Bilkent University
Department of Computer Engineering

Senior Design Project
T2330
vendAR

Analysis and Requirement Report

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08.12.2023

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vendAR : Bring furniture to life

1 Introduction

With the increase in the number of households in the world, the need for furniture and house effects keep increasing. The process of buying new furniture or replacing them can be tedious for most people. Most of the time, people try to pack their furniture in a way that everything barely fits in a room. But sometimes furniture might not fit as expected. Since the delivery and construction of furniture can be costly and time-consuming, seeing the furniture not fit as expected can be very frustrating. What if there was a way to see if a piece of furniture fit into a desired place, without having to buy it and deliver it to your house? vendAR is an application that lets people visualize the furniture they want to buy on their phones with the exact dimensions. It uses Augmented Reality technology with the rear camera of the mobile phones to place the furniture in their surroundings. The users can move and rotate the AR model of the furniture around the room to see if the furniture fits to their desired place. vendAR offers to solve the tediousness and frustration of purchasing furniture by giving the buyers a preview of the product as a 3D model. This report will contain information about vendAR, its constraints, professional and ethical issues, functional and non-functional requirements as well as a market analysis in detail.

2 Proposed System

2.1 Overview

In this section, we will talk about the application's design in detail. Our application has two main layers. The augmented reality part and the mobile application part. We provided functional, non-functional requirements as well as diagrams for both parts of the application.

2.2 Functional Requirements

- Users must be able to login and register the system and log out from it.
- Users must be able to put their products on the app to make it visible to others.
- Users must be able to remove a product from their page.

- Users must be able to assign an AR model to each of their products to allow customers to visualize it in their devices.
- Users must be able to use 3D model templates to create their product models.
- Users must be able to import their own created models if they want to.
- Users must be able to attach animations/audios to their models in interactive products.
- Users must be able to visualize the product they select via using the camera of their device.
- Users must be able to play the animations or audios on the model of their chosen product.

2.3 Non-functional Requirements

2.3.1 Usability

- The application should be released on a mobile application store so the user community can contact each other by downloading and installing it over the store.
- The application should have a user friendly interface so it is usable by people of all ages. A user manual should be provided at the beginning.
- The concept of the application should be easy to understand for people who are not professional in the field.

2.3.2 Reliability

- The application should not crash during installation or running.
- The application should not lag during the camera usage.
- The application should not crash on any mobile-based operating system.

2.3.3 Performance

- The application should be effective in terms of the software system with respect to time and allocation of resources.
- The application should be able to run on older generation smartphones which have cameras.
- The data transaction should be fast so the performance of the program would not be ruined.

2.3.4 Privacy Security

- The program should collect data as needed according to PDPA (1).

- The program should only use the camera of the device as needed while running the program.
- Images or videos should be saved privately in the database if needed.

2.3.5 Scalability

- Many users should be able to use the program at the same time.

2.4 Pseudo Requirements

- Object-oriented approach will be used to implement vendAR.
- Git will be used as the version control system to work properly as a team. We will be using Fork which is an interface for Git to manage the project faster.
- ClickUp will be used to track tasks among team members. We have also looked into applications such as Trello but decided to use ClickUp in the end.
- Flutter framework will be used for implementation which will enable us to build the application for both Android and iOS. Flutter will also provide plugins for implementing AR into our application. We will be writing our code in the Dart language.
- A modular approach will be used to separate the implementation of AR in Android and iOS since Flutter provides different plugins for the two. It will also make our code base more manageable and scalable.
- The expenses of the application, (hosting etc.) will be covered by the team members. If the application grows in user count, we will be using advertisements across the app to cover for the expenses.

2.5 System Models

2.5.1 Scenarios

Scenario 1 Sign Up

Actors: User (either seller or buyer if not specifically written)

Entry Conditions: The user click on the sign up button

Exit Conditions: The user either goes back to the sign in menu or closes the app.

Flow of Events:

1. The user clicks the sign up button on the homepage.
2. The sign up menu is open.
3. The user fills out the relevant information.
4. The user clicks on the sign up button.
5. (Optional) An authentication mail is sent to specified email for verification.

Scenario 2 Sign In

Actors: User

Entry Conditions: The user opens the app.

Exit Conditions: The user closes the app.

Flow of Events:

1. The user fills out the relevant information for signing in
2. The user clicks on the sign in button.
3. The information is checked in the backend.
4. If the information is verified, the user is navigated to the main menu.

Scenario 3 Putting New Furniture Up

Actors: Seller

Entry Conditions: The seller clicks on the add model button located in the main menu.

Exit Conditions: The seller closes the pop-up menu or closes the app.

Flow of Events:

1. The seller is greeted with a pop-up menu upon clicking the sell button.
2. The seller fills out the relevant information, (title, description, photos, etc.)
3. The seller will click on the put up button to upload their furniture to the application.

Sub-Scenario Choosing A Templated Model

Actor: Seller

Flow of Events (continuing from Scenario 3):

1. The seller can open the templated models pop-up by clicking “Choose a templated model”
2. The seller can choose from them depending on the best description of their furniture.
3. The seller will need to provide dimension information regarding their furniture.

Sub-Scenario Using LIDAR To Generate Model

Actor: Seller

Flow of Events (continuing from Scenario 3):

1. If the seller's mobile phone has LIDAR support, "Generate Model" button will be available in the sell pop-up menu.
2. The seller's camera will open and will allow the seller to scan the furniture to generate a model using LIDAR.

Scenario 4 Search For Furniture

Actor: Buyer

Entry Conditions: The user clicks on the search bar from in the main menu.

Exit Conditions: The user clicks on the back button or exits the app.

Flow of Events:

1. The buyer enters the furniture name they are looking for. They can also enter
2. The buyer clicks on the search button.additional search parameters like the color or the material of the furniture.
3. The list of furniture matching the search parameters are retrieved in the result menu.

Scenario 5 Viewing A Furniture

Actor: Buyer

Entry Conditions: The buyer clicks on a piece of furniture in the result menu.

Exit Conditions: The buyer clicks on the back button or closes the app.

Flow of Events:

1. The buyer opens the menu for the specific furniture.
2. The buyer clicks on the view furniture on the camera button.
3. The furniture model is displayed in the camera space through AR.

Scenario 6 Edit Profile

Actor: User

Entry Conditions: The user clicks on the profile button in the main menu.

Exit Conditions: The user goes back to the main menu or closes the app.

Flow of Events:

1. The user is greeted with the profile menu upon clicking on the profile button.
2. The user can edit various information on the profile menu such as contact phone or contact email.

