Bilkent University
Department of Computer Engineering

Senior Design Project
T2330
vendAR

Final Report

22003550, Mehmet Feyyaz Küçük, feyyaz.kucuk@ug.bilkent.edu.tr
22002478, Ege Ayan, ege.ayan@ug.bilkent.edu.tr
22003271, Deniz Çelik, denizc@ug.bilkent.edu.tr
22001983, Ender Utlu, ender.utlu@ug.bilkent.edu.tr
220001422, Parsa Keihan, parsa.keihan@ug.bilkent.edu.tr

Supervisor: Uğur Güdükbay
Course Instructors: Atakan Erdem, Mert Bıçakcı

10.05.2024

Contents

1. Introduction

1.1 Purpose of the system

Along with the rise in the variety of households worldwide the requirement for furnishings as well as home impacts maintain enhancing. The procedure of acquiring brand-new furnishings or changing them can be laborious for lots of people. A lot of the time individuals attempt to load their furnishings by doing this that whatever barely suits an area. However, in some cases furnishings may not fit as anticipated. Considering that the distribution as well as building and construction of furnishings can be expensive plus time-consuming seeing the furnishings not fit as anticipated can be really aggravating. What happens if there was a method to see if an item of furnishings suit a wanted area, without needing to acquire it and also supply it to your home? vendAR is an application that allows users to picture the furnishings they intend to purchase on their phones with the specific measurements. It utilizes Augmented Reality innovation with the back electronic camera of the cellphones to put the furnishings in their environments. The customers can relocate as well as turn the AR design of the furnishings around the area to see if the furnishings fits to their preferred area. vendAR supplies to address the tediousness and also stress of acquiring furnishings by providing the purchasers a sneak peek of the item as a 3D design. This record will certainly have info concerning vendAR, its restrictions specialist plus honest problems, useful as well as non-functional needs in addition to marketing research carefully.

1.2 Overview

Purpose: VendAR intends to fix the irritation of acquiring furnishings by offering an examination of the item as a 3D version in the customer's room utilizing AR innovation. This enables customers to see if the furnishings suit their wanted area prior to purchasing it.

Architecture: VendAR adheres to a client-server style where the customer is a Flutter application in charge of the customer interface, AR making plus interacting with the web server. The web server is a Spring Boot application in charge of information storage space, control, plus taking care of API demands.

Client Subsystems:

- View Layer: Handles providing the customer interface making use of Flutter parts.
- Controller Layer: Handles customer input along with sending out ideal requests for the web server.

Server Subsystems:

- Logic Layer: Responsible for establishing endpoints taking care of inquiry reasoning together with service reasoning procedures.

- Data Layer: Handles information versions as well as engages with the data source (PostgreSQL) held on AWS RDS.

Hardware/Software Mapping:

- Hardware: Mobile tools (Android and also iPhone) for running the Flutter application plus taking advantage of the electronic camera for AR, AWS EC2 circumstances for holding the Spring Boot web server, AWS RDS for the PostgreSQL data source.
- Software: Flutter for the customer application, Spring Boot for the web server application, PostgreSQL for the data source plus various other sustaining innovations like Google Drive for design storage space as well as AWS solutions.

Persistent Data Management: User qualifications, item versions, plus item functions are saved in the PostgreSQL data source organized on AWS RDS. Item designs are likewise saved in Google Drive making use of NetworkImage.

Safety and Access Control: User login qualifications are secured plus saved in the data source. Token-based verification is made use of for safe and secure interaction in between the customer as well as web server. Cam consents are asked for from the individual's tool.

Key Features:

- Real-time furnishings visualization in the individual's room making use of AR,
- Adjustable choices for dimension together with shade,
- Capability to conserve and also share styles,
- Advanced AR monitoring as well as providing modern technologies for a reasonable and also immersive experience,

2. Requirements Details

Functional Requirements:

User Management:

- User registration with email, name, password, contact number
- User login with email/ password or social login (Google, Apple)
- User account administration (view/edit account information).

Product Catalog:

- Search items by classification search, including listings.
- View comprehensive item info (title, summary, pictures measurements functions).
- Filter/sort item listings based upon standards like rate, rankings and so on.

AR Visualization:

- Find surface areas/ airplanes in the video camera sight to position AR designs.
- Provide 3D item versions with exact scaling based upon measurements.
- Enable repositioning, revolving resizing of AR version.
- Alternative to see items in various colors/materials if offered.
- Save/share AR visualization as photo/video.

Version Creation:

- Upload 3D version documents from regional storage space or cloud.
- Individualize version measurements, products, shades.
- Connect design with an existing or brand-new item listing.

Favorites/Wishlist:

- Add/remove items to a favorites/wishlist.
- View and manage favorites/wishlist.

Non-Functional Requirements:

Usability:

- User-friendly as well as easy to use user interface adhering to modern-day style techniques.
- Straightforward navigating as well as clear calls-to-action.
- Smooth AR combination within the application circulation.

Performance:

- Fast lots times for web pages as well as AR versions (+6.0+).
- Smooth AR visualization at 30+ FPS on the majority of gadgets.
- Reliable memory use along with battery optimization.

Compatibility:

- Most current Android (6.0+) as well as iOS (11.0+)variations.
- Maximized for various display dimensions and also resolutions.

Security:

- Secured interaction in between client-server.
- Saved individual passwords hashed along with salted.
- No delicate information kept on the customer.

Scalability:

- Capability to manage 100,000+ simultaneous individuals.
- Extremely offered web servers with tons of harmonizing.
- Smooth scaling of data source and also storage space.

3rd Party Integrations:

- APIs to incorporate with significant ecommerce systems.
- Repayment entrances for in-app acquisitions.
- Social sharing SDKs.

Ease of access:

- Assistance for VoiceOver, TalkBack for aesthetic problems.
- Different message for pictures, designs.
- Flexible message dimensions plus shade contrasts".

3. Final Architecture and Design Details

3.1. Overview

In this part, we will first clarify subsystem decomposition, where the part framework of our system is defined thoroughly with layouts and also the classes. After that we will provide hardware/software mapping of the system which reveals the allotment of sources in our program. After that we will discuss the persistent data management.

3.2. Subsystem Decomposition

vendAR will primarily be based on client-server architecture. The client side is the Flutter app responsible for displaying the UI and handling the routing and AR logic. It is also responsible for communicating with the server upon specific input events. The server side is the Spring Boot app responsible for storage, data flow and manipulation.

The client side will be decomposed into two subsystems (i.e. layers). These layers will be the View Layer and the Controller Layer. The View Layer is responsible for displaying the UI of our application using the Flutter framework. Each mockup (see Analysis and Requirement report, Sec. 2.5.5) we created is represented as a view component in the View Layer. The Controller Layer is responsible for handling input and sending the appropriate requests to the server side based on the received input. Every view component has its controller component associated with it that handles the input on that specific page.

The server side will also be decomposed into two subsystems. These layers will be the Logic Layer and the Data Layer. The Logic Layer is responsible for setting up endpoints for data retrieval, insertion, deletion and handling the query logic for these operations. The Data Layer is responsible for handling model classes to represent the E/R diagram we created, (see Analysis and Requirement Report, Fig. 4).

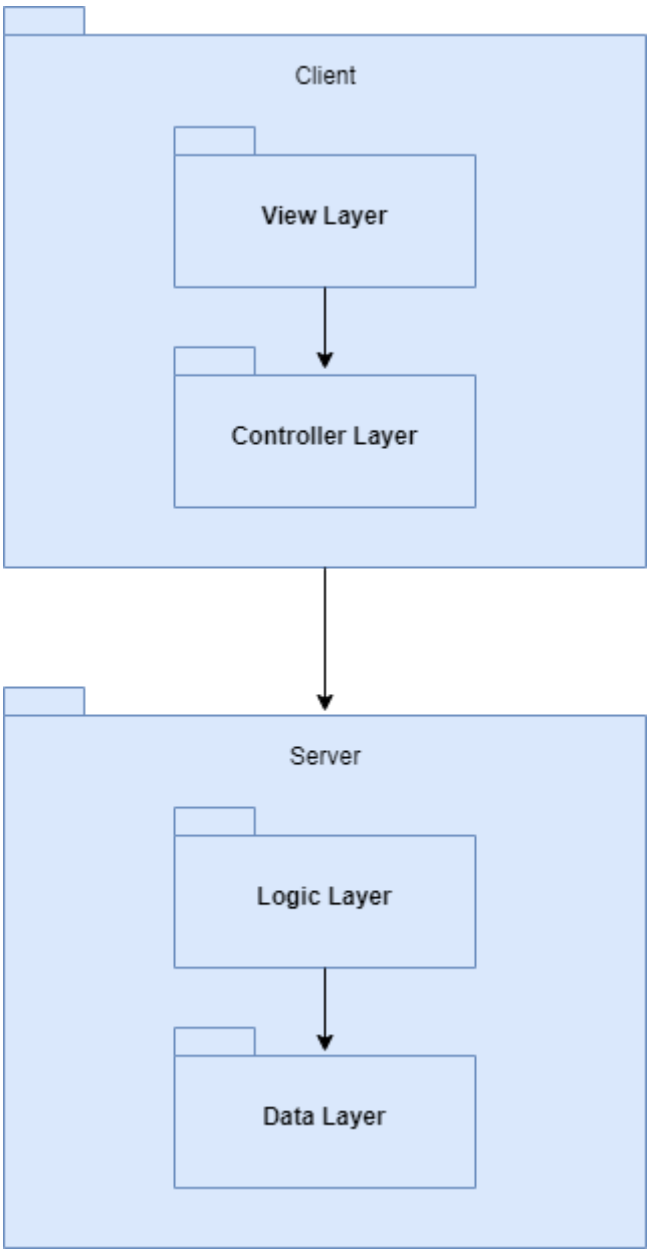

Fig. 1. Subsystem decomposition into client-server architecture

3.3. Hardware/software mapping

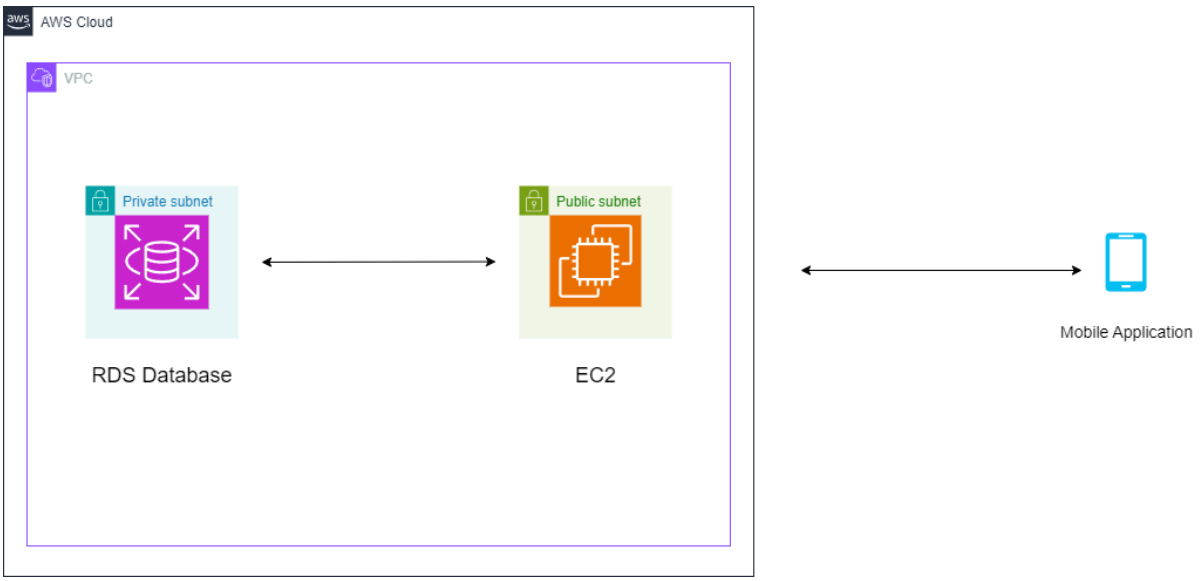

Fig. 2. Hardware/software mapping diagram

vendAR will be developed for Android and İOS with Flutter. Vendar will make use of the camera of the mobile device to present an AR service to the end users. Users will create models using the template model bases in vendAR. They will be stored in Google Drive using *NetworkImage*.

