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Interior Designing with Augmented Reality

A Practical Implementation Using Java and ARCore

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Abstract: This paper presents a mobile-based interior design solution using Augmented Reality (AR) to help users visualize furniture in their own space before making a purchase. The system is designed using Java, the Android SDK, Google's ARCore framework, and Firebase for backend support. It enables furniture owners to upload their furniture, which can then be viewed in real-time by customers through AR. Initially developed using Unity and ARCore for rapid prototyping, the system was later rebuilt with native Java for better Android integration and flexibility. This paper outlines the challenges in traditional interior design methods, the motivation for using AR, and the step-by-step development of an AR-based shopping interface for interior design. Our goal is to bridge the gap between imagination and reality by allowing users to digitally place and preview furniture in their real environment, improving decision-making and reducing product return rates.

Keywords - Augmented Reality (AR), Interior Designing, Unity Engine, ARCore, Java, Android SDK, Firebase, Real-Time Visualization, 3D Furniture Placement, Mobile AR Experience

I. INTRODUCTION

Picking out furniture for your home or office can be quite the challenge, especially when you're not sure how it'll look or fit in the space you have. Many people rely on catalogs or visit showrooms, but those options often don't give a true picture of how the furniture will feel in their own environment. With online shopping becoming more popular, there's a real need for better ways to preview products before buying—especially for something as visual and space-sensitive as furniture.

That's where our AR-based interior design app comes into play. It lets you see how furniture would look right in your own space using just your smartphone camera. We've combined Google's ARCore with native Java and the Android SDK to create a system where you can place 3D furniture models in your room in real time. This app benefits both buyers and sellers: customers can make knowledgeable decisions, while sellers can display their products in a much more engaging way.

At first, we used Unity along with ARCore for their user-friendly 3D model integration and quicker prototyping. But for the final version, we made the switch to Java and Android SDK. This gives us greater control over the app's features, ensures smoother performance, and makes it easier to connect with Firebase for backend support. Firebase handles user authentication, stores images and models, and manages product data.

Our motivation for this project stems from a desire to cut down on furniture returns and customer dissatisfaction that happens when expectations don't match reality. With AR, we take the guesswork out of the equation. This approach perfectly illustrates how innovative technologies like AR can upgrade everyday decision-making and pave the way for smarter shopping experiences.

In the sections ahead, we'll take a look at similar projects, lay out our proposed solution, dive into the system architecture and implementation, and share what we found during testing. We'll also discuss potential improvements, like adding features for real-time measurements, catalog filtering, and a more user-friendly interface using modern frameworks.

II. LITERATURE REVIEW

The use of Augmented Reality (AR) in interior designing and furniture visualization is not entirely new, but it has seen a sharp rise in popularity due to advancements in mobile hardware and AR development tools. Many companies now offer mobile-based tools that allow users to “try before they buy” by placing 3D models of products in their real-world surroundings using smartphones. This section explores the key technologies, earlier systems, and gaps that inspired our approach.

2.1 Augmented Reality in Interior Design

Augmented Reality blends digital objects with the real world, offering a mixed-reality experience. In interior design, AR helps customers visualize how an object, such as a chair or table, will look in their room. Apps like IKEA Place and Houzz have successfully integrated AR to give users the ability to place furniture virtually. However, many such applications are limited to specific brands or offer restricted customization.

Our system draws inspiration from such apps but aims to support multiple furniture providers and individual sellers, making the system more flexible and open. Unlike commercial apps that require large development teams, our project shows how AR furniture visualization can be built using open-source tools and Firebase services in a student-level environment.

2.2 Tools and Frameworks for AR Development

ARCore by Google is one of the most popular platforms for Android-based AR development. It provides motion tracking, environmental understanding, and light estimation—essential features for creating realistic AR experiences. Initially, our project used ARCore within Unity because Unity simplifies 3D rendering and scene management. However, Unity adds bulk to the app and less flexibility in native Android operations.

In our final version, we shifted to using **Java with ARCore SDK**, giving us better control over Android-specific functions and a lighter app size. This transition also made it easier to integrate Firebase for authentication, storage, and database management.

2.3 Firebase in Mobile Applications

Firebase is widely used in mobile apps for real-time database operations, cloud storage, and user authentication. In our case, it helps store furniture data, 3D models, and user details securely in the cloud. It also helps in building user-specific experiences, such as letting a furniture owner upload new models or allowing a customer to view and filter available items.