2.5.2 Use-Case Model

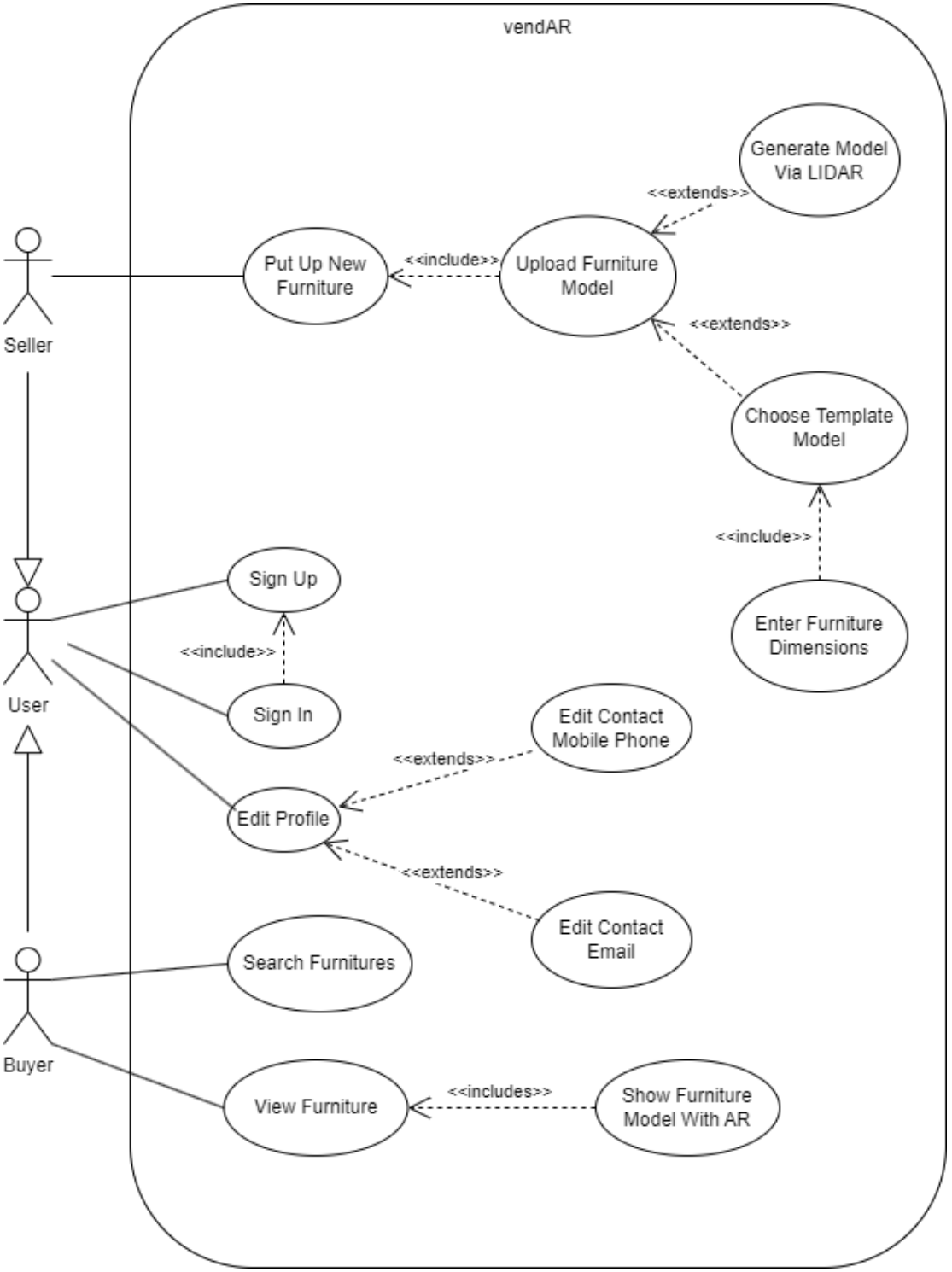

Fig. 1. Use Case diagram of vendAR

2.5.3 Object and Class Model

Augmented Reality Object and Class Model

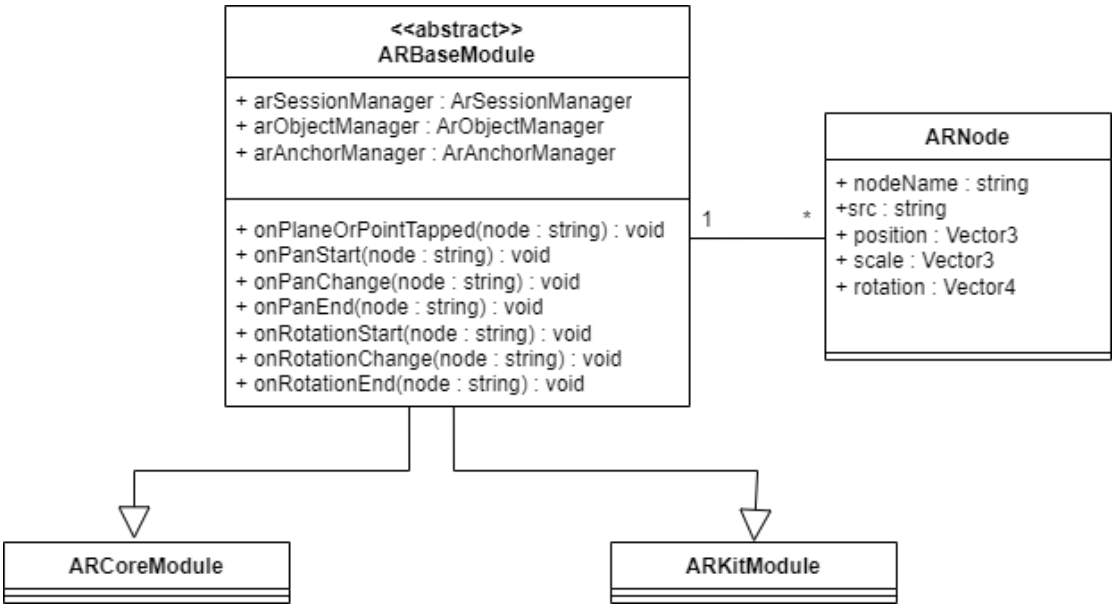

Fig. 2. Object and Class model of AR system

- To efficiently implement AR for Android and iOS, we will create wrapper classes around *arcore_flutter_plugin* and *arkit_flutter_plugin* which Flutter provides respectively. These wrapper classes will inherit from the *ARBaseModule* abstract class which will contain our platform independent API for AR. The wrapper classes will implement the functions of the base module by using their respective plugins. Then, we will be able to build our application by using a boolean flag for Android and iOS easily.