Flutter allows us to utilize the mobile device's hardware resources in order to place the models in desired locations via its camera. We will use Java Spring Boot that is deployed in the AWS EC2 machine to manage API calls to our PostgreSQL database and communicate with the database which also is hosted in AWS's RDS service. AWS machines and the client mobile device will be the hardware that is used. Flutter, spring boot and PostgreSQL will be the software parts of vendAR.

3.4. Persistent data management

vendAR needs to store user credentials, product models and product features in order to fetch and manipulate them when needed. We use GoogleDrive *NetworkImage* to store the product models. For the user credentials and the product details we use PostgreSQL in AWS cloud service. It stores our data in tables since it's a relational database and returns the queries as JSON objects to our application when requested. It is up 24/7 and we can take snapshots for backup both automatically and manually through AWS to prevent possible data losses.

4. Development/Implementation Details

4.1. Frontend

4.1.1 Architecture

For the frontend development side of our application, we have used Flutter in order to make our mobile app compatible with both Android and IOS. We have followed the classic MVC (Model - View - Controller) architecture. For implementing such a feature, for each of the pages we have in our application we have a different folder which contains view and controller files. In controller files, the programming logic and API calls took place as in the view files we only had the UI elements. By not holding data or logic inside the view files, we could easily adjust our UI elements. After fetching the JSON format from our backend with API calls, we have converted it to our predefined models so that we can use them easily both in our controllers and views.

4.1.2 Augmented Reality

For the AR (Augmented Reality) part of our application we have used Google's ARCore library in order to scan the surface and place a 3D object there. After replacement, the user can rotate and replace the object via the custom modifications we have made in our library. In order to integrate Google's Android-native ARCore library into our Flutter project we have used a wrapper library named arcore-flutter that is available in pub.dev repository.

4.2. Backend

4.2.1. Security

We have used Spring Security library for the security implementation of our application. It allows us to create security chains that define our security criteria including accessible endpoints, allowed user types, behavior on rejected requests and response management. It is an exceptional library that changes the way your app runs from the moment it is imported into the project. This ensures all endpoints have access permission definitions since it rejects the request coming to them otherwise. We also used encoded passwords for users' privacy.

4.2.2. Authentication

For the authentication of our application, we have used JWT to give access to the correct users with the token information. We made it obligatory for all endpoints other than register and login to include a user token for the request to be valid. This allows us to fetch the

correct user's data and makes sure that a user has access to only his own data. This token also eases our job in our endpoints via giving the user's unique information directly.

4.2.3. Model Classes

Model classes are responsible for representing our E/R diagram in terms of properties.

4.2.4. Controller Classes

Controller classes are responsible for setting up the endpoints and executing relevant queries by communicating with the database.

4.3. Database

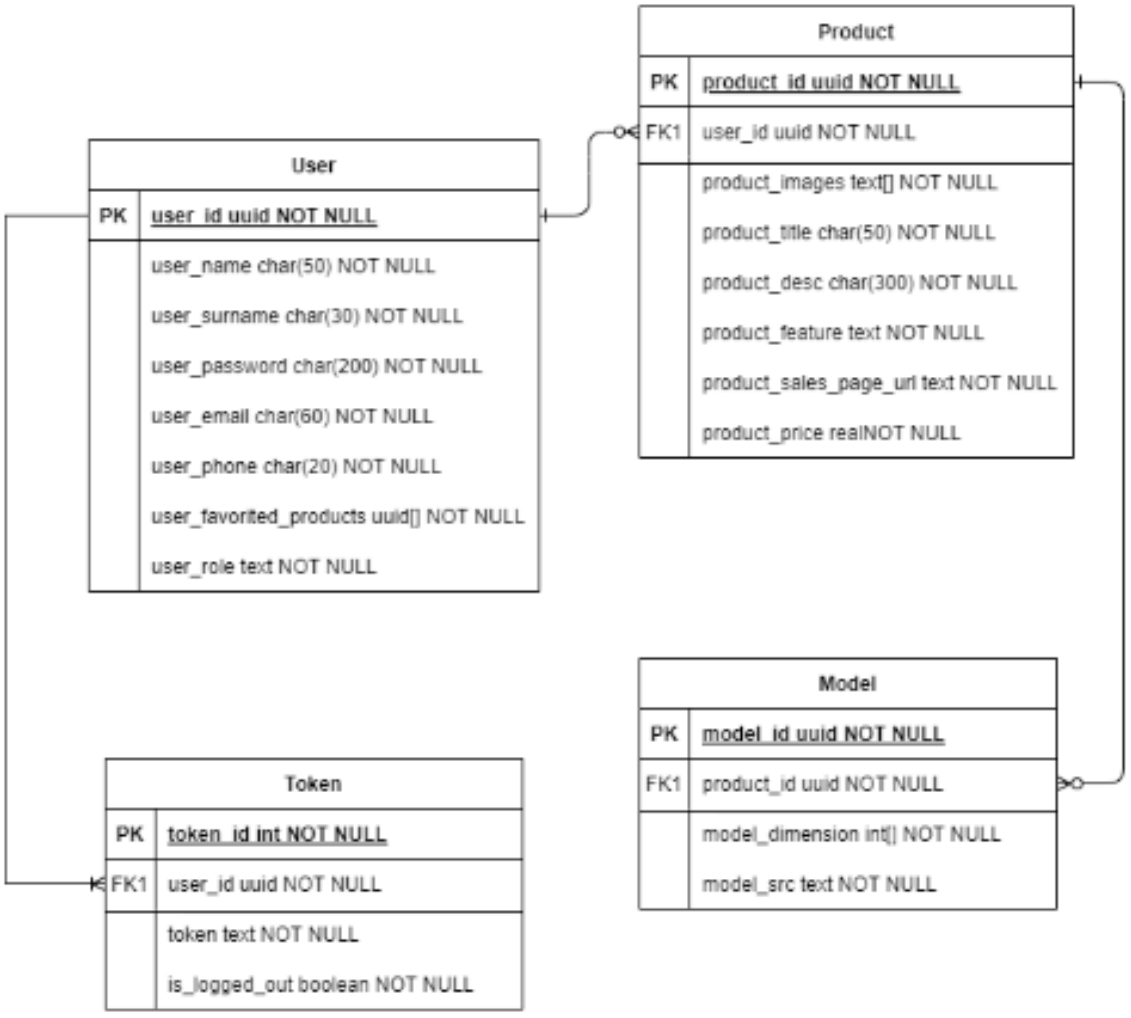

Fig. 3: vendAR E/R diagram

We have four tables in our database. Each user is associated with a token so that their session can be established. User and product entities have one-to-many relationship so, users can hold many products. Product and Model entities have one-to-one relationship so, the products have a model associated with them.

4.4. Models

We used Blender [1] to make and adjust the models. Later, we exported them as .glb [2] files to use in the AR Flutter Library [3].

5. Test Cases and Results

5.1 Functional Test Cases

Test Case 1: TC_Login_01

Description: To test if a successful login can be made and the home page can be reached with the account.

Preconditions: Login Page is launched. There is an account to be used for the test.

Test Steps:

1. Enter the account information.
2. Press the confirmation button.

Result: Success

Test Case 2: TC_Login_02

Description: To test if a successful login can be made without filling both fields.

Preconditions: Login page is launched.

Test Steps:

1. Enter the account information for one of the fields or don’t enter at all.
2. Press the confirmation button.

Result: Success

Test Case 3: TC_Login_03

Description: To test if a successful login can be made with incorrect account information.

Preconditions: Login page is launched.

Test Steps:

1. Enter the wrong account information for one of the fields or both fields.
2. Press the confirmation button.

Result: Success

Test Case 4: TC_Login_04

Description: To test if a successful login can be made using the Sign in with Google option.

Preconditions: Login page is launched. There is a Google account that is logged in on the phone.

Test Steps:

1. Press the Sign in with Google button.
2. Select the Google account and give the necessary permissions Google asks for.

Result: Not implemented yet

Test Case 5: TC_Login_05

Description: To test if a successful login can be made using the Sign in with Apple option.

Preconditions: Login page is launched. There is an Apple account that is logged in on the phone. The phone is an IOS phone.

Test Steps:

1. Press the Sign in with Apple button.
2. Select the Apple account and give the necessary permissions Apple asks for.

Result: Not implemented yet

Test Case 6: TC_SignUp_01

Description: To test if a successful sign up can be made by creating an account.

Preconditions: Login page is launched. The email that will be used for new account creation isn't already used in an already existing account.

Test Steps:

1. Press the Sign Up button.
2. Enter the account information.
3. Press the confirm button.
4. After the Login Page is launched enter the account information to login
5. Press the confirm button.

Result: Success

Test Case 7: TC_SignUp_02

Description: To test if a successful sign up can be made by creating an account with an already used email.

Preconditions: Login page is launched. The email that will be used for new account creation is already used in an already existing account.

Test Steps:

1. Press the Sign Up button.
2. Enter the account information.
3. Press the confirm button.

Result: Success

Test Case 8: TC_SignUp_03

Description: To test if a successful sign up can be made by creating an account when the name or the surname fields are empty.

Preconditions: Login page is launched. The email that will be used for new account creation isn’t already used in an already existing account. A unique phone number is used for the testing.

Test Steps:

1. Press the Sign Up button.
2. Enter the account information leaving one or both of the name fields empty.
3. Press the confirm button.

Result: Success

Test Case 9: TC_SignUp_04

Description: To test if a successful sign up can be made by creating an account when the phone number field is empty.

