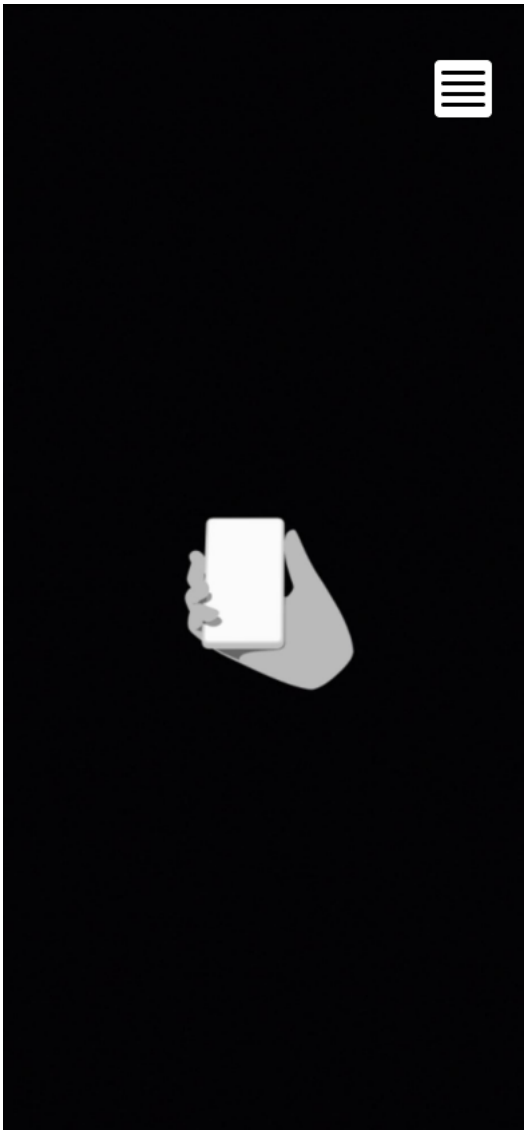

Figure 5.1: Loading page

5.2.2 App burger button

The burger button is a button that is present on every page of the app. It is used to open the side menu. The side menu is used to navigate through the app. In the burger button, we can access the following options: QR scanner, Library, and EXIT. The QR scanner scans a QR code and loads a 3D model and guide into the user's smartphone. The Library is used to display all the 3D models that the user has scanned. The EXIT button is used to exit the app.

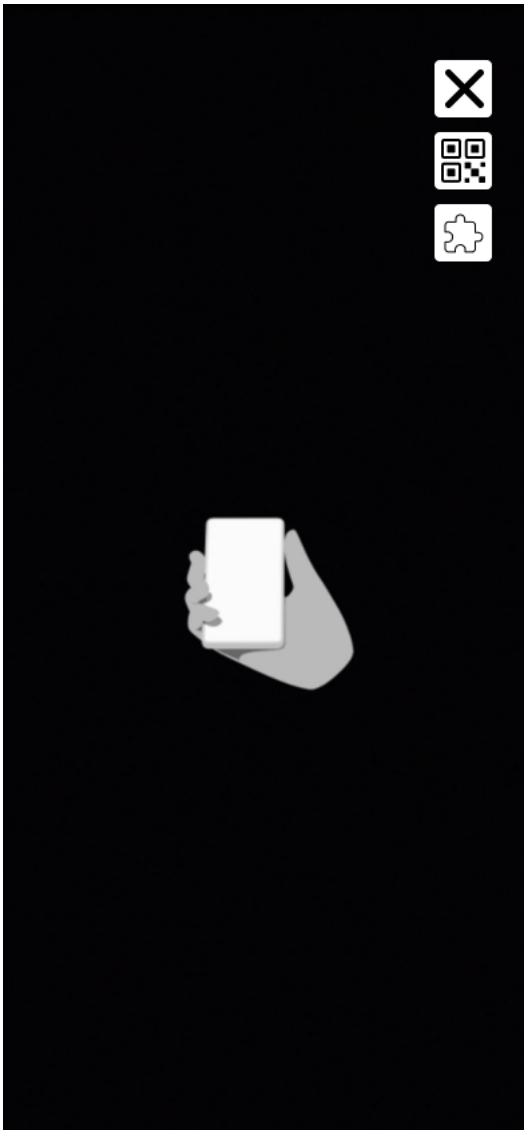

Figure 5.2: Burger button menu

5.2.3 QR code scanner

In this mode, a camera view will be displayed on the user's screen. The user will have to scan a QR code. The QR code will contain a link to a 3D model and a guide. The app will download the 3D model and the guide and display them on the user's screen. The model loaded from the QR code will be ready without entering the Library menu. The guide will be displayed on the user's screen, and the user must follow the guide to assemble the 3D model.

Figure 5.3: QR code scanner interface

5.2.4 QR code valdiation

If the QR code is valid, the app will display a message that the QR code is valid and will load the 3D model and the guide. If the QR code is not valid, the app will display a message that the QR code is not valid.

Figure 5.4: QR code is valid

5.2.5 AR vision

After a model is loaded, the AR module will use the phone's camera to determine the user's surroundings. It will make a 3D model of the environment and place the 3D model on top of the environment. The user will have a guide of the app in understanding the surroundings (a mesh of the planes will be displayed on the screen).

Figure 5.5: AR vision interface

5.2.6 Adding a model

After the app has a basic understanding of the surroundings and a model loaded, the user can click on the screen to add an object to the scene. This object will be placed on the screen, and the user can move it around it. The user can move the object around the screen by press-and-hold the object and moving the phone around or dragging the object with his/her finger across the screen. The user will be able to rotate the object by rotating the model using two fingers (like opening a bottle cap(rotating clock-wised) or closing a bottle cap(rotating counter-clock-wised)). The user will be able to scale the object by pinching the screen. The user is not bound to use just a single object. The user can add multiple objects to the scene and move them around the screen. The user can add another object by clicking on the screen in a place where an object is not present.

Figure 5.6: Adding a model

5.2.7 Removing a model

The user can remove the object by clicking and holding on the object and then clicking on the remove button. The user will be able to remove multiple objects at the same time by clicking on the reset all button.

Figure 5.7: Removing a model

5.2.8 Library

The app will display the Library interface when the user clicks on the Library button in the burger menu. The Library interface will display all the 3D models the user has scanned. The user can select a model and load it into the AR vision mode. In the Library interface, the user can search for and add a model to the Library. The user can also delete a model from the Library.

Figure 5.8: Library interface

5.2.9 Using multiple models at the same time

The user will be able to use multiple models at the same time. The user can add multiple models to the scene and move them around the screen. The user can add another model by clicking on the screen in a place where an object is not present. The guide for assembling or building a model will be displayed on the screen when the scene has just one object.

Figure 5.9: Using multiple models

Chapter 6

Conclusion

In the concluding chapter, we will summarize the main results of the thesis and we will present future work.

6.1 Summary

6.2 Future work

In this section we will present the future work that will be done to improve the application.

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