Client Object and Class Model

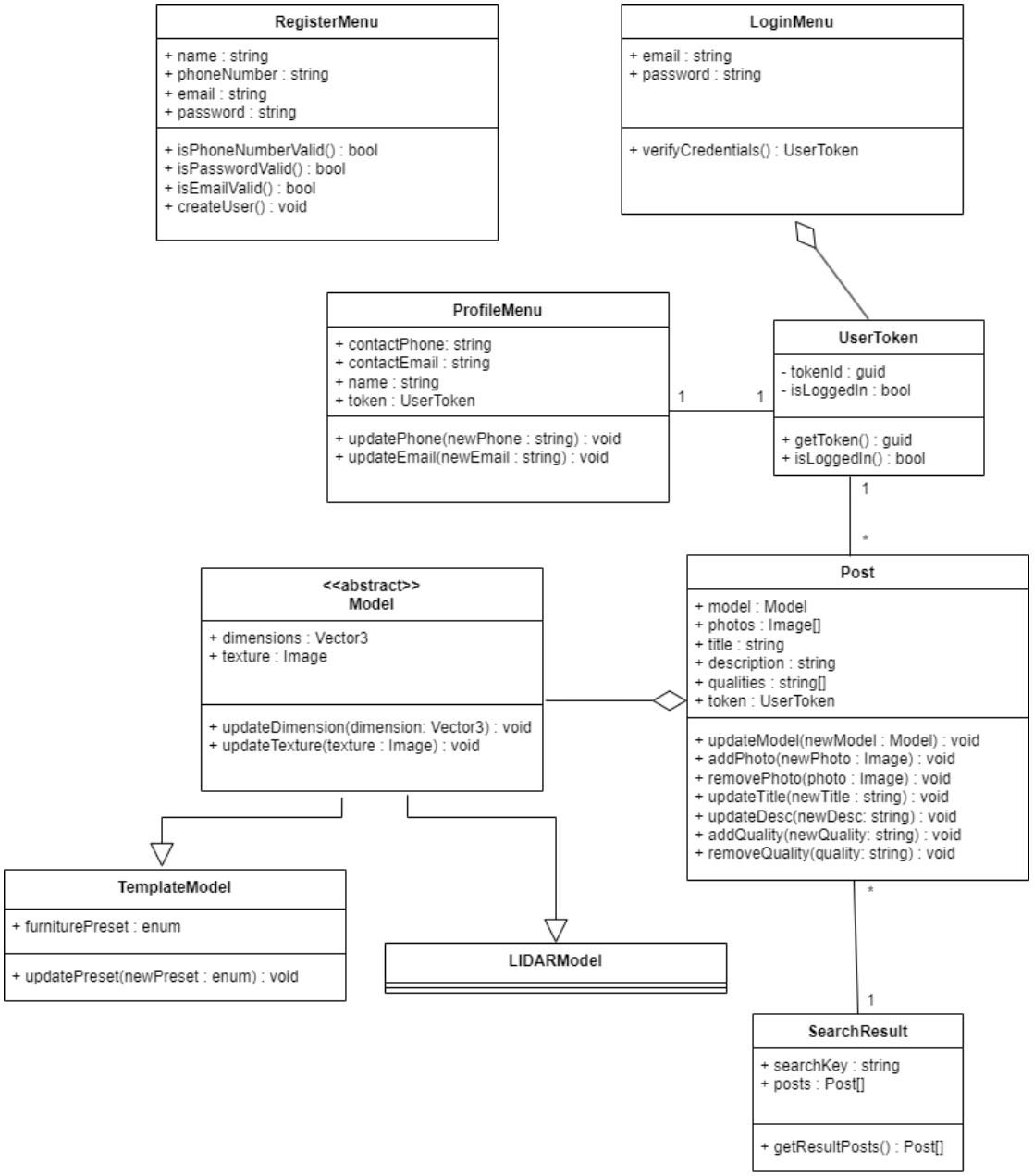

Fig. 3. Client side class diagram of vendAR

- UserToken will be created by the server-side if the user successfully logs in. This user token will be cached in the application for the whole duration of the session and will be deleted if the user logs out or stays inactive for a certain amount of time. The user token will be used across all pages, and will be used to retrieve relevant information from the server to the specific page

Server Entity And Relationship Model

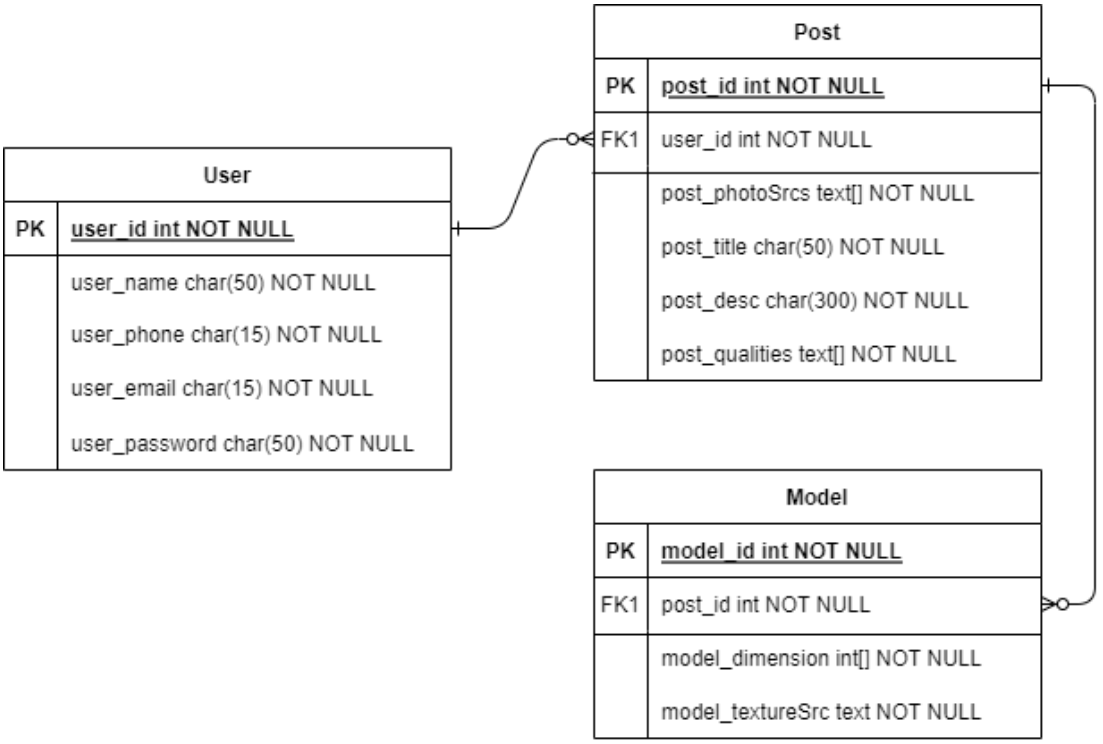

Fig. 4. Server side entity relationship diagram of vendAR

- Something important to note here is that we will not be storing images directly on our database. Images will be uploaded to another cloud service such as Google Drive. In our database, we will hold the source links as strings to these images in order to be able to retrieve them from the other cloud service.