Preconditions: Login page is launched. The email that will be used for new account creation isn’t already used in an already existing account. A unique name and surname is used for the testing.

Test Steps:

1. Press the Sign Up button.
2. Enter the account information leaving the phone number field empty.
3. Press the confirm button.

Result: Success

Test Case 10: TC_SignUp_05

Description: To test if a successful sign up can be made by creating an account when the phone number of the account is used before.

Preconditions: Login page is launched. The email that will be used for new account creation isn't already used in an already existing account. The phone number that will be used is already used in another account.

Test Steps:

1. Press the Sign Up button.
2. Enter the account information using the phone number that was already used for another account.
3. Press the confirm button.

Result: Success

Test Case 11: TC_HomePage_01

Description: To test if the Home Page can be used to interact with the categories.

Preconditions: A successful login has been made. The Home Page is launched. There are some products created that have specified categories.

Test Steps:

1. Select a category from the top part of the Home Page
2. Press on the selected category panel.

Result: Success

Test Case 12: TC_HomePage_02

Description: To test if the Home Page can be used to interact with the products.

Preconditions: A successful login has been made. The Home Page is launched. There are some products created.

Test Steps:

1. Select a product from the top part of the Home Page
2. Press on the selected products panel.

Result: Success

Test Case 13: TC_HomePage_03

Description: To test if the Home Page can be used to open the Product Creation Page.

Preconditions: A successful login has been made. The Home Page is launched.

Test Steps:

1. Press the Product Creation button. (Bottom right button with the plus sign)

Result: Success

Test Case 14: TC_HomePage_04

Description: To test if the Home Page can be used to use the search function.

Preconditions: A successful login has been made. The Home Page is launched. There some products created so that they can be searched.

Test Steps:

1. Press the search icon on the top right.
2. Write existing tags or product names that already exist so they can be searched.
3. Press the confirm button to finalize the search.

Result: Success

Test Case 15: TC_HomePage_05

Description: To test if the Home Page can be used to toggle dark mode.

Preconditions: A successful login has been made. The Home Page is launched.

Test Steps:

1. Press the kebab menu (3 dots) on the top right.
2. Press the dark mode switch on the drop down menu that is displayed.

Result: Not implemented yet

Test Case 16: TC_HomePage_06

Description: To test if the Home Page can be used to change language.

Preconditions: A successful login has been made. The Home Page is launched.

Test Steps:

1. Press the kebab menu (3 dots) on the top right.
2. Press the language button on the drop down menu that is displayed.
3. Pick the language you want from the drop down menu that is displayed.

Result: Not implemented yet

Test Case 17: TC_HomePage_07

Description: To test if the Home Page can be used to view Terms of Service and Privacy Policy.

Preconditions: A successful login has been made. The Home Page is launched.

Test Steps:

1. Press the kebab menu (3 dots) on the top right.
2. Press the Terms of Service or Privacy Policy button on the drop down menu that is displayed.

Result: Not implemented yet

Test Case 18: TC_HomePage_08

Description: To test if the Home Page can be used to traverse the application using the navigation bar at the bottom.

Preconditions: A successful login has been made. The Home Page is launched.

Test Steps:

1. Press an option from the navigation menu.
2. Press the option that wasn't pressed on the previous step.
3. Press on the home option.

Result: Success

Test Case 19: TC_ProductCreation_01

Description: To test if the Product Creation can be successfully completed.

Preconditions: A successful login has been made. The Product Creation Page is launched from the Home Page.

Test Steps:

1. Fill out all the information for the product.
2. Import a model or select a template.
3. Press the confirm button to complete the creation.

Result: Success

Test Case 20: TC_ProductCreation_02

Description: To test if the Product Creation can be successfully completed without all the fields completely filled out.

Preconditions: A successful login has been made. The Product Creation Page is launched from the Home Page.

Test Steps:

1. Fill out all the information for the product except one field. This can be any field from the product name, price, images or the model.
2. Press the confirm button to complete the creation.

Result: Success

Test Case 21: TC_ProductCreation_03

Description: To test if the Product Creation can be successfully canceled.

Preconditions: A successful login has been made. The Product Creation Page is launched from the Home Page.

Test Steps:

1. Fill out some fields of the page.
2. Press the cross on the top left of the Product Creation Page.

Result: Success

Test Case 22: TC_ProductPage_01

Description: To test if the Product Model can be successfully viewed from the Product page and if it can be viewed in AR and in 3D.

Preconditions: A successful login has been made. The Home Page is launched. There is at least one product that exists.

Test Steps:

1. Select and press on a product.
2. In the product page press on the View Model button.
3. After the model page is launched press on the model switch to view in AR.
4. Press the cross on the top left to return to the product page.

Result: Success

Test Case 23: TC_ProductPage_02

Description: To test if the product can be bought by using the Order Here button.

Preconditions: A successful login has been made. The Home Page is launched. There is at least one product that exists.

Test Steps:

1. Select and press on a product.
2. In the product page press on the Order Here button.
3. Choose the browser you will use from the menu that will be displayed.

Result: Success

Test Case 24: TC_ProductPage_03

Description: To test if the product can be marked as favorite.

Preconditions: A successful login has been made. The Home Page is launched. There is at least one product that exists.

Test Steps:

1. Select and press on a product.
2. In the product page press on the star button on the top right.

Result: Success

Test Case 25: TC_ProductPage_04

Description: To test if the Product Page can be exited.

Preconditions: A successful login has been made. The Home Page is launched. There is at least one product that exists.

Test Steps:

1. Select and press on a product.
2. In the product page press on the cross on the top left.

Result: Success

Test Case 26: TC_FavoritesPage_01

Description: To test if the Favorites Page can be used for opening a Product.

Preconditions: A successful login has been made. The Favorites Page is launched. There is at least one product that is added to the favorites.

Test Steps:

1. Select and press on a product.
2. In the product page press on the cross on the top left.

Result: Success

Test Case 27: TC_FavoritesPage_02

Description: To test if the Favorites Page can be used for opening a Product to unfavorite the product.

Preconditions: A successful login has been made. The Favorites Page is launched. There is at least one product that is added to the favorites.

Test Steps:

1. Select and press on a product.
2. In the product page press on the star icon on the top right.
3. In the product page press on the cross on the top left.

Result: Success

Test Case 28: TC_ProfilePage_01

Description: To test if the Profile Page can be used for editing account information.

Preconditions: A successful login has been made. The Profile Page is launched. The new information for the email and phone number is unique.

Test Steps:

1. Select an information field to change.
2. Press the edit button and update the information.

Result: Success

Test Case 29: TC_ProfilePage_02

Description: To test if the Profile Page can be used for editing account information that is used in other accounts.

Preconditions: A successful login has been made. The Profile Page is launched. There is another account that uses the updated information.

Test Steps:

1. Select an information field to change.
2. Press the edit button and update the information.

Result: Success

Test Case 30: TC_ProfilePage_03

Description: To test if the Profile Page can be used changing the password.

Preconditions: A successful login has been made. The Profile Page is launched.

Test Steps:

1. Press the Change Password button.
2. Enter your old password.
3. Enter your new password.
4. Enter your new password again and press confirm.

Result: Success

Test Case 31: TC_ProfilePage_04

Description: To test if the Profile Page can be used for removing a product.

Preconditions: A successful login has been made. The Profile Page is launched. User has a product they created.

Test Steps:

1. Press on the desired product from the My Models section.
2. Press the Remove Model button.

Result: Success

5.2 Non-Functional Test Cases

Test Case 32: TC_Usability_01

Description: To test the ease of installation from the mobile application store.

Preconditions: The application is available on the mobile application store.

Test Steps:

1. Search for the application on the mobile application store.
2. Download and install the application.

Result: Not implemented yet

Test Case 33: TC_Usability_02

Description: To test the user interface's friendliness for users of all ages.

Preconditions: The application is launched.

Test Steps:

1. Use the application interface across different age groups, including children and elderly users.
2. Refer to the user manual that will be provided for guidance.

Result: Success

Test Case 34: TC_Usability_03

Description: To test the clarity of the application concept for non-professionals.

Preconditions: The application is launched.

Test Steps:

1. Present the application concept to individuals not familiar with the field.
2. Observe their understanding and gather feedback.

Result: Success

Test Case 35: TC_Reliability_01

Description: To test the application's stability during installation and running.

Preconditions: The application is installed and running.

Test Steps:

1. Monitor for any crashes or unexpected terminations during installation.
2. Continuously use the application and monitor for any crashes during runtime.

Result: Success

Test Case 36: TC_Reliability_02

Description: To test the responsiveness of the application during camera usage.

Preconditions: The application is running, and the camera feature is accessed.

Test Steps:

1. Utilize the camera feature extensively within the application.
2. Observe for any delays or lags in camera responsiveness.

Result: Success

Test Case 37: TC_Reliability_03

Description: To test the application's compatibility across mobile-based operating systems.

Preconditions: The application is installed on different mobile-based operating systems.

Test Steps:

1. Run the application on various mobile-based operating systems.

Result: Success

Test Case 38: TC_Performance_01

Description: To test the efficiency of resource allocation and execution time.

Preconditions: The application is running.

Test Steps:

1. Monitor the application's resource usage and execution time during various tasks.

Result: Success

Test Case 39: TC_Performance_02

Description: To test the application's compatibility with older generation smartphones.

Preconditions: The application is installed on older generation smartphones.

Test Steps:

1. Run the application on older generation smartphones with camera functionality.

Result: Success

Test Case 40: TC_Performance_03

Description: To test the speed of data transactions within the application.

Preconditions: The application is running and performing data transactions.

Test Steps:

1. Measure the time taken for various data transactions within the application.

Result: Success

Test Case 41: TC_PrivacySecurity_01

Description: To test the compliance with PDPA regarding data collection.

Preconditions: The application is running and collecting user data.

Test Steps:

1. Review the data collected by the application and compare it with PDPA guidelines.

Result: Success

Test Case 42: TC_PrivacySecurity_02

Description: To test the camera usage privacy controls.

Preconditions: The application is running and accessing the device's camera.

Test Steps:

1. Monitor camera usage and permissions granted by the application.

Result: Success

Test Case 43: TC_PrivacySecurity_03

Description: To test the privacy of saved images or videos.

Preconditions: The application is running and saving images or videos.

Test Steps:

1. Review the storage location and access permissions for saved images or videos.

Result: Success

Test Case 44: TC_Scalability_01

Description: To test the application's ability to handle concurrent user access.

Preconditions: The application is running with multiple users accessing it simultaneously.

