

VIETNAM NATIONAL UNIVERSITY, HO CHI MINH CITY  
UNIVERSITY OF ECONOMICS AND LAW  
FACULTY OF INFORMATION SYSTEM

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**FINAL PROJECT REPORT**

**MOBILE E-COMMERCE DEVELOPMENT**

**TOPIC: DEVELOPMENT OF AN AR-BASED PERSONALIZED  
RECOMMENDATION AND VIRTUAL TRY-ON SYSTEM FOR MOBILE  
FASHION ACCESSORIES**

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## **ACKNOWLEDGEMENTS**

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We would like to extend our heartfelt gratitude to the University of Economics and Law for organizing the course “Mobile E-Commerce Development”, which has provided us with invaluable knowledge and practical insights into the role of mobile technologies in transforming digital commerce. The university’s academic environment, along with its excellent resources and facilities, greatly supported us throughout the development of this project.

We are particularly thankful to Mr. Tran Duy Thanh for his dedicated mentorship and continuous support during the entire course. His thoughtful guidance, engaging lectures, and hands-on exercises were instrumental in helping us bridge the gap between theory and practice. We deeply appreciate his time, expertise, and encouragement, which significantly contributed to the successful completion of this work.

We would also like to acknowledge the contributions of everyone who supported us along the way, friends, family, and peers whose encouragement and feedback inspired us to keep striving for improvement.

Completing this project has been a highly enriching and meaningful experience. While we have done our best to ensure the quality of this report, we are aware that there is always room for growth and welcome any constructive feedback for future enhancement.

Once again, we sincerely thank all those who have been part of this journey.

Ho Chi Minh City, June 30th, 2025

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## **COMMITMENTS**

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We hereby affirm that the project titled “Development of an AR-Based Personalized Recommendation and Virtual Try-On System for Mobile Fashion Accessories” is the result of our team’s independent research and development efforts. The project was carried out under the guidance and supervision of Ph.D. Tran Duy Thanh at the University of Economics and Law, Vietnam National University – Ho Chi Minh City.

All content presented in this report reflects our original work in research, system design, and application development. Any ideas, data, or insights derived from external sources have been properly cited and referenced in accordance with academic integrity guidelines and ethical research standards.

We further confirm that this report has not been submitted for credit in any other course or program and does not contain any plagiarized material. The findings, analysis, and conclusions are the result of our collaborative effort, and we take full responsibility for the accuracy and authenticity of the work submitted.

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## LIST OF ABBREVIATIONS

No	Abbreviation	Full Meaning
1	AR	Augmented Reality
2	AI	Artificial Intelligence
3	ML	Machine Learning
4	VTO	Virtual Try-On
5	VR	Virtual Reality
6	UI	User Interface
7	UX	User Experience
8	UCD	User-Centered Design
9	HCI	Human-Computer Interaction
10	UML	Unified Modeling Language
11	DFD	Data Flow Diagram
12	ERD	Entity-Relationship Diagram
13	BPMN	Business Process Model and Notation
14	OTP	One-Time Password
15	IDE	Integrated Development Environment
16	VS Code	Visual Studio Code
17	API	Application Programming Interface
18	SQL	Structured Query Language
19	SQLite	SQL Lightweight (database engine)
20	BaaS	Backend-as-a-Service
21	PR	Performance Requirements
22	PC	Platform Constraints
23	AP	Accuracy and Precision
24	AD	Adaptability
25	SC	Security
26	CF	Collaborative Filtering
27	CBF	Content-Based Filtering
28	NLP	Natural Language Processing
29	TF-IDF	Term Frequency – Inverse Document Frequency
30	LLMs	Large Language Models

31	2D	Two-Dimensional
32	3D	Three-Dimensional
33	HMD	Head Mounted Display
34	CSV	Comma-Separated Values
35	JSON	JavaScript Object Notation
36	ORM	Object-Relational Mapping
37	CRUD	Create, Read, Update, Delete
38	SDK	Software Development Kit
39	FAQ	Frequently Asked Questions
40	BRDF	Bidirectional Reflectance Distribution Function
41	ID	Identifier

## ABSTRACT

In recent years, the growth of online shopping in Vietnam has made fashion items more accessible; however, it also presents issues in helping consumers assess whether a product truly matches their style or fits their body, especially for accessories where small design details matter. Without the ability to try items on, shoppers often rely on limited information and may purchase products that do not meet their expectations. This behavior contributes to unnecessary consumption, increasing environmental waste and raising concerns about sustainability. To address these issues, this study proposes a mobile-based Virtual Try-On (VTO) system that integrates Augmented Reality (AR) and Machine Learning (ML) to enhance the shopping experience and promote mindful consumer behavior. Unlike platforms that rely on static images and generic suggestions, the system enables users to visualize accessories on their bodies in real time, using MediaPipe for landmark detection and Google Filament for realistic 3D rendering all without requiring specialized hardware. It also incorporates a hybrid recommender engine combining collaborative and content-based filtering to provide personalized suggestions. Optimized for Android smartphones, the system ensures accessibility and smooth performance for the Vietnamese market. Results from testing indicate that the application enhances purchase satisfaction, encourages more deliberate consumption, and supports broader sustainability goals. Overall, this study demonstrates a practical approach for Vietnamese fashion brands to leverage AR and ML technologies, helping them reduce waste, strengthen customer engagement, and promote eco-friendly shopping behaviors.