2.5.4 Dynamic Models

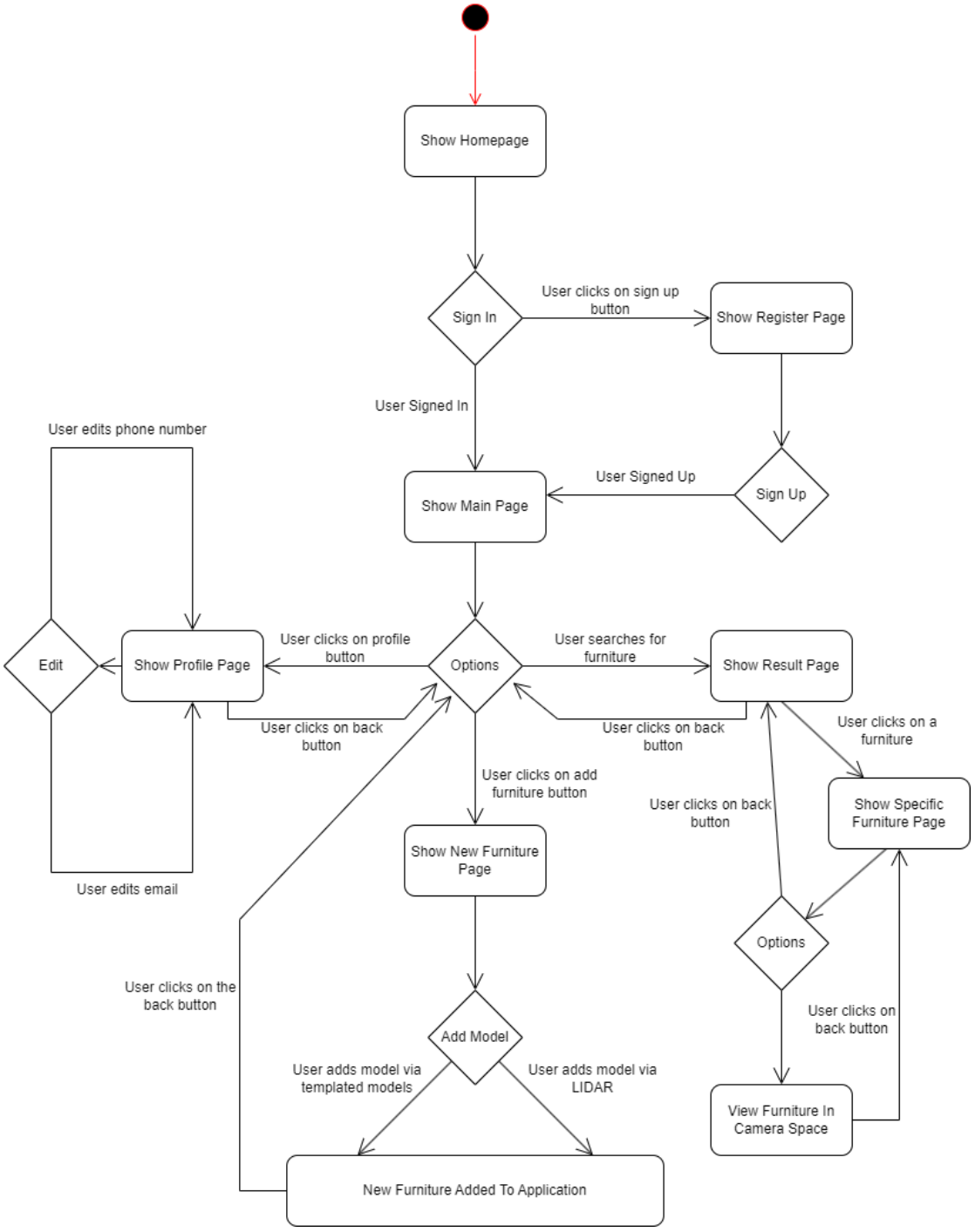

Fig. 5. Activity diagram of vendAR

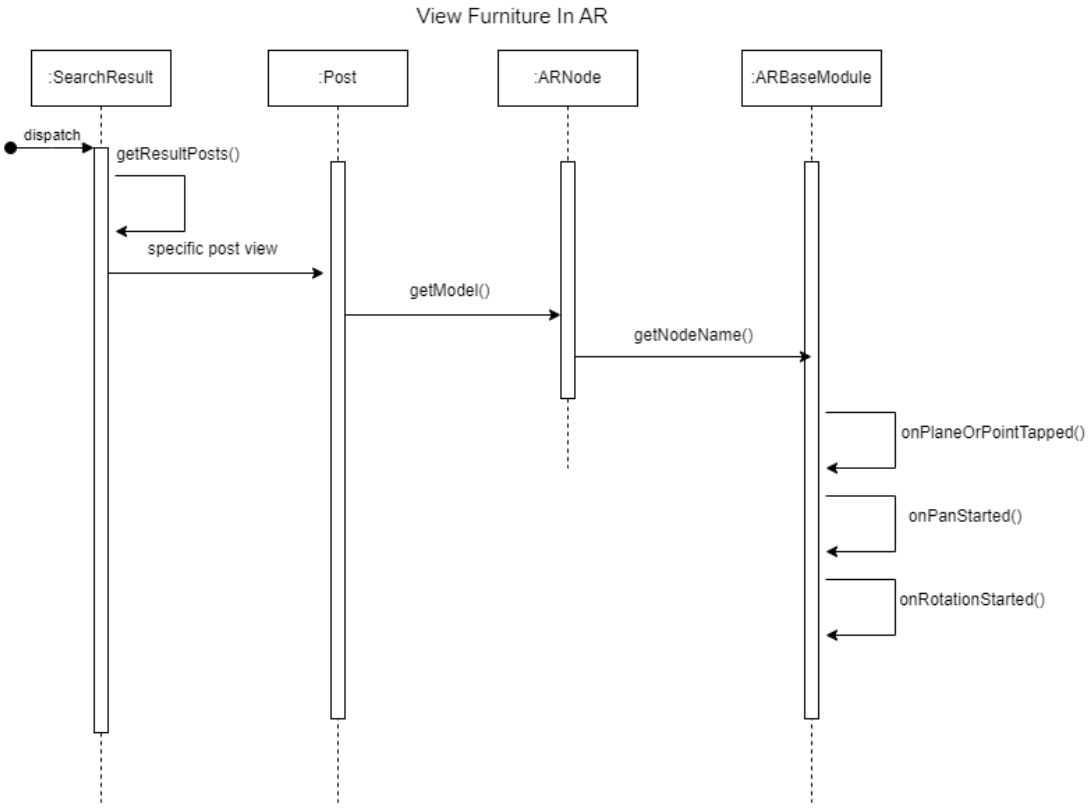

Fig. 6. Sequence diagram of viewing furniture in camera space

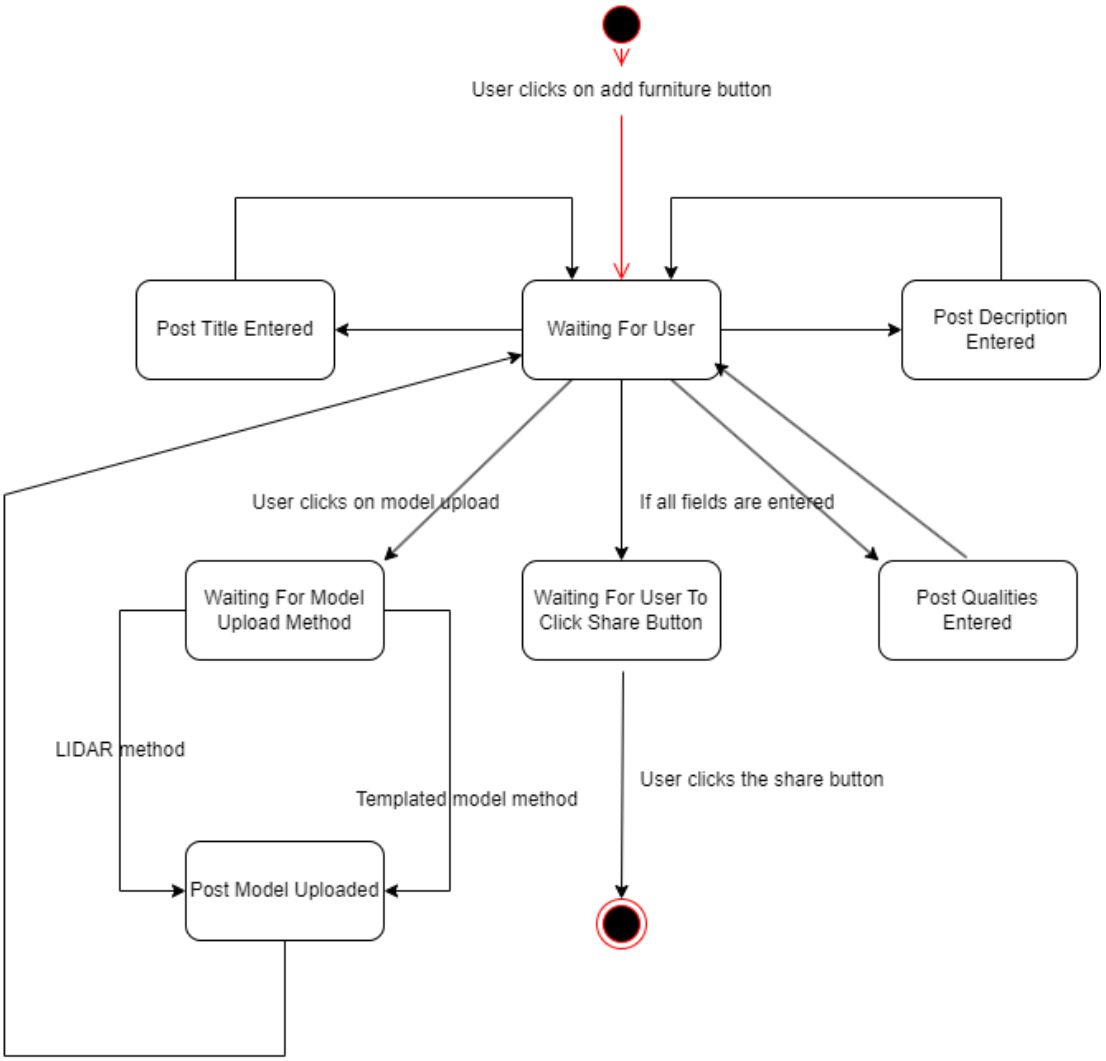

Fig. 7. State diagram of adding a new furniture

2.5.5 User Interface

2.5.5.1 Launch Screen

Fig. 8. Launch Screen of the Application

2.5.5.2 Login/ Sign up screen

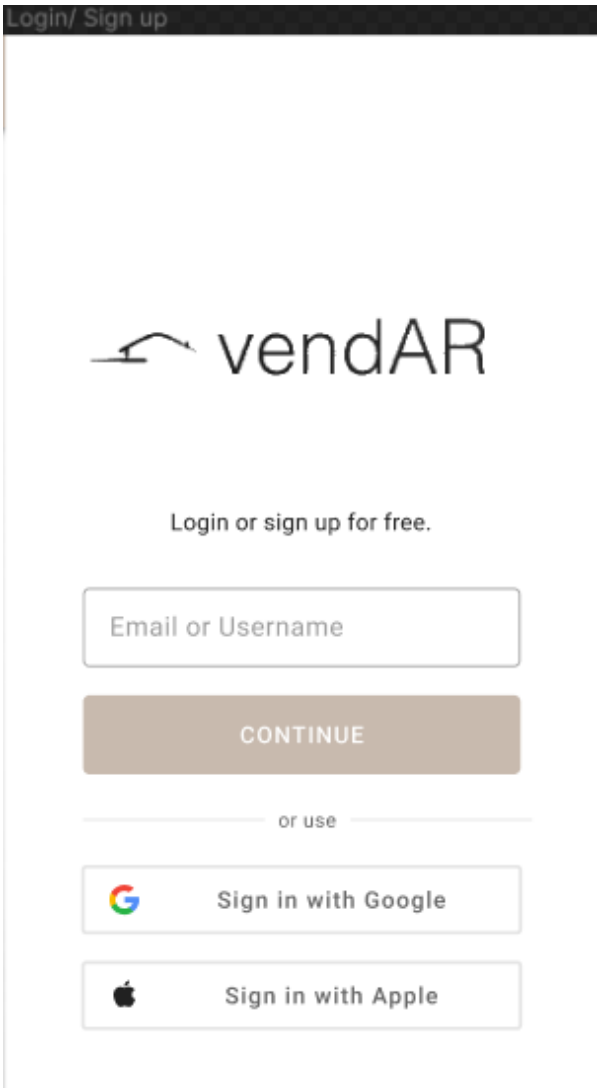

Fig. 9. Login and Sign up Screen for the Application

2.5.5.3 Main Page

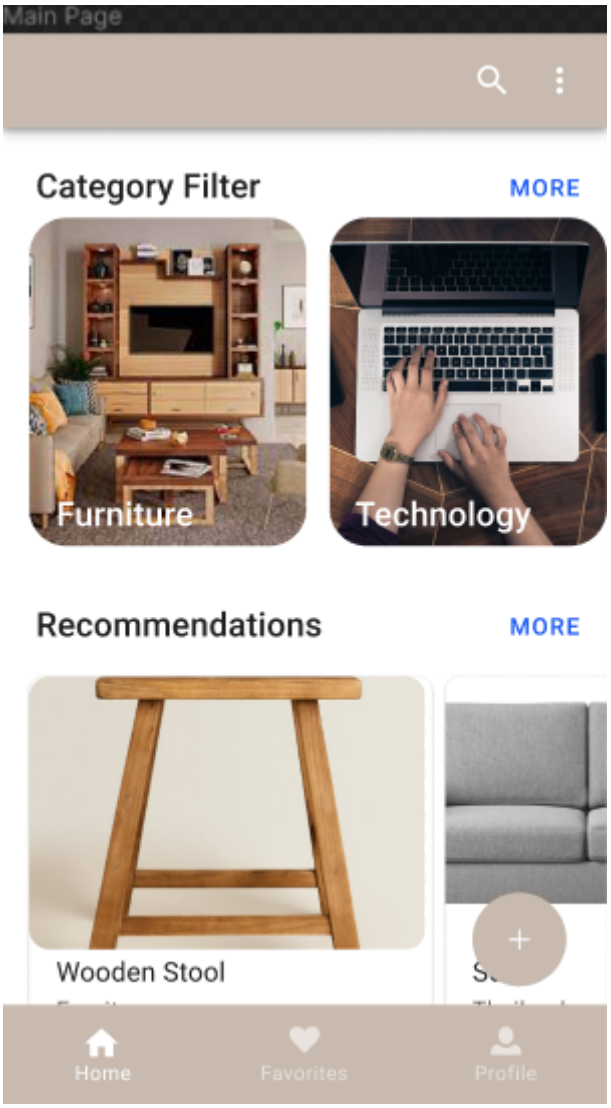

Fig. 10. Main Page of the Application