Test Steps:

1. Simulate high user traffic accessing the application concurrently.

Result: Success

6. Maintenance Plan and Details

Software Program Updates and Patches:

- On a regular basis keep track of and also use updates/patches for Flutter, Android, iphone, ARCore, ARKit and also various other third-party collections made use of
- Examination updates extensively throughout various tools as well as OS variations prior to manufacturing rollout
- Developed automated develop as well as release pipes

Performance Monitoring and Optimizations:

- Carry out surveillance devices to track application efficiency, web server lots, data source wellness
- Maximize 3D versions, structures and also shaders for effective making on varied tools
- Account plus maximize code bases (Flutter, Spring Boot) for memory use and also responsiveness
- Take advantage of cloud auto-scaling abilities to manage height individual tons

Security Audits and Penetration Testing:

- Perform normal safety audits together with infiltration screening to determine susceptibilities
- Execute protected coding techniques as well as code evaluations
- Use protection spots in a prompt way
- Restore along with upgrade SSL certificates for HTTPS interaction

Content Refreshes and Integrations:

- Routine revitalizes of the 3D item brochure by including brand-new versions
- Develop procedures to take apart outdated/unavailable item listings
- Incorporate with most recent item data/model resources from furnishings suppliers
- Update along with expand e-commerce system combinations as called for

User Feedback and Issue Management:

- Carry out collision record coupled with customer comments collection systems
- Triaging plus focus on concerns based upon intensity as well as effects
- Keep a stockpile of pests, adjustment demands together with brand-new attribute asks for
- Interact routinely with customers on problem standing plus launch notes

Framework Maintenance:

- Screen and also update AWS facilities (EC2, RDS, networking) as required
- Data source upkeep - back-ups, indexing, question optimizations
- Storage space upkeep for 3D versions and also individual information on AWS/Google Cloud

Team Training and Knowledge Sharing:

- Constant training of group on most current AR/3D/mobile/ cloud innovations
- Inner understanding sharing sessions on much better execution techniques
- Onboarding prepare for brand-new staff member on task style and also codebases

7. Other Project Elements

7.1. Consideration of Various Factors in Engineering Design

- User needs and expectations for an AR furniture visualization app
- Technical feasibility of implementing AR and 3D rendering on mobile devices
- Performance and resource constraints of target mobile hardware
- Integration requirements with existing e-commerce platforms
- Compliance with platform guidelines (Apple, Google) for AR apps
- Data privacy regulations for handling user data
- Scalability to support a growing user base and product catalog

7.1.1 Constraints

Hardware Constraints:

- Limited computing power and memory on mobile devices for AR/3D rendering
- Camera quality and AR tracking capabilities of different device models
- Battery life implications of running AR experiences

Software Constraints:

- Limitations of the chosen AR frameworks (ARCore, ARKit) and 3D engines
- Compatibility across different Android/iOS versions and devices
- Performance constraints of the Flutter cross-platform framework

Data Constraints:

- Storage requirements for 3D product models and their metadata
- Bandwidth constraints for downloading high-poly 3D models

7.1.2 Standards

- AR Development: ARCore guidelines (Android), ARKit best practices (iOS)
- Security: OWASP mobile app security guidelines, encryption standards
- Usability: Material Design (Android), Human Interface Guidelines (iOS)
- Accessibility: Web Content Accessibility Guidelines (WCAG)
- Data Exchange: JSON, REST API design standards for integration
- 3D Model Formats: Standards like .obj, .gltf for import/export

7.2. Ethics and Professional Responsibilities

Privacy and Data Protection:

- Guaranteeing appropriate information defense as well as personal privacy steps are executed for managing individual information like login qualifications, individual info and also use information accumulated.
- Being clear regarding what information is gathered exactly how it is utilized, as well as providing customers regulate over their information with clear personal privacy plans.
- Executing safe information storage space, security of delicate info as well as adhering to information personal privacy laws like GDPR.

Responsible and Ethical AR Content:

- Guaranteeing that the 3D versions and also AR visualizations do not consist of any kind of offending, discriminatory, or unsafe material that might adversely influence customers.
- Carrying out small amounts as well as filtering system systems to protect against abuse of the AR abilities for underhanded or prohibited functions.

Fair Business Practices:

- Incorporating with shopping systems along with dealing with item info transparently, without any illegal methods or misstatement of items.

- Revealing any kind of funded web content, promotions, or associate advertising and marketing plainly to individuals.
- Supplying exact and also truthful info concerning the abilities as well as constraints of the AR visualization innovation.

Professional Conduct:

- Preserving discretion and also shielding copyright of included events (customers, companions, suppliers).
- Following software program licensing contracts as well as making use of third-party libraries/frameworks properly.
- Guaranteeing clear interaction as well as taking care of assumptions with stakeholders throughout the growth procedure.
- Advertising a collective comprehensive as well as moral workplace within the advancement group.

7.3. Teamwork Details

7.3.1. Contributing and functioning effectively on the team

We have shared the workload among ourselves such that each team member can work with the part that he is interested in and can bring the most contribution to the team and to the project. While assigning tasks and forming teams which are front-end, back-end and AR, we seek the past experiences such as internships and part-time working experiences of each team member. Ege has hands-on experience with the front-end development through various projects, so he takes the lead for the mobile application development side of the project. For the AR implementation and its integration with the application, Deniz is responsible since he took courses related to computer graphics before and is familiar with 3D modeling with Blender. For the backend implementation, Feyyaz, the leader of our team, also takes the lead with back-end development due to his past experiences along with Ender. Ender is also responsible for creating and maintaining the hosting environment through AWS due to the cloud computing course he is taking. Parsa is responsible for ensuring Android and IOS compatibility of our application along with testing. By having this kind of sharing of workload, we get the most from each team member to our project which increases our overall efficiency.

7.3.2. Helping creating a collaborative and inclusive environment

Despite the fact that all of us have our individual tasks, we never hesitate to ask each other for help. Ege, a frontend developer, might assist Feyyaz and Ender with some

issues related with the backend development or database queries if he can. Deniz, originally responsible for AR, might contribute to the overall architecture of the software as well as designing how the API calls will take place in the middleware. Parsa might also assist with the front-end development by contributing to creation of some pages whenever needed. Ender can also require help from Ege who is also familiar with hosting services. Since all of us have knowledge about multiple concepts, we can easily get assistance from each other. Since we have created a very inclusive environment from the beginning, we can ask for help from each other without any hesitation. By helping to create a more collaborative and inclusive environment, we contribute not only to our tasks but also each other's task to improve the quality of the project and efficiency.

7.3.3. Taking lead role and sharing leadership on the team

Even though our team leader is Feyyaz, each of us can take the lead whenever necessary for some specific topic or issue. A democratic, inclusive environment is ensured whenever we need to make a decision about a very general concept that concerns all aspects of the project. If the issue is too specific, anyone who has the knowledge and experience about it can lead the team through the process of handling it. Our team leader, Feyyaz, is responsible for the delivery of reports, assigning meetings and process tracking of each member where each member can lead the subtasks and take responsibility for it. Overall, the leadership is shared among the team and each member is capable of leading the whole team whenever it is necessary.

7.3.4. Meeting objectives

We were able to come up with a fully working application with a finished frontend and backend application connected to each other. In the AR functionality, We were able to upload GLB files and use template models but we were not able to integrate LIDAR or able to set up dimensions for the template objects. Overall, the application is in a stable state and can be polished further with more time.

7.4 New Knowledge Acquired and Applied

Augmented Reality (AR) Development:

The core capability of VendAR focuses on increased fact visualization of 3D furnishings designs. We obtained understanding together with abilities in establishing AR applications recognizing AR structures and also SDKs (such as ARCore for Android plus ARKit for iphone) executing AR monitoring and also providing, as well as managing the complexities of incorporating 3D designs in real life settings.

3D Modeling as and Rendering:
To present precise as well as reasonable 3D designs of furnishings in the Air Conditioning atmosphere, we found out strategies for 3D modeling, appearance mapping, illumination, as well as optimizing 3D versions for effective making on smartphones. We made use of 3D modeling software programs or obtained expertise in taking care of 3D documents styles like .glb or .gltf.

Cross-Platform Mobile Development:
Given That VendAR is being established for both Android as well as iphone systems making use of Flutter, we obtained understanding in creating cross-platform applications with Flutter comprehending its style, as well as dealing with platform-specific obstacles or combinations (e.g., with AR structures).

Client-Server Architecture with API Development:
We discovered creating along with executing client-server interaction establishing RESTful APIs, dealing with information circulation in between the customer plus web server, together with incorporating with cloud solutions like AWS.

Database Administration and persistent Data Storage:
We found out about data source layout, information modeling and also carrying out relentless information storage employing PostgreSQL, a relational data source monitoring system. They would certainly have gotten understanding in questioning information taking care of data source purchases together with incorporating the data source with the server-side application.

User Experience (UX) Design:
We discovered and used concepts of UX layout, interface layout and also functionality screening to guarantee a smooth and also interesting experience for customers.

8. Conclusion and Future Work

The vendAR app efficiently provides a cross-platform mobile application that permits users to envision furnishings in increased truth prior to buying choice. By leveraging sophisticated modern technologies like ARCore, ARKit, 3D providing as well as Flutter we produced an immersive and also straightforward experience.

The crucial functions such as real-time AR visualization, precise spatial mapping, personalized item choices as well as social sharing abilities supply a sensible sneak peek decreasing the uncertainty associated with getting furnishings. Via strenuous style, growth as well as screening procedures, we conquered technological obstacles as well as supplied a durable, scalable, and also safe and secure remedy.

Future Work:

While vendAR completes its core purposes there are numerous opportunities for future improvements as well as development:

1. Collaborative AR Experience: Implement real-time multi-user AR sessions making it possible for pals, family members or indoor developers to collaborate basically in picturing and also embellishing areas.

2. AI-Powered Design Recommendations: Leverage artificial intelligence to examine area measurements, existing design and also individual choices to offer tailored furnishings referrals as well as format pointers.
3. VirtualTry-On for Clothing/Accessories: Extend the AR abilities to make it possible for online try-on experiences for garments, fashion jewelry, as well as style devices improving the on the internet buying experience throughout several item groups.

4. Voice Commands plus Gesture Controls: Integrate voice regulates coupled with gesture-based controls for an extra all-natural together with hands-free AR communication boosting availability plus functionality.

5. Integration with Smart Home Ecosystems: Collaborate with wise house system service providers to allow AR visualization of linked house devices, illumination, and also automation systems within the customer's real atmosphere.

6. Augmented Product Manuals: Leverage AR to offer interactive detailed setting up directions and also upkeep overviews for furnishings and also residence items boosting the post-purchase experience.

7. Expansion to Enterprise as well as B2B Markets: Adapt the AR visualization system for business applications such as workplace intending, store layout and also trade convention cubicle simulations.

By continuously innovating together with increasing the function collection, vendAR can concrete its placement as a leading remedy in the increased truth and also shopping domain names driving client contentment, commitment, and also organization development.

9. User Manual

-Login Page

In this page a user can enter his/her email and the correct password. Afterwards, the user can press on the login button to enter the program. If the user doesn't have an account he/she may create one by pressing the register button to navigate to the related page.