2.4 Existing Gaps and Motivation

While there are plenty of AR apps for furniture, they often have limitations:

- They are tightly coupled to a single brand or vendor.
- Users cannot upload their own furniture.
- AR visualization might not always reflect the actual size or context properly.

Our project addresses these challenges by offering a customizable, user-driven experience. It is also more lightweight and adaptable for educational or startup-level use.

III. THEORETICAL BACKGROUND

The system is a mobile-based furniture shopping and visualization app built using Java, Android SDK, ARCore, and Firebase. It aims to help customers preview furniture items in their real-world space using Augmented Reality before making a purchase, while also enabling furniture owners to list their items online.

3.1 System Overview

There are two primary types of users in this system: furniture owners and customers. Owners can upload their furniture by providing details such as the item's name, category, price, description, and 3D model file. On the other hand, customers can browse available furniture and visualize it in their home using the phone's camera and AR.

This system helps bridge the imagination gap customers often face when buying furniture online. By giving users the power to place virtual furniture in their own room, the app makes the shopping experience more realistic and confident.

3.2 Flow of the System

The application starts with a login/signup screen powered by Firebase Authentication. Once logged in, furniture owners can add new listings. Each listing includes basic product information along with a 3D model file (in .glb or .gltf format), which is stored in Firebase Cloud Storage. The metadata about the item is stored in Firebase Firestore.

Customers, after logging in, can explore the furniture catalog. When they find an item they like, they can tap to launch the AR viewer. This activates the phone's camera and loads the selected 3D model using ARCore. The model appears on a detected flat surface (like the floor), and users can move or rotate it to see how it fits.

If the customer likes the furniture, they can save it to favorites or proceed to a purchase screen. The system is designed to be interactive, clean, and easy to use—even for someone without any technical knowledge.

3.3 Technology Stack and Reasoning

This app is built entirely using Java with Android SDK. AR functionality is provided through Google's ARCore, which helps detect surfaces, track motion, and render 3D models in real time. Firebase is used for authentication, cloud storage, and database management.

Initially, we used Unity Engine because of its drag-and-drop simplicity with AR, but we later switched to Java. The reason was mainly for better control over Android features, smaller app size, and easier integration with Firebase. With Java, we were also able to create a more native Android experience and reduce the need for external plugins.

All 3D models are stored in the cloud using Firebase Storage, and user data (like saved furniture or uploaded items) is handled through Firestore. Firebase also helps manage access rights—only verified furniture owners can upload items, and only signed-in users can view or interact with AR features.

3.4 Features of the AR System

The AR module includes several key capabilities:

- Detecting real-world surfaces using the smartphone camera.
- Allowing users to place, move, rotate, or resize the furniture models.
- Real-time lighting adaptation so the virtual object looks like it's actually in the room.
- Loading high-quality 3D models that help users make more confident decisions.

3.5 Security and User Roles

Firebase ensures that user data is securely stored and only accessible to the right users. Owners can only manage their own listings, while customers can only interact with the public catalog. All uploads are validated to avoid corrupted files or unsupported formats.

The final system is built with the goal of being lightweight, fast, and visually appealing—something that offers a modern shopping experience through the power of AR.

IV. System Design and Implementation

The design of the AR-based interior design system is modular, scalable, and focused on usability. It consists of several components that work together to allow a seamless AR experience while maintaining secure data flow between users and the cloud. This section explains the architecture, app flow, major modules, and their roles.

4.1 System Architecture Overview

The architecture consists of four key layers:

1. **User Interface Layer** – This includes all the screens and activities seen by the user, such as login, home screen, furniture listing, upload screen, and the AR view.
2. **Business Logic Layer** – This handles app operations like uploading furniture, processing user input, switching between screens, and handling events like taps and gestures.
3. **AR Visualization Layer** – Powered by ARCore, this layer manages camera input, surface detection, anchoring 3D models, and rendering them in the real-world space.
4. **Backend Services Layer** – Firebase handles all the backend services: authentication (for login), Firestore (for storing furniture data), and Firebase Storage (for uploading 3D model files and images).

These layers work in sync to provide a real-time, immersive AR experience without requiring any backend server setup.