Main Page of the application. It showcases categories of products and some recommended products for the user. Users can go to the Favorites Screen, Profile Screen, and Create Model Screens with the buttons below. Favorites screen will showcase the favorite models in a similar manner to this page and the Profile page.

2.5.5.4 Detail View

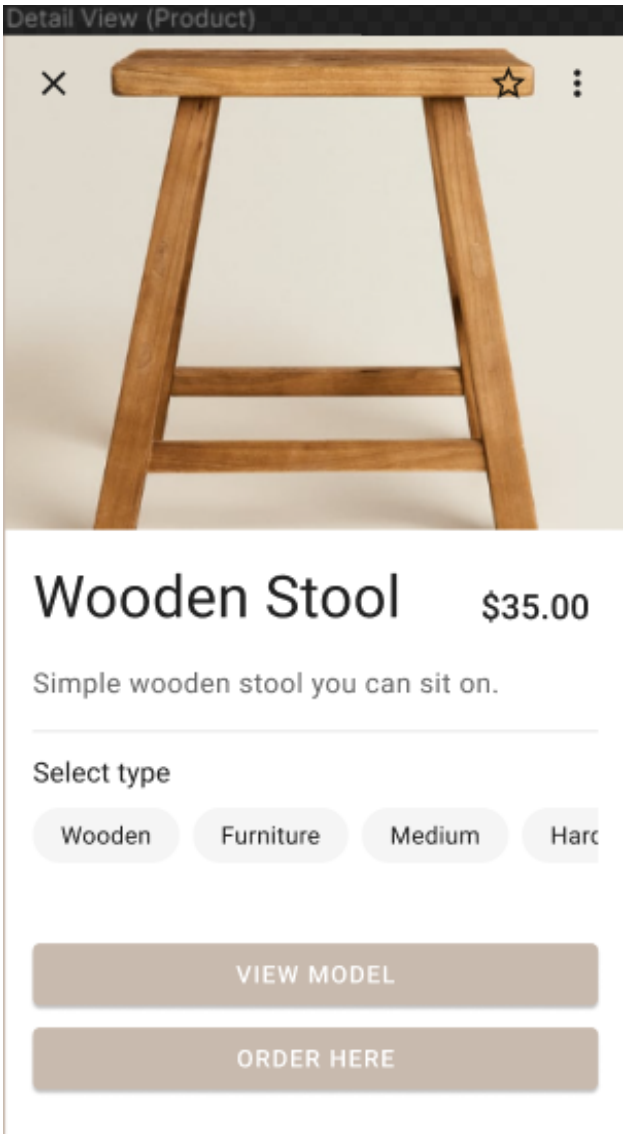

Fig. 11. Detail View for models of the Application

This is the detailed product view where the user can see the pictures of the product and associated tags with it along with its price. Using the buttons down below the user can be redirected to the 3D model or the website the product is being sold. Users can favorite the products to view them later.