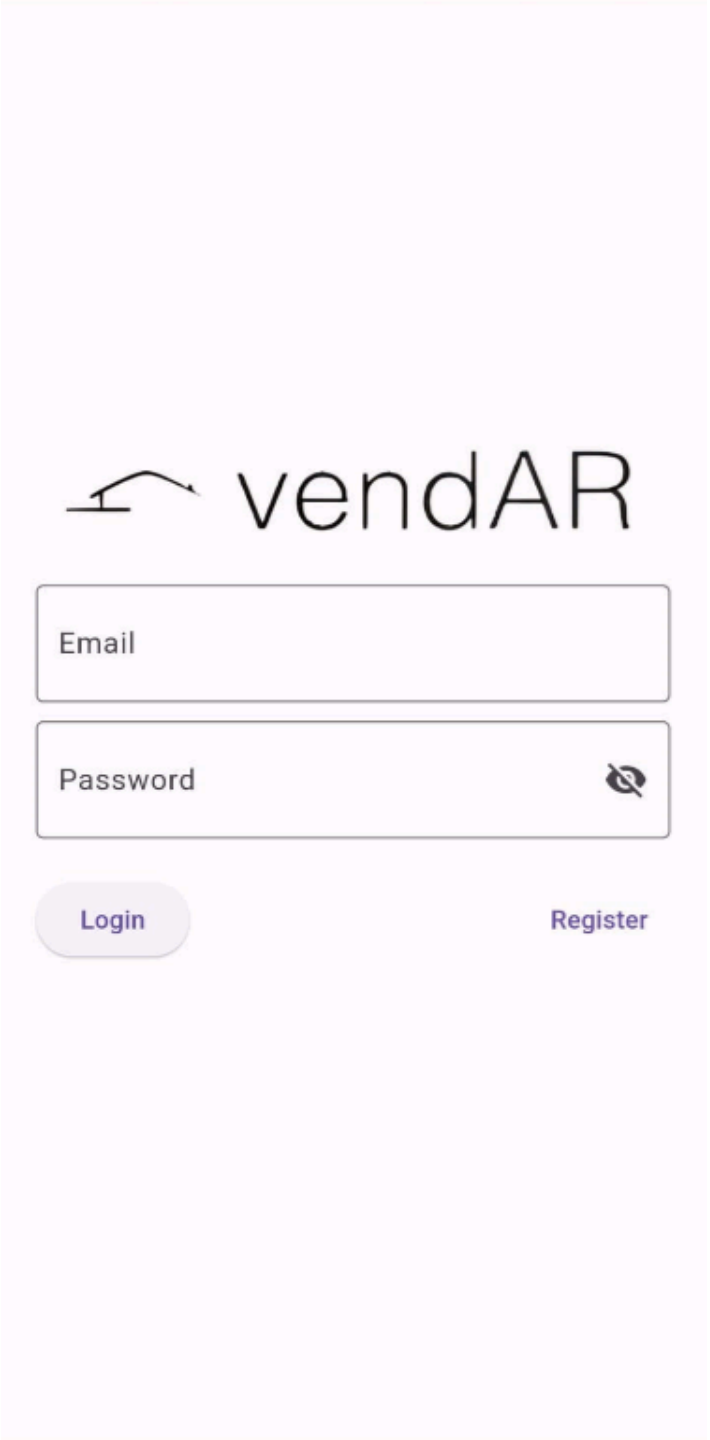

Fig. 4: vendAR Login Screen

-Register Page

In this page a user can create a new account by filling out the blank areas accordingly. He/She may press on the register button to create the account or press on the below hyperlink to get back to the login page.

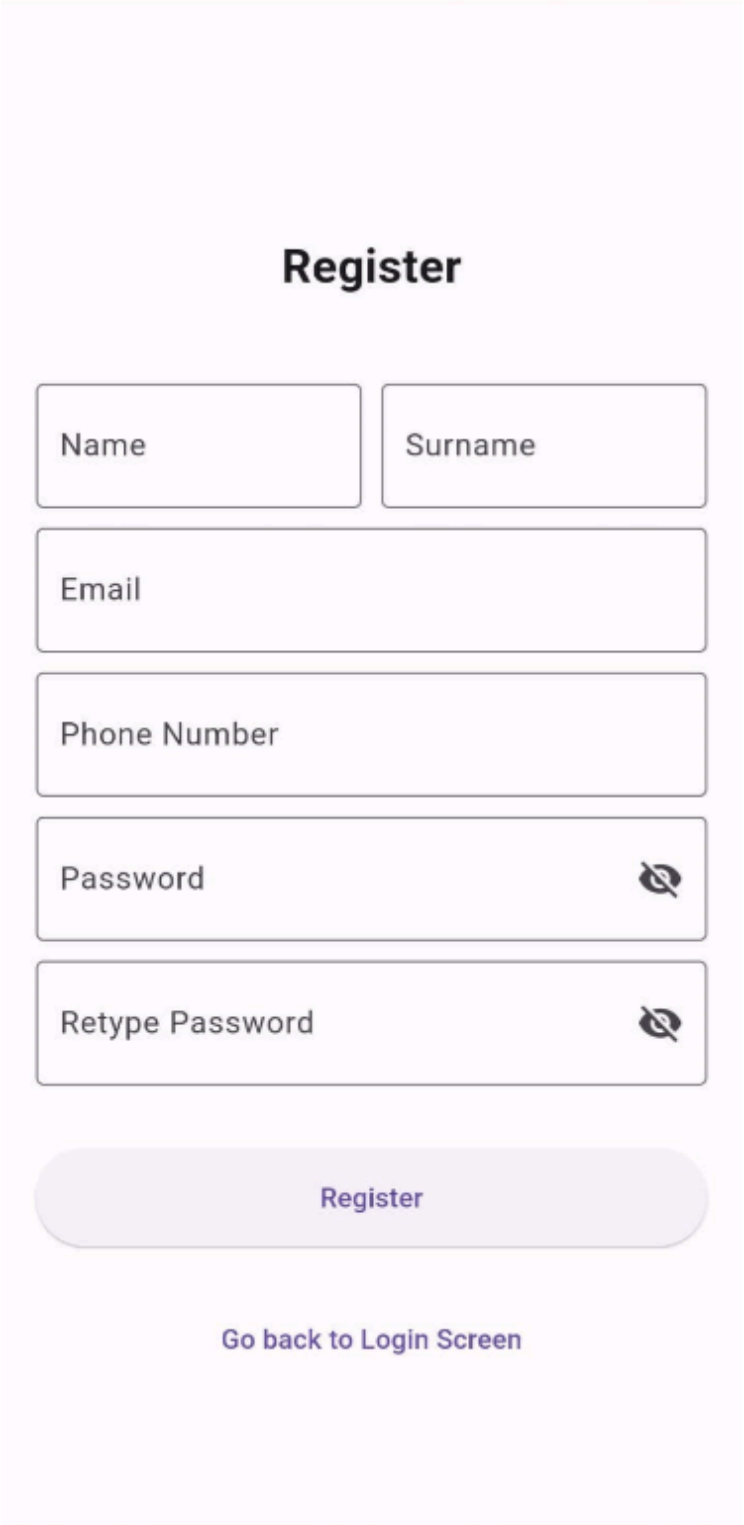

Fig. 5: vendAR Register Screen

-Home Page (Marketplace)

This is the page with most of the basic functionalities. Here, the user may visualize the products in different ways: filtering, searching or navigating through items by scrolling. The user may also click on a specific product to see the details accordingly. He/She may also add a new model by clicking on the add button on the bottom of the page or navigate to other sections as needed.

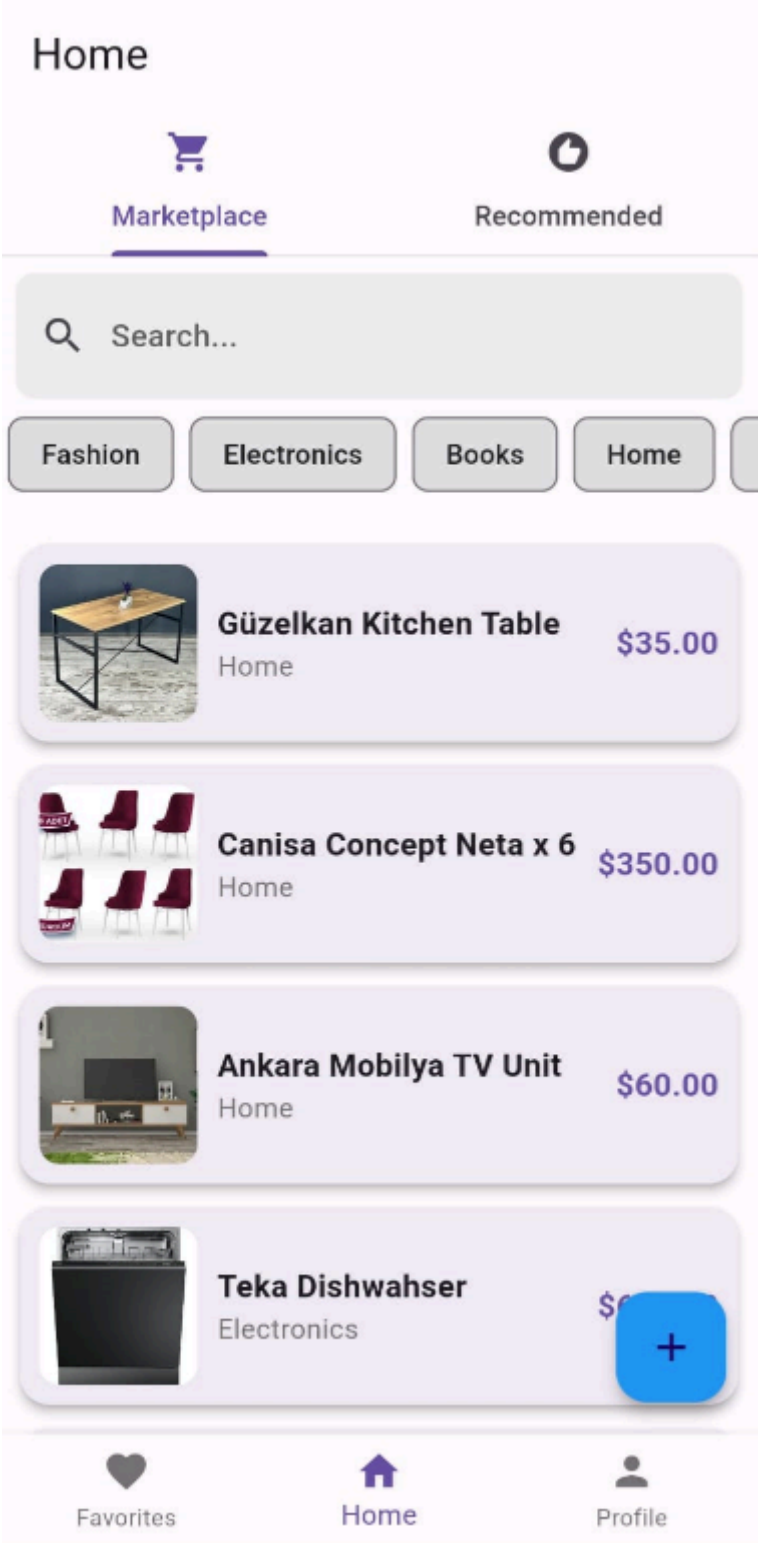

Fig. 6: vendAR Home Screen (Marketplace)

-Home Page (Recommended)

In this page the user may see a list of recommended items which are clickable and navigate through them by scrolling.