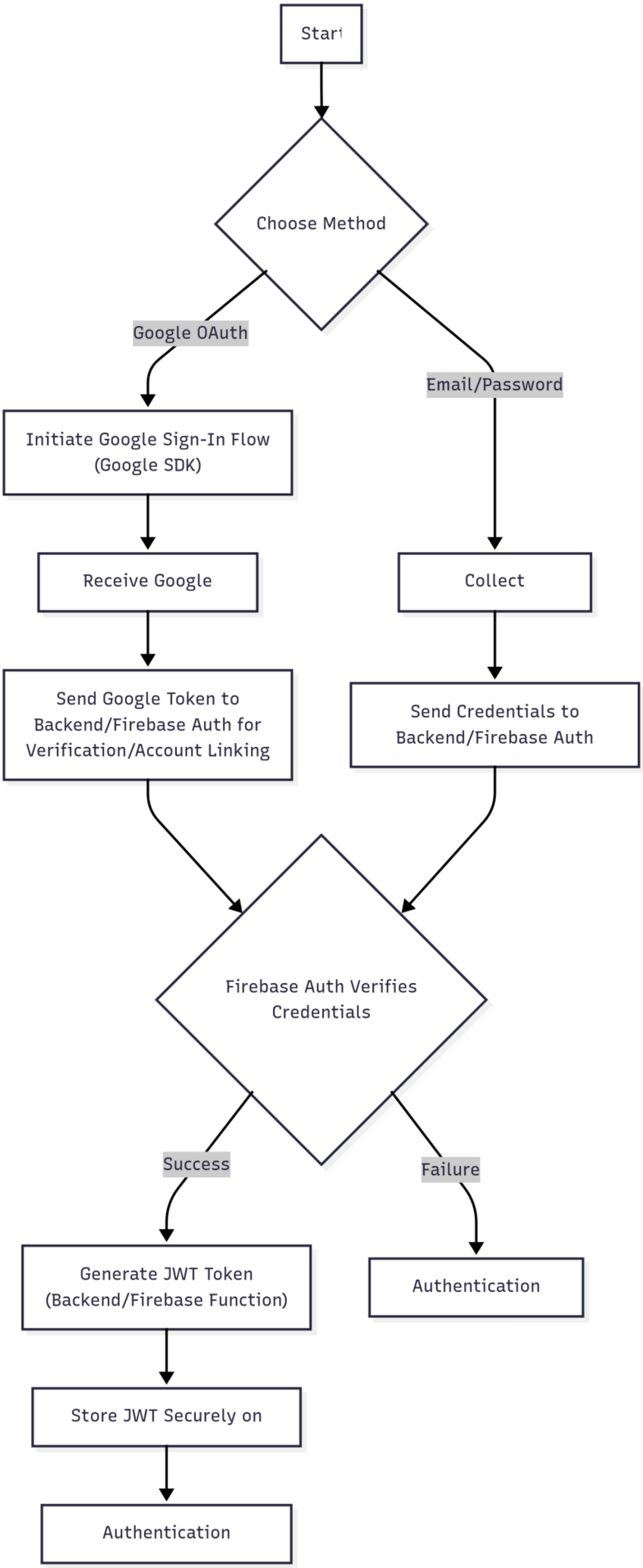
4.2 Application Flow

Here’s how the app works from start to finish:

1. **User Login / Sign-Up**:
Users sign in using Firebase Authentication. Their details are stored securely, and their user role (owner or customer) determines what actions they can perform.
2. **Home Screen**:
After login, the user is directed to a dashboard. Furniture owners see options to add new items, while customers see a grid of available furniture.
3. **Upload Furniture (for Owners)**:
Owners can tap on "Add Furniture" and fill in details like item name, category, description, price, and upload a 3D model file. The file is uploaded to Firebase Storage, and the metadata is saved to Firestore.
4. **View Furniture List (for Customers)**:
Customers browse a scrollable catalog of furniture. Each item card shows an image, name, and a button to try it in AR.
5. **Augmented Reality Preview**:
On tapping "View in AR", the AR camera opens. ARCore detects horizontal surfaces, and once a surface is found, the selected 3D model is anchored onto it. The user can move around it, zoom in/out, and check its size and look in the room.
6. **Interaction and Purchase**:
The customer can either favorite the item or proceed to a mock purchase screen. These actions are logged in Firestore for future use.