2.5.5.5 3D Model View

Fig. 12. 3D Model View of the Application

2.5.5.6 AR Model View

Fig. 13. AR Model View of the Application

2.5.5.7 Create Model Screen

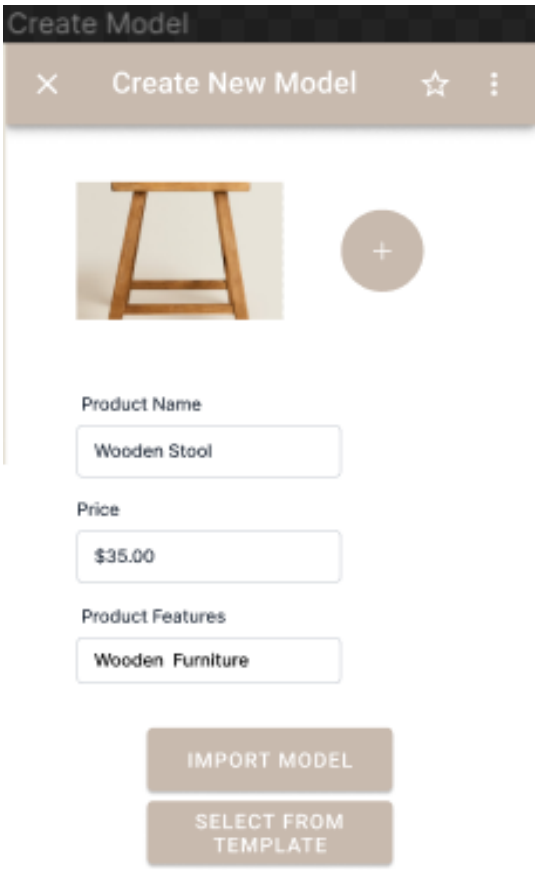

Fig. 14. Create Model Screen of the Application

This screen is used for creating new models. The user can add multiple pictures for the product. The user will also add a 3D model for the product. The model can be imported from external sources. If the user doesn't have a 3D model on hand, they can choose from the various templates that would resemble their product.