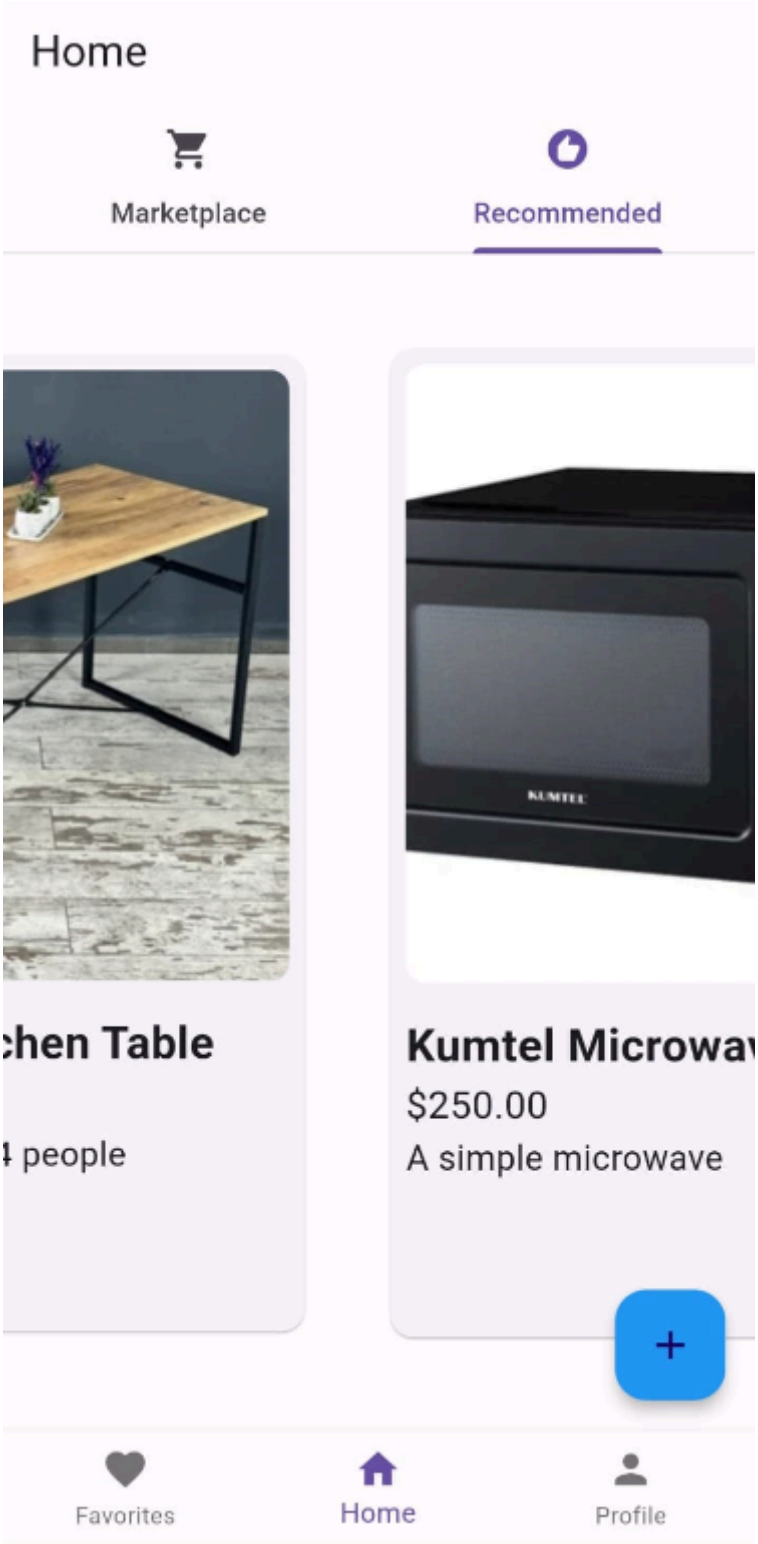

Fig. 7: vendAR Home Screen (Recommended)

-Add a new Model Page

In this page users can add a new model to the system by uploading a GLP or using an already existing template.

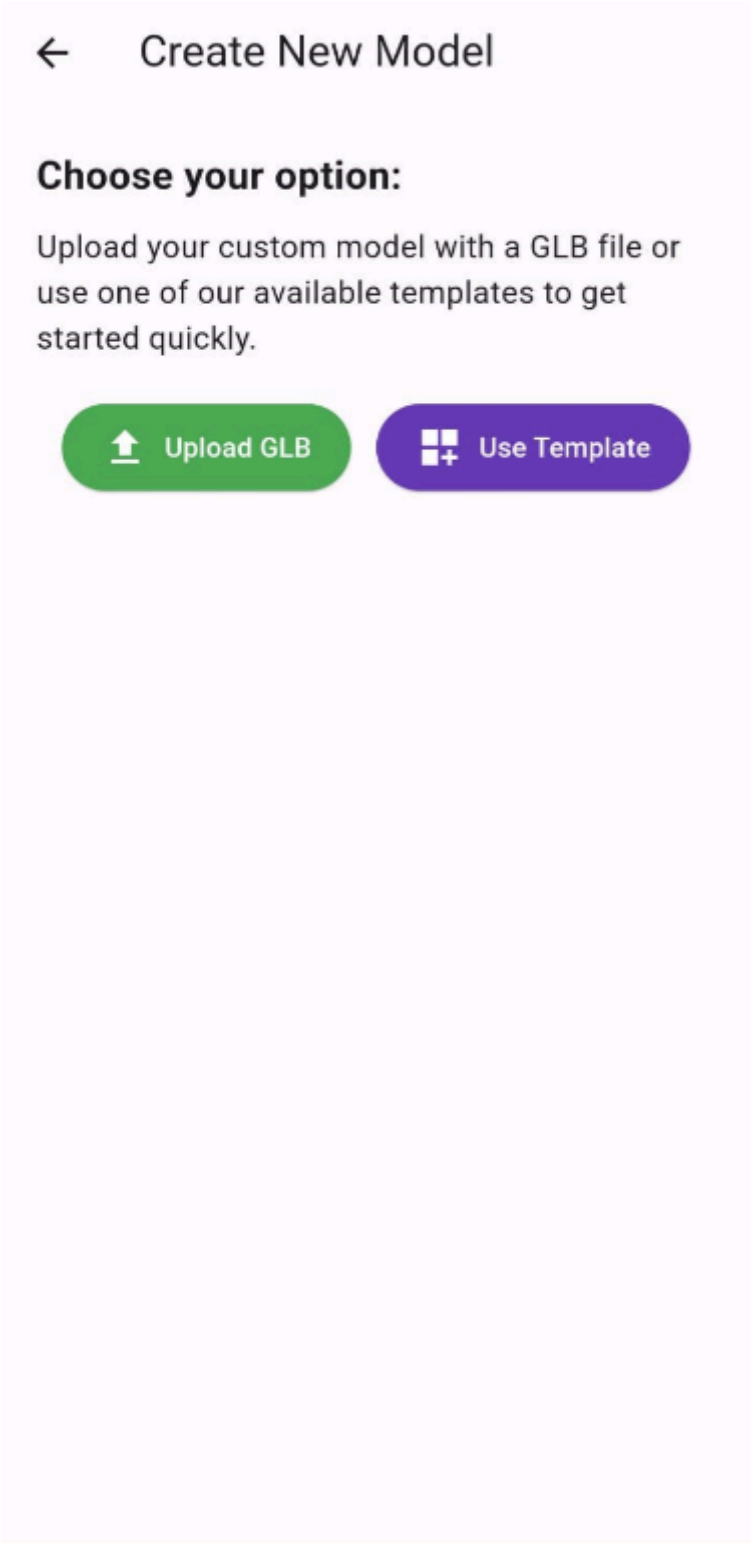

Fig. 8: vendAR Add New Model Screen

-Add a new GLB Model

In this page the user may add a new model to the system by filling the blank areas and add the images together with GLB format of their model accordingly. Afterwards, he/she may click on the Add Model button to add the model to the system.

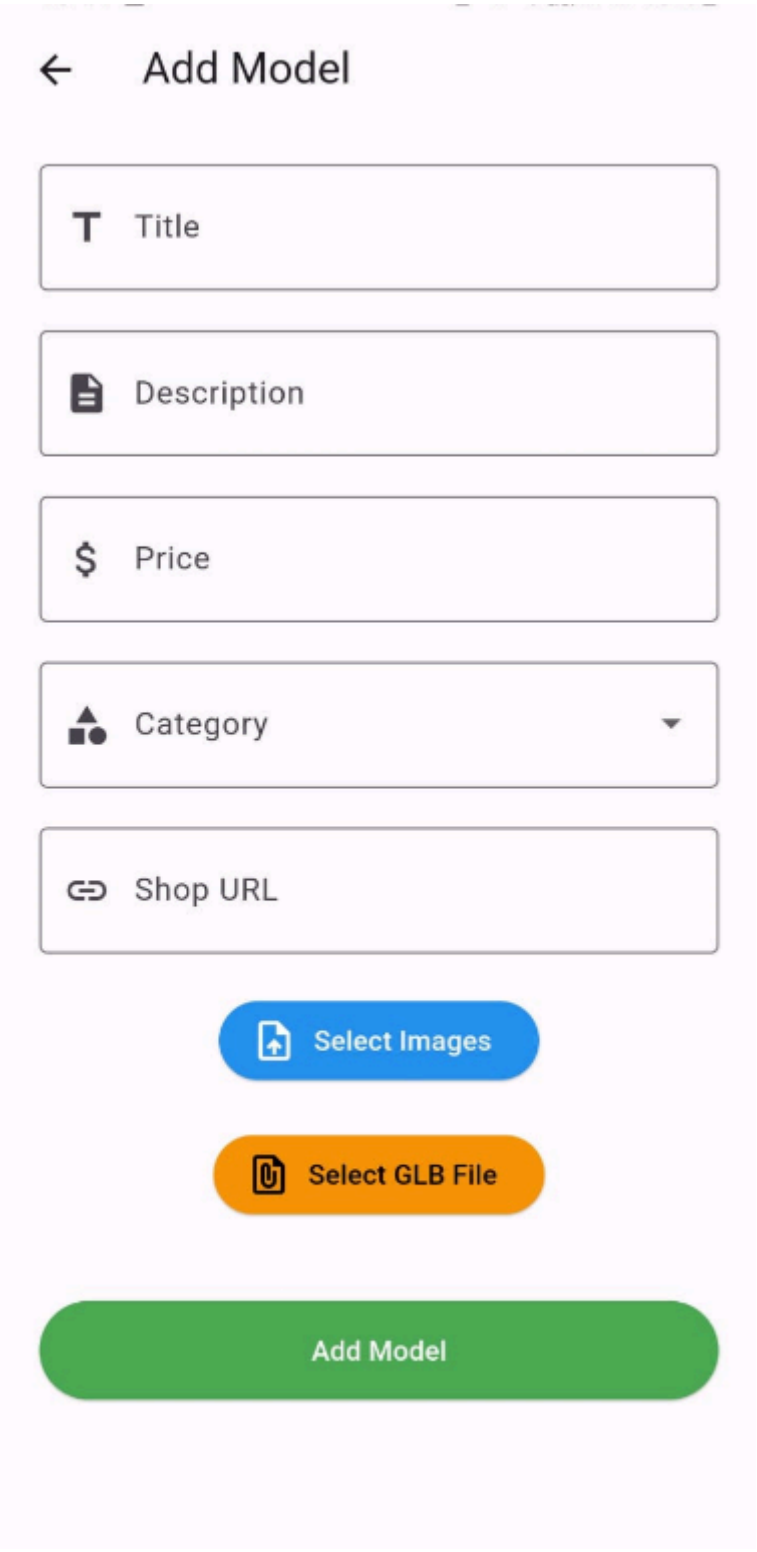

Fig. 9: vendAR Add New Model Details Screen

-Add a new Model (template) - step 1

In this page users can select an already existing template by searching or scrolling through them.