4.3 Module Descriptions

- **Authentication Module**:
Manages login and sign-up using Firebase Authentication. Ensures secure access and user-specific features.
- **Catalog Module**:
Fetches all uploaded furniture from Firestore and displays them in a grid layout. Users can tap for more details or preview in AR.
- **AR Preview Module**:
Uses ARCore to open the camera, detect real-world planes, and place the selected 3D object. Includes touch gestures for interaction.
- **Favorites & Purchase Module**:
Customers can save items to their favorites or simulate a purchase, with data saved to Firestore under their user ID.



4.1 Authentication workflow

4.4 Use Case Diagram Description (Textual)

Here's a simple breakdown of key use cases:

- **Furniture Owner**:
  - Logs into the system
  - Uploads new furniture with 3D model
  - Views list of uploaded items
- **Customer**:
  - Logs into the system
  - Browses catalog
  - Previews selected furniture in AR
  - Saves favorite items
  - Places a mock order

4.5 Backend Design with Firebase

- **Authentication**:

Each user has a unique UID. Based on their role, access is restricted using Firebase rules.

- **Firestore Database Structure**:
  - /furniture: stores all listed furniture with owner UID, name, category, price, and model URL.
  - /users: stores user details, including name, email, role, and favorites.
- **Firebase Storage**:
  - Stores .glb or .gltf 3D model files uploaded by furniture owners.
  - URLs of these files are saved in Firestore and used for rendering in the AR scene.

4.6 Technology Stack Summary (in text)

- Programming Language: Java (Android SDK)
- Augmented Reality Framework: ARCore (Google)
- Backend: Firebase (Authentication, Firestore, Cloud Storage)
- 3D Models: .glb or .gltf format
- IDE: Android Studio

4.7 Environment of Development

The development of this Augmented Reality-based interior design system was carried out entirely using **Java in Android Studio**, which is the official Integrated Development Environment (IDE) for Android app development. Android Studio provided all the essential tools like emulators, debugging utilities, layout editors, and Gradle support to manage dependencies.

The entire project was built and tested on a system running **Windows 11**, equipped with:

- Intel Core i5 processor (11th Gen)
- 16GB RAM
- SSD storage
- Android Studio version: **Hedgehog | 2023.1.1**
- JDK version: **Java 17**
- Android SDK version: **API Level 34**

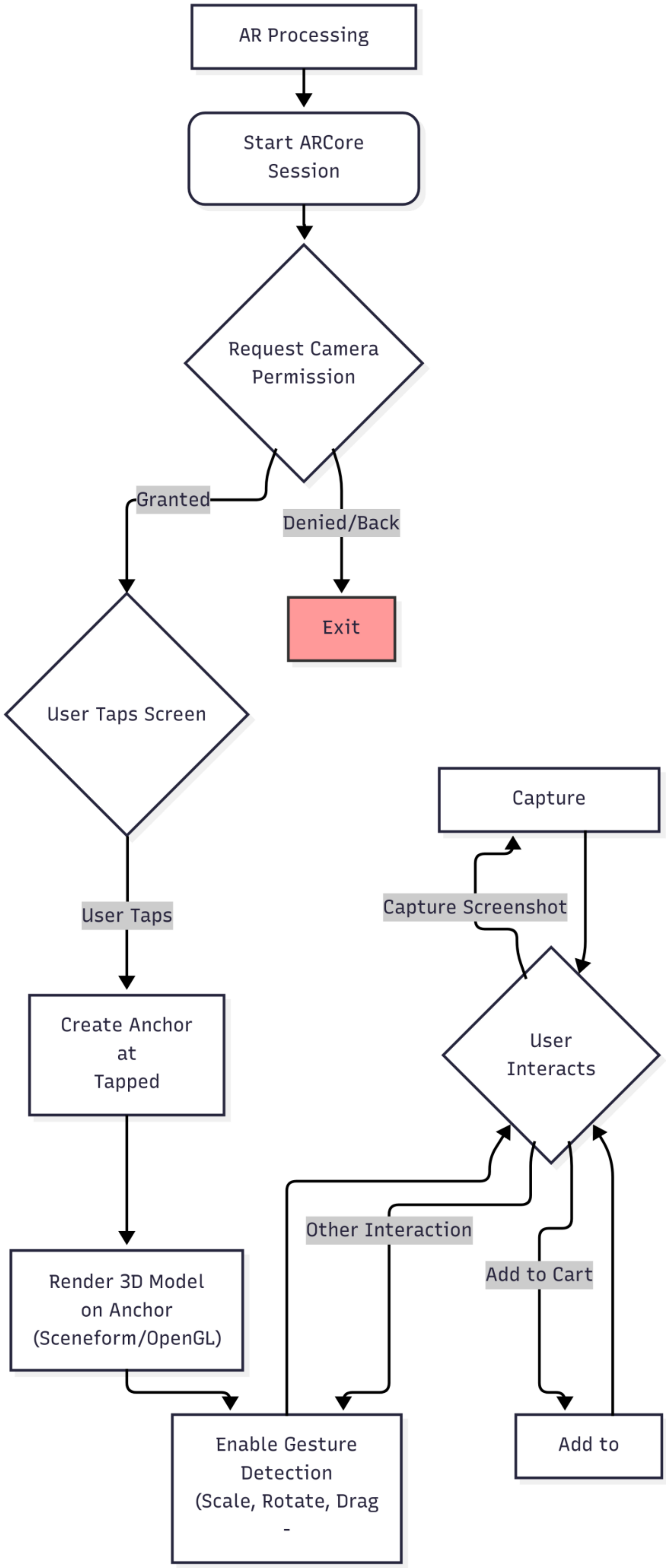
For testing the AR features, we used **physical Android smartphones** that support **ARCore** (e.g., Samsung Galaxy A52, OnePlus Nord CE). The AR emulator in Android Studio is not reliable for real-time AR placement, so real devices were necessary to test surface detection and 3D model rendering.