2.5.5.8 Profile Screen

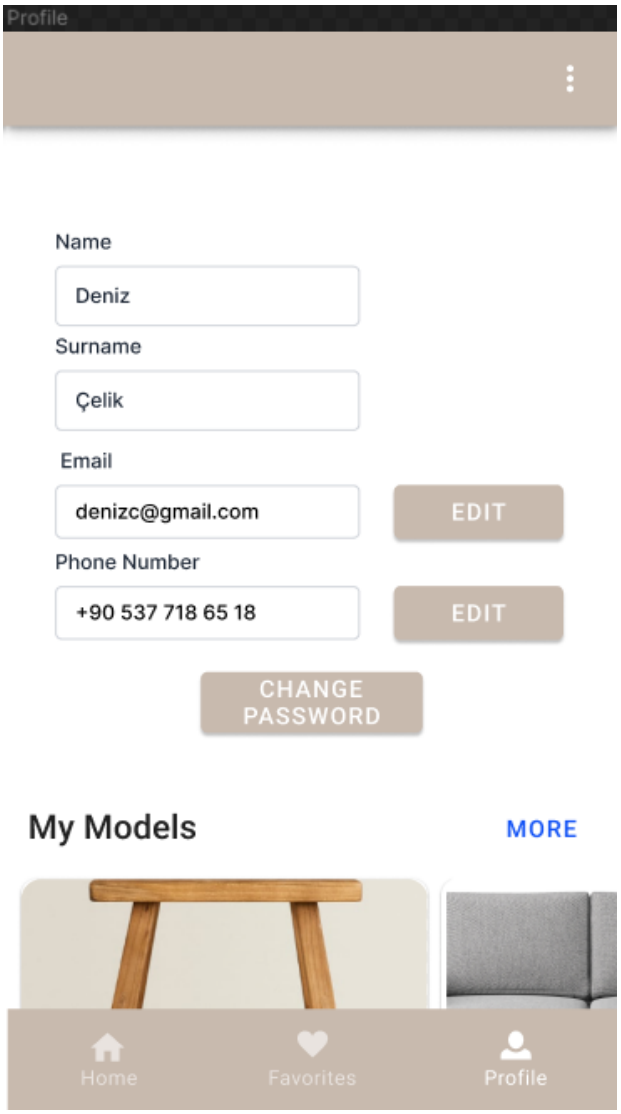

Fig. 15. Profile Screen of the Application

Profile page of the user where the user's information is displayed. Phone number, email and password can be changed through here. Users can see their uploaded models from here as well.

3 Other Analysis Elements

3.1 Consideration of Various Factors in Engineering Design

3.1.1 Constraints

Implementation Constraints

The implementation will be performed on two different platforms of IOS and Android using ARKit and ARCore libraries for Augmented Reality Technology and proper LIDAR library for the scanning objects that will be displayed. So having a built-in library for both of these utilities for both platforms is very pivotal since it would be very difficult to implement the project without them.

Economic Constraints

Our project depends mainly on free resources and libraries for the software side. However, in case of deciding to proceed with the Apple Vision Pro as the hardware, we need financial support from the companies that are willing to become our team's sponsor. Without the external financial support, the application will be modified such that it can run on the mobile devices that are either Android or IOS. So, sponsorship is decisive for the implementation of our project.

Ethical Constraints

It is important for our project to not violate any software license right through pirated content or any other illegal method. Also, the program should be easy to learn and understand by a vast range of users with various backgrounds. It should not have content that is discriminatory to some groups with different religion, nation, ethnicity or culture.

3.1.2 Standards

Through design processes we must stick on to established standards to ensure quality and prevent any confusion. For the UML diagrams we will proceed with the UML (Unified Modeling Language) 2.4.1 standards to establish a common convention for all of our diagrams. We will also take advantage of the IEEE 830's guidelines for our reports to reach certain standards and enhance understandability.

3.2 Risks and Alternatives

The project faces several risks that need to be carefully considered. One potential risk is the likelihood of users encountering compatibility issues with their machines while using the application. This is a risk that if it happens, it could lead to a reduction in user count, impacting the project's overall success since the user cannot use the app in this case. To address this, alternative technologies that support lower android/ios versions could be used..

Another identified risk pertains to the possibility of inappropriate image uploads by users. It shouldn't be ignored since if it happens the application may be subjected to legal punishments. To control this risk, the project should have a content moderation system in place. This involves implementing measures such as user reporting and having an administrative team actively monitoring and removing inappropriate content promptly. By incorporating these alternatives into the project plan, the team can proactively address potential risks.

3.3 Project Plan

Below you can see various tables that you will make use of.

The project plan can be reported by a list of work packages and their content.

For better readability, a Gant chart based on work packages can also be added.

Table xx: Factors that can affect analysis and design.

	Effect level	Effect
Public health	Low	Illegal substances shouldn’t be present as models inside the application.
Public safety	High	Models that are present inside the application should be within safe boundaries determined by law and other safety factors.
Public welfare	High	Target audience should be able to afford the products listed with certain ease.
Global factors	Medium	Products should abide by global standards.

Cultural factors	Medium	Models that are present inside the application should not be culturally discriminative.
Social factors	Medium	There should not be socially discriminative material inside the application
Environmental factors	Low	There is not much environmental impact on this project.
Economic factors	High	The software is highly hardware dependent which makes economic factors vital

Table xx: Risks

	Likelihood	Effect on the project	B Plan Summary
User's machine is incompatible with the application	Low	User count reduces	Support for lower android/ios versions
Inappropriate image uploads	Low	Project may be prohibited by authorities	Have an admin removing certain content

Table xx: List of work packages

WP#	Work package title	Leader	Members involved
WP1	Analysis	Parsa	Everybody
WP2	Design	Ege	Everybody
WP3	Detailed Design	Feyyaz	Everybody
WP4	Development 1	Deniz	Everybody
WP5	Development 2	Ender	Everybody

WP6	Testing	Feyyaz	Everybody

WP 1: *Analysis*			
Start date: *01.12.2023* **End date:** *08.12.2023*			
Leader:	*Parsa*	**Members involved:**	*Everybody*
Objectives: *The aim of this work package is to prospect the functional and non-functional, and pseudo requirements of the system. We also look into system models such as scenarios, usa-case models, object & class models, dynamic models, and user interface of the program. The constraints and standards of the application are also analyzed together with risks and alternatives of the implementations. Last but not least, project plan, teamwork, ethics & professional responsibilities, and strategies that are used are mentioned.*			
Tasks: ***Task 1.1 Requirement Meetings*** **:** *Arranging meetings to analyze and determine the functional and non-functional requirements of the project together with specifications.* ***Task 1.2 Specification Report*** **:** *Writing reports after the requirement meetings for the specifications.* ***Task 1.2 Analysis Report*** **:** *Preparing a report for the cases, dynamic modes and development skeleton of the application.*			