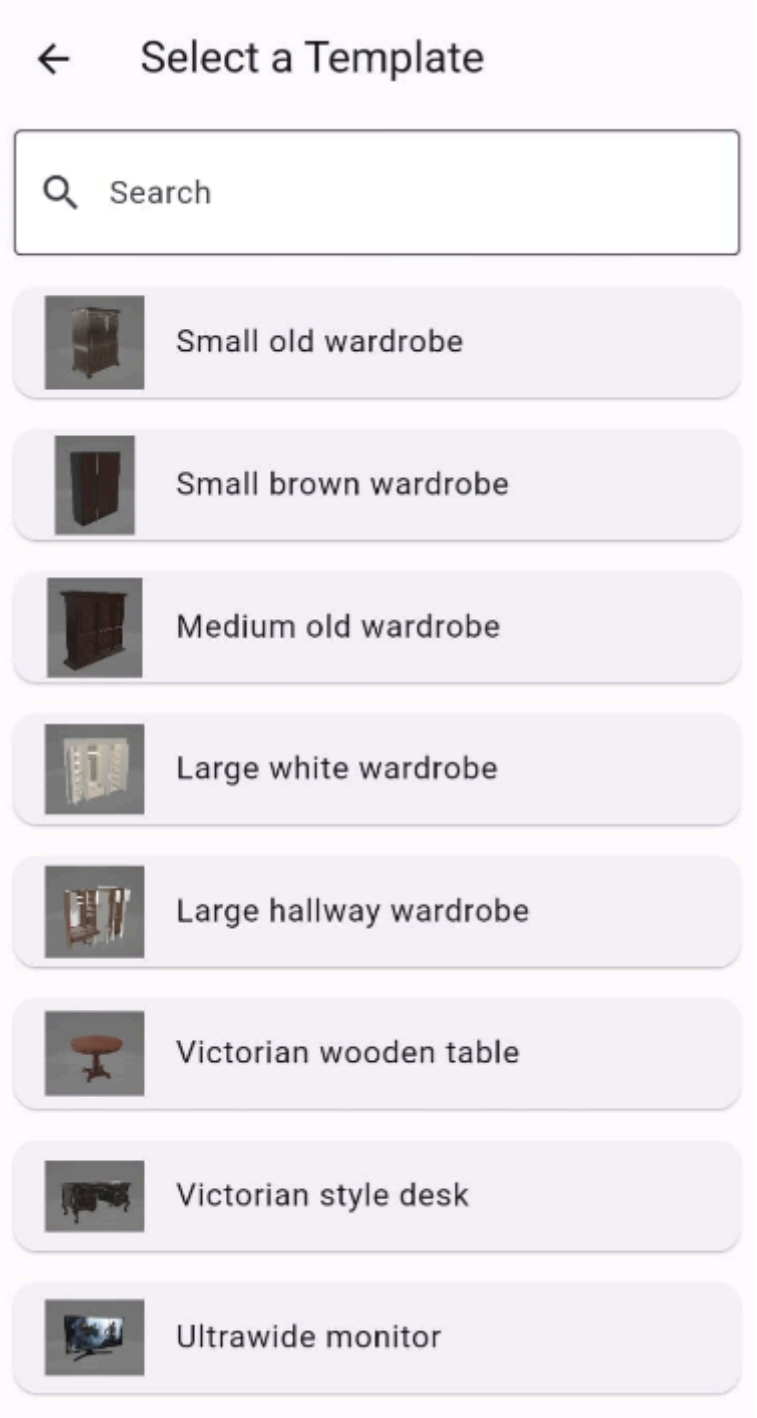

Fig. 10: vendAR Select Template Screen

-Add a new Model(template)-step 2

In this page users can fill in the blank areas after selecting the model template as needed and upload the corresponding image to add a new model to the system. The Save Change button is to add the model at the end.

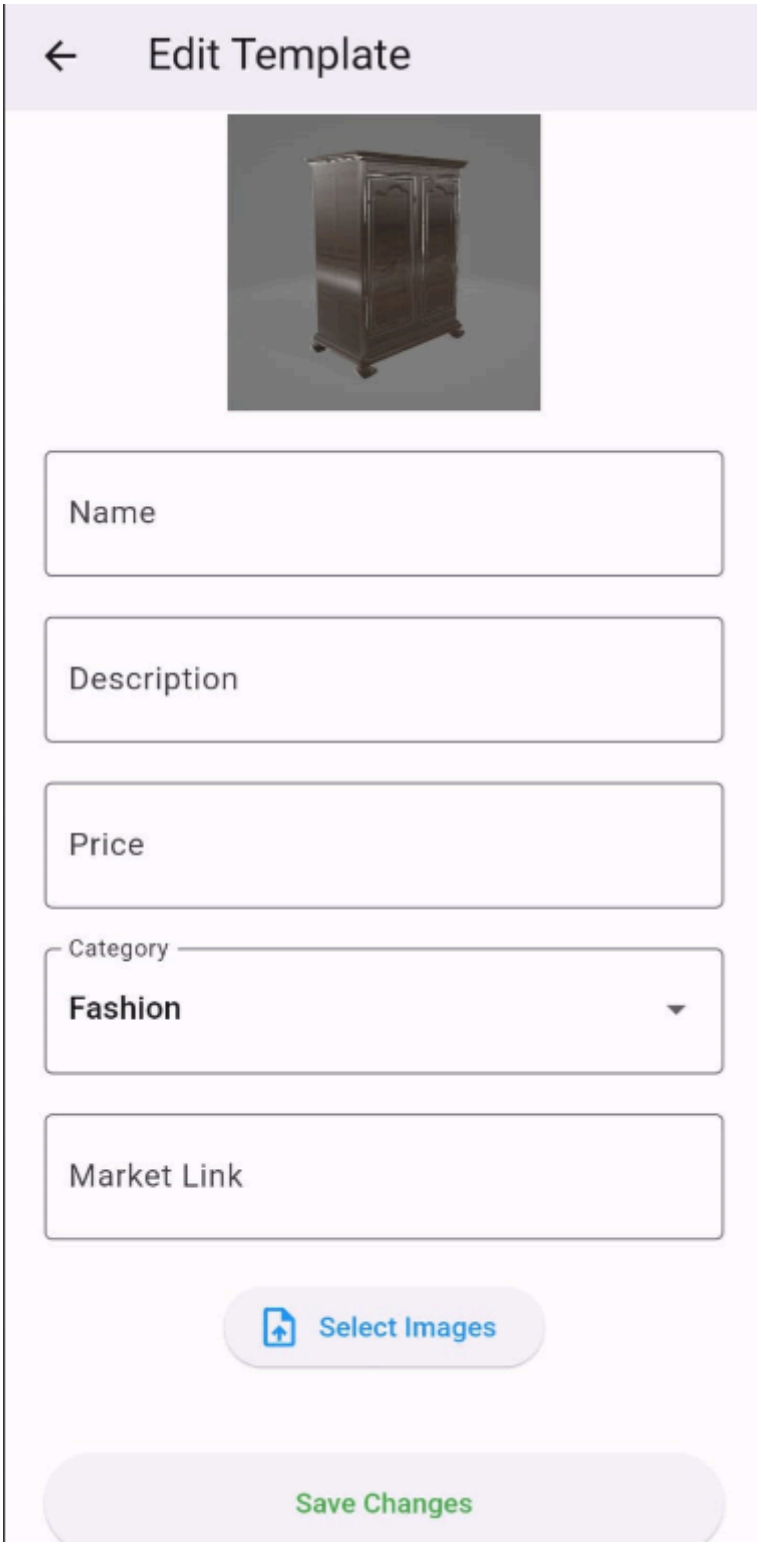

Fig. 11: vendAR Add New Model Details Screen

-Model Page

In this page the user can see the details related to a single model. He/She may view the model in their desired location by pressing on the “View Model Here” button or directly order the model by redirecting to the shopping website by clicking on the “Order Model Here” button. Also, there is a favorite button on the top right corner to add the model to the favorites page.