All Firebase services—Authentication, Firestore, and Cloud Storage—were managed using the **Firebase Console** linked with the Android app through the official Firebase SDK for Java.

To manage 3D models, we used .glb and .gltf file formats, created and exported using tools like **Blender** and **Sketchfab**. These models were uploaded to Firebase Storage and then fetched at runtime for AR visualization.

Dependencies like ARCore SDK and Sceneform libraries were added via **Gradle**, and versioning was maintained through a GitHub repository for backup and collaboration. The GitHub repo also served as a reference during development for integration and bug tracking.

Overall, the development environment was kept lightweight, cost-effective, and fully based on open-source and free-to-use tools, making it ideal for academic or prototype-level AR applications.



4.2 Augmented Reality workflow.

V. RESULTS

5.1 Functional Verification

Each major feature of the application was tested individually and as part of the full flow. The following functionalities were successfully verified:

- **Authentication:**

Firebase Authentication worked smoothly for both furniture owners and customers. Account creation, login, and session management were all tested without any major issues.

- **Furniture Upload and Storage:**

Furniture owners were able to upload items with details like name, price, category, and 3D models. The 3D model files were correctly stored in Firebase Storage, and metadata was stored in Firestore.

- **Furniture Browsing:**

The app loaded and displayed a scrollable list of furniture items from Firestore. Clicking on any item correctly navigated to a detailed view, showing description, image, and options for AR preview.

- **AR Preview**

The AR module detected horizontal surfaces like floors and tables using the smartphone camera. Once detected, the 3D furniture model was anchored onto the surface. Users could walk around, zoom in, or rotate the object to get a realistic preview.

- **Performance on Devices:**

Testing was done on mid-range smartphones (e.g., Samsung Galaxy A52, OnePlus Nord CE). The AR performance was smooth, and model rendering was realistic with accurate lighting and shadows.

5.2 Visual Output Examples

The application was tested with multiple .glb and .gltf 3D models of sofas, chairs, and tables. Here are some visual results:

- **Model Placement:**

A virtual sofa was placed in a real living room environment. The model appeared stable and accurately scaled, aligning well with the floor and walls.

- **Lighting Adjustment:**

ARCore’s light estimation feature matched the furniture’s shading with the ambient light, making it appear natural in different lighting conditions.

- **Interaction Experience:**

Users could tap, drag, rotate, and resize the furniture models using common touch gestures. The responsiveness was fluid and intuitive.