Deliverables ***D1.1:*** *Specification Report* ***D1.2:*** *Analysis Report*			
WP 2: *Design*			
Start date: *10.12.2023* **End date:** *30.12.2023*			
Leader:	*Ege*	**Members involved:**	*Everybody*
Objectives: *Provide a design for the application at the system level. AR implementations for both Android and IOS will be designed. Also, user interface and LIDAR subsystems and their interactions will be discussed by choosing appropriate software architecture. UML diagrams will be heavily utilized through Design Reports.*			
Tasks: ***Task 2.1 Deciding System Architecture*** **:** *Appropriate System Architecture will be decided for the application* ***Task 2.2 Creating UML Diagrams for the System*** **:** *UML diagrams will be created for the system which*			
Deliverables ***D2.1:*** *Design Report* ***D2.2:*** *UML Diagrams for High Level Architecture*			

WP 3: *Detailed Design*			
Start date: *07.01.2024* **End date:** *30.01.2024*			
Leader:	*Feyyaz*	**Members involved:**	*Everybody*
Objectives: *Subsystems such as LIDAR, Android AR and IOS AR will be designed detailly for low level architecture. The baseline for the implementation will be formed. Functions will be decided along with their implementation choices.*			
Tasks: ***Task 3.1 Deciding Architecture for each Subsystem*****:** *For each submodule, appropriate architecture will be decided.* ***Task 3.2 Creating UML Diagrams for Android AR*** **:** *Class Diagrams and Dynamic Diagrams will be created for the Android side of the project that aligns with the decided architecture.* ***Task 3.2 Creating UML Diagrams for IOS AR*** **:** *Class Diagrams and Dynamic Diagrams will be created for the IOS side of the project that aligns with the decided architecture*			

Task 3.2 Creating UML Diagrams for User Interface **:** *Class Diagrams and Dynamic Diagrams will be created for the Flutter side of the project that aligns with the decided architecture*
Deliverables ***D3.1:*** *UML Diagrams for low-level architecture*

WP 4: *Implementation 1*			
Start date: *10.12.2023* **End date:** *30.12.2023*			
Leader:	*Deniz*	**Members involved:**	*Everybody*
Objectives: *The aim of this work package is to prepare the general skeleton of the basic structure of our application. This implementation is to be used for the presentation and demo.*			
Tasks: ***Task 4.1 Deciding System Architecture*** **:** *Preparing a general structural system architecture of the application.* ***Task 4.2 Creating UML Diagrams for the System*** **:** *Preparing the UML diagrams of for example classes and modules for the general structure of the system.* ***Task 4.3 Creating basic User Interface*** **:** *Preparing the mockup pages of the mobile application for demo and presentation.*			
Deliverables ***D4.1:*** First demo and presentation ***D4.2:*** *UML Diagram of the system*			

WP 5: *Implementation 2*			
Start date: TBD **End date:** TBD			
Leader:	*Ender*	**Members involved:**	*Everybody*
Objectives: *The aim of this work package is to create the final advanced structure of the project application for the final presentation and released demo.*			
Tasks: ***Task 5.1 Server and Database*****:** *Implementing the proper server and database to save the data needed for the specification of the project.*			

Task 5.2 Advanced User Interface**:** *Implementing a user friendly UI for the daily usage of the users that can handle camera usage requests for AR-based visualization.* ***Task 5.2 AR implementation*** **:** *Implementing the proper AR visualization for the supplies' locations.*
Deliverables ***D5.1:*** *Final product* ***D5.2:*** *Demo and Presentation for the CS Fair*

WP 2: *Test*			
Start date: *01.04.2024* **End date:** *10.04.2024*			
Leader:	*Feyyaz*	**Members involved:**	*Everybody*
Objectives: *The application tests will be held in both unit level and system level. Each corner case and possible scenarios will be performed on the final product. The aim will be to ensure that the application can perform its functionality without any function without any issues to ensure the final product is robust and stable.*			
Tasks: ***Task 6.1 Unit Test*****:** *Tests of each submodule will be held.* ***Task 6.2 System Test*** **:** *Test of the whole system will be held*			
Deliverables ***D6.1:*** *Unit Test Results* ***D6.2:*** *System Test Results*			

3.4 Ensuring Proper Teamwork

We have created a ClickUp account for our team to divide the workload between ourselves. By doing this we have ensured that the work is developed fairly between team members while seeking their interests and abilities. Also, we have formed the work packages such that they will be under the leadership that can handle the package best. For each package, all of the members are assigned such that they will have equal and fair contribution which will ensure the proper teamwork through the whole project.

3.5 Ethics and Professional Responsibilities

We must approach the project in a professional manner both through design and development processes. By handling the problems that we may have in terms of the development process or within the team in a professional and ethical way, we can easily solve the problems with taking the minimum casualty. Also, it is important for our project to not violate any software license right through pirated content or any other illegal method. Also, the program should be easy to learn and understand by a vast range of users with various backgrounds. It should not have content that is discriminatory to some groups with different religion, nation, ethnicity or culture.

3.6 Planning for New Knowledge and Learning Strategies

Our primary learning strategy is self-learning. We do research such as watching online videos and reading online articles to discuss new knowledge that is going to be used in our project in the meetings. In senior design projects AR technology will mainly be used to locate different supplies anywhere using telephone cameras. Hence, our group will have to learn how to implement AR and integrate it with the daily usage of applications. We may use some other technologies such as HR, LIDAR, ARCore, and ARKit if needed.

4 Glossary

- Augmented Reality (AR): Augmented reality (AR) is an interactive experience that combines the real world and computer-generated content. (2)
- Hyper Reality (HR): The term we use to refer to the AR and mixed-reality experience that is provided by Apple Vision.
- LIDAR: LIDAR, an acronym of "light detection and ranging" or "laser imaging, detection, and ranging") is a method for determining ranges by targeting an object or a surface with a laser and measuring the time for the reflected light to return to the receiver. For vendAR it is a potential tool that would help users to make 3D models for their products. (3)
- ARCore: ARCore is Google’s augmented reality SDK offering cross-platform APIs to build new immersive experiences on Android, Unity, and Web.
- ARKit: Similar to ARCore, ARKit is Apple’s augmented reality SDK offering APIs to build immersive experiences on iOS devices.

5 References

1- Wikimedia Foundation. (2023a, August 11). *Personal Data Protection act 2012*. Wikipedia. https://en.wikipedia.org/wiki/Personal_Data_Protection_Act_2012

2- Wikimedia Foundation. (2023, November 12). *Augmented reality*. Wikipedia. https://en.wikipedia.org/wiki/Augmented_reality

3- Wikimedia Foundation. (2023c, November 12). *Lidar*. Wikipedia. https://en.wikipedia.org/wiki/Lidar