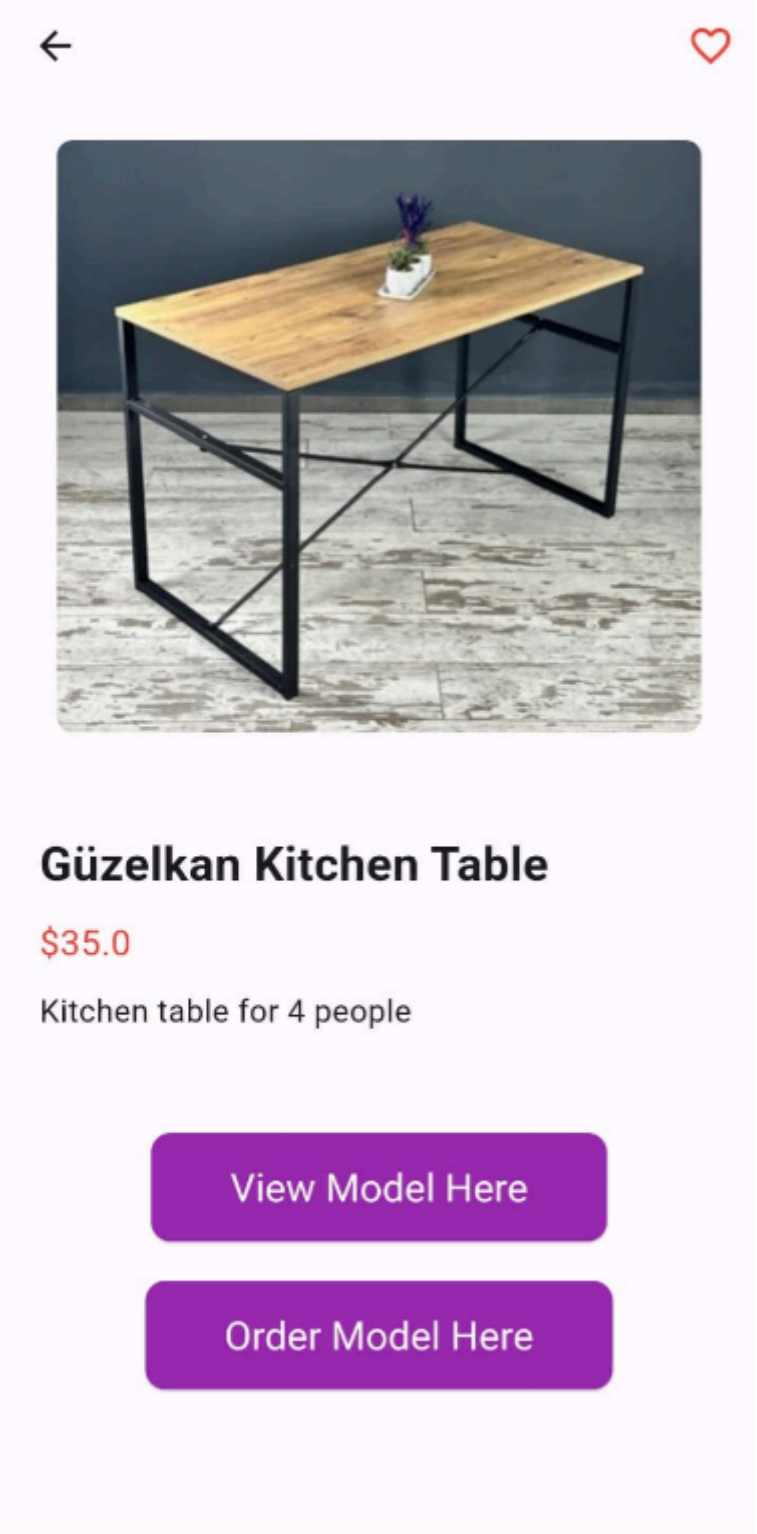

Fig. 12: vendAR View Product Screen

-Favorites Page

In this page users can see a list of previously liked models.

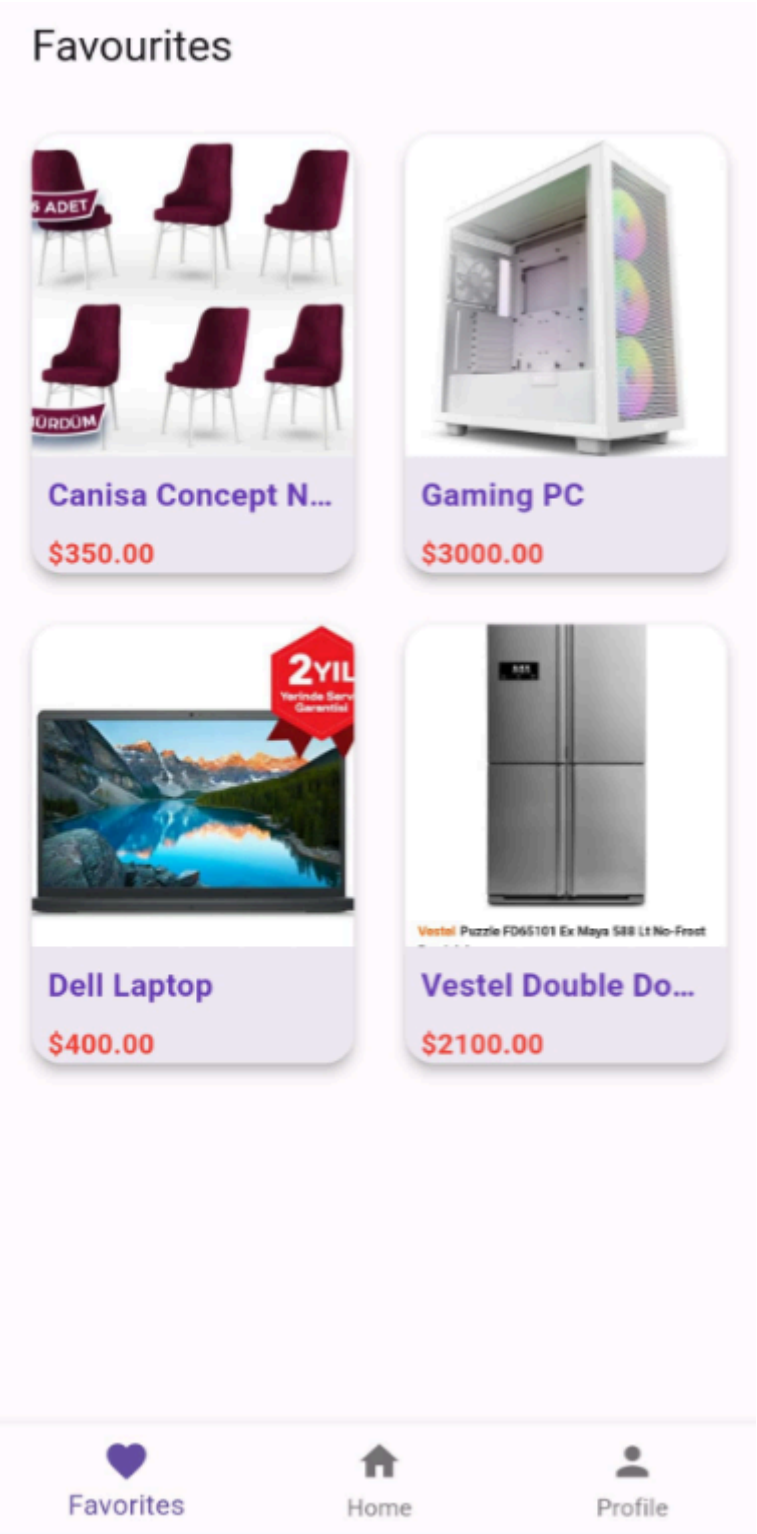

Fig. 13: vendAR Favourites Screen

-Profile Page

In this page the user can change his/her email/phonenumber/password as needed. Also, there is a section for the models user him/herself added to the system.

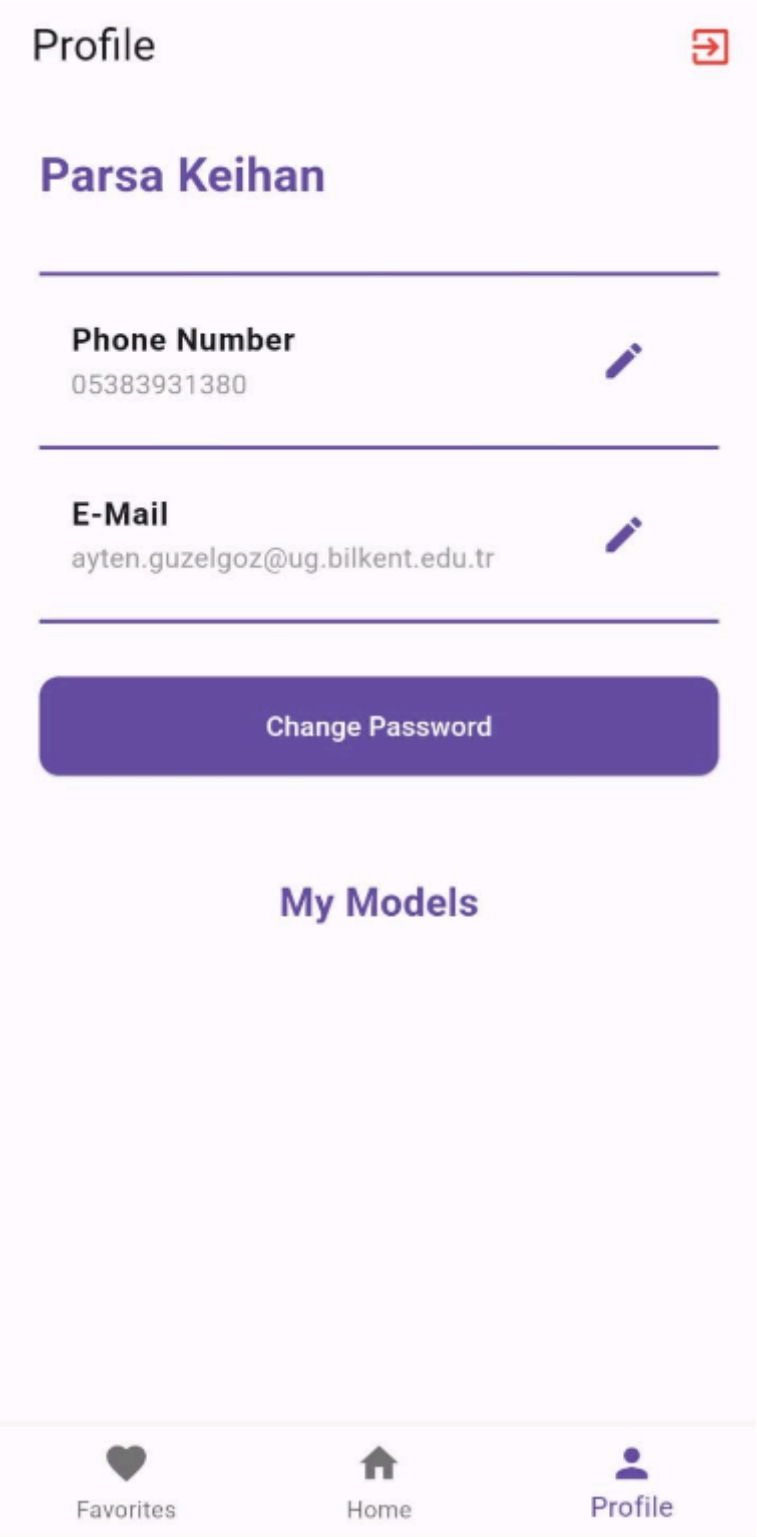

Fig. 14: vendAR Profile Screen

10. Glossary

UML: Unified Modeling Language

AWS: Amazon Web Services

AR: Augmented Reality

DAO: Data Access Object

GLB: GL Transmission Format Binary (file)

11. References

[1] B. Foundation, “Home of the blender project - free and open 3D creation software,” blender.org, https://www.blender.org/ (accessed May 13, 2024).

[2] K. Iqbal, GLB, https://docs.fileformat.com/3d/glb/ (accessed May 13, 2024).

[3] “Ar_flutter_plugin: Flutter Package,” Dart packages, https://pub.dev/packages/ar_flutter_plugin (accessed May 13, 2024).