- **Example 1: Login Page for Users**

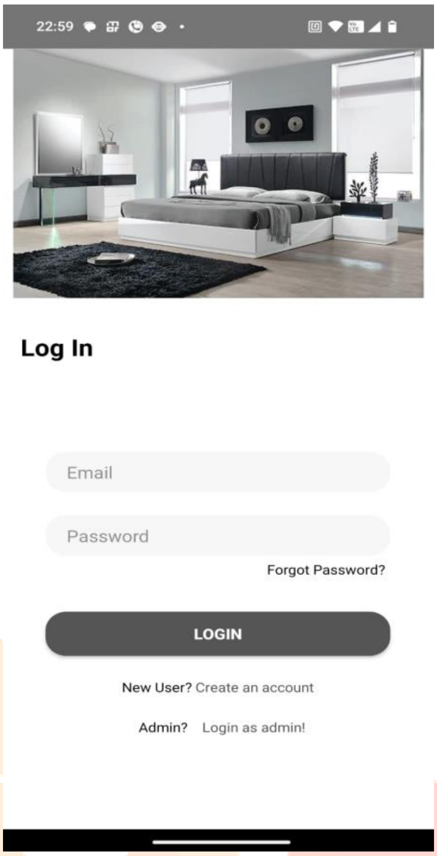


Fig.5.1- app login page.

- **Example 2: AR in Action (Student)**

Fig.5.2- placing an object in the AR scene

- **Example 3: App profile page**

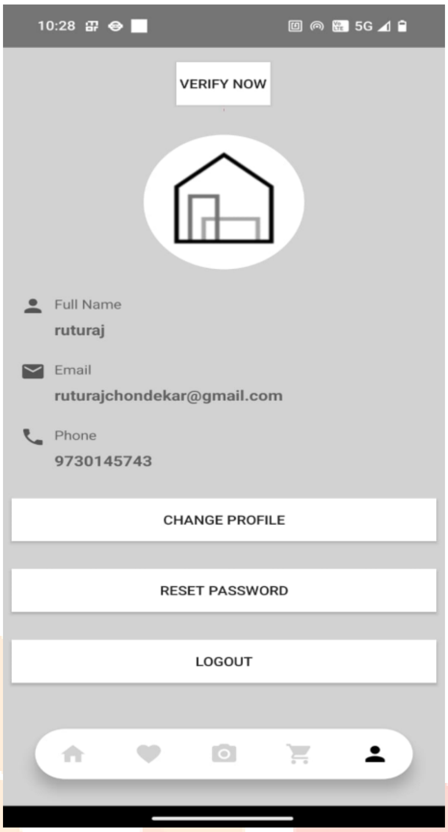


Fig.5.3 – the user profile page on the app

- **Example 4: Multiple AR object placement**

Fig.5.4 – Multiple AR object placement

5.3 User Experience Feedback

Informal user testing was done with college students and staff. Their feedback was encouraging:

- Most users found the app easy to use and engaging.
- The ability to view furniture in their own room was highlighted as the most exciting feature.
- Users appreciated that they didn't need to download large models or visit showrooms.

However, some users suggested improvements:

- Adding more customization options like color or fabric changes.
- Improving UI appearance with better filtering options (e.g., by price, size, room type).
- Making the AR loading time even faster for larger 3D models.

5.3.Discussion

The results indicate that the project has met its core objectives. The AR experience delivered is reliable, intuitive, and helps bridge the gap between online furniture shopping and real-life visualization. By integrating Firebase, we ensured secure and real-time data handling without needing our own backend server.

The major strength of the system lies in:

- Its **simple architecture** using Java and Firebase.
- A **native Android experience** that doesn't rely on bulky engines like Unity.
- Real-world usability with **accurate AR tracking** and realistic rendering.

Challenges such as handling large 3D models and providing highly dynamic customization are areas that require further enhancement.

Nonetheless, the app stands as a strong prototype for real-world AR-based interior design solution

System architecture Diagram:

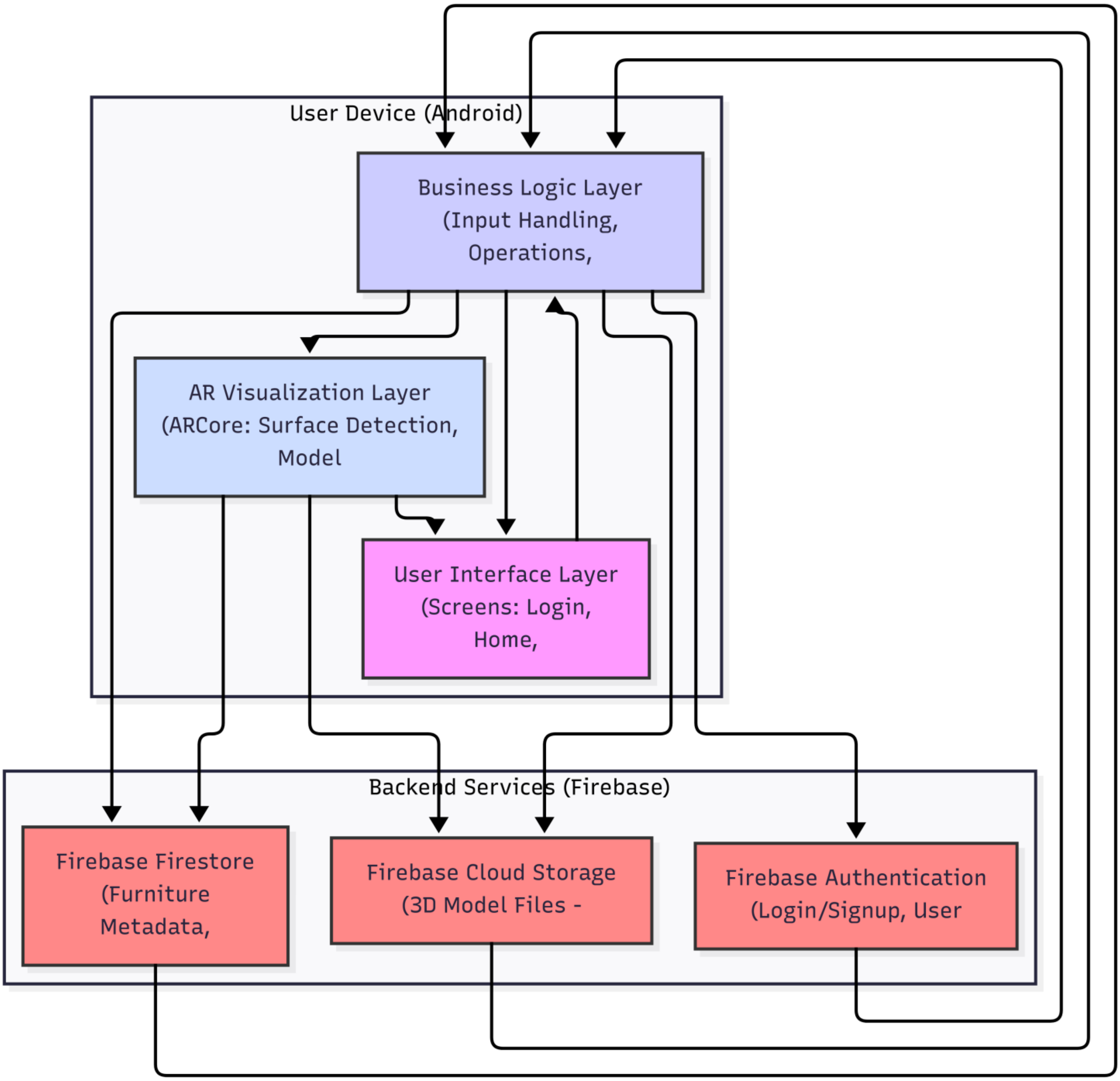


Fig.5.6-Complete architecture of the AR-based interior design application:

VI. Discussion

The functional verification and user feedback clearly demonstrate that the developed application successfully meets its primary goal: enabling users to visualize furniture in their real environments through augmented reality. The integration of Firebase services for authentication, storage, and real-time database operations provided a robust backend infrastructure that minimized complexity while ensuring data reliability and security.

A key achievement of the project is the seamless AR experience delivered on mid-range Android devices without relying on heavier platforms like Unity. This lightweight approach, built using native Java and ARCore, not only maintained performance but also ensured broader accessibility across a range of smartphones. The AR module's ability to accurately detect surfaces and render 3D models with lighting adaptation contributed significantly to the realism and user immersion.

From a usability standpoint, the intuitive interface and responsive model interactions were well-received by users. The most appreciated feature was the real-time AR visualization, which effectively addressed a common pain point in online furniture shopping—uncertainty about how an item would look or fit in a real space. The fact that users did not need to download large files or physically visit showrooms was seen as a major convenience.

However, the feedback also highlighted areas for future development. Customization options such as changing fabric or color were commonly requested, suggesting the potential for enhancing personalization features. Additionally, while the app performed well with mid-sized models, performance issues were noted with larger or more complex 3D assets, indicating a need for model optimization techniques or progressive loading.

4.7 Environment of Development

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Overall, the development environment was kept lightweight, cost-effective, and fully based on open-source and free-to-use tools, making it ideal for academic or prototype-level AR applications.Moreover, the current UI could benefit from enhancements, particularly around filtering and categorization, to support a smoother shopping experience. Implementing features like room-based recommendations or size filters could further align the app with commercial-grade standards.

In summary, the application serves as a compelling prototype for AR-driven interior design and online furniture retail. It combines functional efficiency, technical feasibility, and user-centric design. With targeted improvements in customization, performance scalability, and interface design, the system has strong potential for real-world deployment and commercial viability.

VII. Conclusion

This project aimed to bridge the gap between traditional interior design planning and the immersive capabilities of modern augmented reality. By developing an AR-based application using Java, ARCore, and firebase, we created an intuitive system that allows users to place and interact with virtual furniture in real-time within their actual environment.

The early phases of development using Unity provided us with foundational insights into AR workflows, 3D rendering, and interaction models. However, due to limitations such as increased application size and platform dependency, we transitioned the project to native Android using Java. This decision resulted in better performance, more efficient memory handling, and tighter integration with Android's core system features.

The final application achieved its goal of providing a seamless augmented reality experience for interior designing. Users could select furniture models, place them accurately on detected surfaces, and manipulate them through natural gestures like pinch-to-zoom and rotate. Feedback from initial testers highlighted the app's usefulness in helping them make faster and more confident decisions about room layout and decor. For instance, visualizing a full-sized sofa or table within their room helped users better understand spacing and compatibility — something that's nearly impossible with static images or 2D plans.

firebase played a key role in enhancing the visual interface, improving user engagement through smoother interactions, and offering a more modern, commercial-ready feel. The result is a mobile application that not only functions well technically but also feels polished from a user experience perspective.

From a technical standpoint, the successful integration of ARCore's surface detection, real-time object tracking, and depth APIs enabled accurate and stable model placement. The app's architecture was designed to be modular and scalable, making it easier to introduce new models, support multi-room planning, or integrate cloud-based features in the future.

In summary, this project demonstrates how augmented reality can evolve from a niche technology into a practical tool for consumers. The fusion of real-world environments with virtual objects opens up exciting opportunities in design, planning, and visualization — particularly in industries like interior design, real estate, and retail.

With the strong foundation developed here, there's clear potential to expand the scope of this application and further enhance the user experience through advanced features such as saving designs, collaborating on layouts, and integrating with e-commerce platforms

Future Works

- **Support for Multi-Room Layouts**

At present, the app focuses on placing furniture in a single room at a time. Future development can include support for complete home layouts with multiple rooms. This would allow users to switch between different spaces (like bedroom, kitchen, or living room) and design each section individually, providing a full-house design experience.

- **Cloud-Based Model Library and User Profiles**

Currently, all 3D models are stored locally. A cloud-integrated library would allow dynamic fetching of new models without needing to update the app. Additionally, user profiles could be introduced to store preferences, saved layouts, and history, enabling more personalized experiences.

- **Measurement Tools and Smart Suggestions**

Another valuable addition would be to integrate measurement tools that can calculate room dimensions using ARCore's depth API. Based on the size of the detected space, the system could suggest suitable furniture models or flag oversized pieces that may not fit.

- **Real-World Dimension Matching**

To enhance design accuracy, the app could include a room measurement feature that allows users to scan the dimensions of their space using the phone's camera. The app can then scale furniture precisely to match the real-world size of the room, eliminating the guesswork in design.

- **Improved Object Anchoring and Physics**

Although ARCore provides good tracking, in complex environments object drift may occur. Further refinement in object anchoring and physics, possibly using additional sensors or machine learning models, could improve accuracy and realism.

VIII. Acknowledgements

We would like to express our heartfelt gratitude to everyone who contributed to the successful completion of this project. First and foremost, we thank our project guide **Prof.Mohammed Juned** for their constant support, constructive feedback, and valuable technical guidance throughout the development of this work.

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Special thanks to the testers and peers who actively participated during the user testing phase. Their feedback helped us refine the user interface, resolve edge-case issues, and enhance the overall user experience of the application.
Lastly, we acknowledge the contributions of the open-source development community behind **ARCore**, **Firebase**, and the Android SDK, whose libraries and documentation made it possible to build this system with clarity and efficiency.
This project would not have been possible without the combined support of everyone involved.

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