**Keywords:** *Augmented Reality, Virtual Try-On, Personalized Recommendation, Fashion Accessories, Mobile Application*

## CHAPTER 1. INTRODUCTION

Nowadays, Augmented Reality (AR) and Artificial Intelligence (AI) are transforming the way people shop online, especially in fashion and accessories. Globally, the AR market is growing rapidly. According to Precedence Research (2024), the global AR market is expected to reach over USD 2.8 trillion by 2034. In retail, AR is gaining strong momentum, with the market projected to hit USD 60.23 billion by 2032 (Zion Market Research, 2024), showing the rising demand for interactive and personalized shopping experiences. In the jewelry industry, AR helps customers try on products virtually before buying. A report by Dataintelo (2023) states that the AR market for jewelry was valued at USD 1.5 billion in 2023 and is expected to grow significantly. However, most AR tools focus on common jewelry like rings and bracelets. Smaller and more personalized items, such as piercing jewelry (earrings, nose rings, etc.) are still underserved. Also, many AR systems are not yet connected with AI technologies that can recommend suitable products based on individual preferences, physical traits, or personal style.

In Vietnam, the e-commerce market has experienced rapid growth, largely driven by mobile shopping. Younger generations, particularly Gen Z and Millennials, demonstrate a strong interest in virtual try-on (VTO) experiences. According to Statista (June 2022), 38% of Vietnamese users stated they would purchase more fashion items if VTO technologies were fully developed, while 39% reported that VTO had influenced a recent purchase decision. Additionally, 49% expressed a willingness to use VTO for fashion and cosmetic products. According to a report by Astute Analytica, artificial intelligence (AI) adoption in Vietnam's e-commerce sector has expanded to include voice assistants, augmented reality (AR) for virtual try-on experiences, and advanced data analytics, enhancing users' ability to explore fashion and jewelry products online. For instance, Tiki integrated ChatGPT in May 2023 to improve product search functionality and review summarization (Đặng, N., 2025). Meanwhile, Shopee has utilized AI to personalize product recommendations, resulting in an estimated 20% increase in user engagement, and has also implemented AI-powered chatbots capable of handling millions of customer interactions daily (Astute Analytica, 2024).

Despite the growing adoption of Augmented Reality (AR) in e-commerce, especially in fashion and accessory sectors, several technical and experiential challenges remain unresolved. In the case of small-sized items like body piercing jewelry, users often struggle to accurately visualize products through static images alone. Issues such as precise item placement, realistic rendering, and compatibility across various mobile devices continue to hinder broader AR adoption.

This project aims to address these gaps by developing a mobile application specifically designed for virtual try-on of body piercing jewelry, optimized for Android smartphones. The proposed system will provide an AR-based, real-time try-on experience for lightweight fashion accessories, tailored to users who engage in online

shopping and expect personalized, interactive experiences. Key features of the application will include:

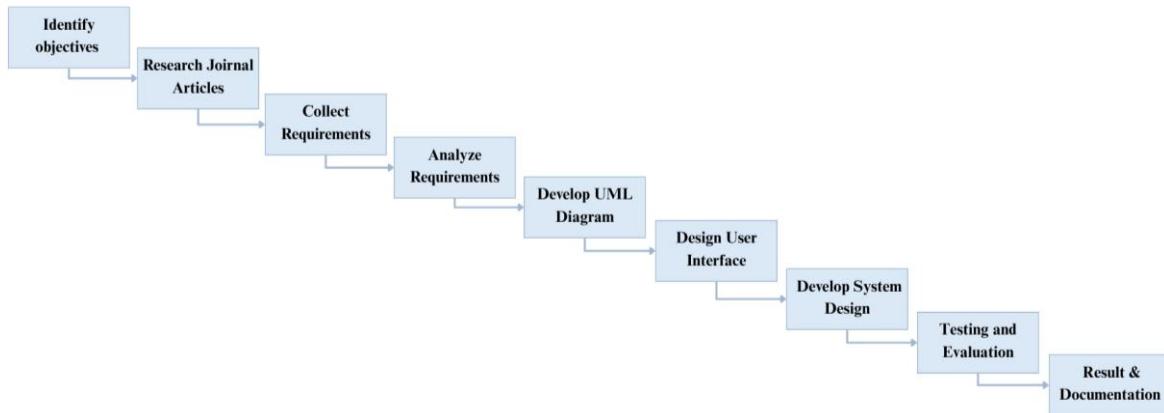
- **User Authentication:** This feature ensures secure access to the application by allowing users to register and log in using personal credentials.
  - **Product Browsing and Purchase Functionality:** Users can explore a curated catalog of body piercing jewelry, including filters by type, material, size, and price. Each product listing includes detailed descriptions and high-quality images..
  - **Booking Service System:** This module allows users to book physical appointments for piercing services or in-person consultations with staff. It includes real-time scheduling, availability tracking, and confirmation notifications.
  - **Customer Account Management:** Users can manage their personal profile, saved addresses and booking history.
  - **Help & Information Section:** This section provides users with access to commonly asked questions and contact options for live support via chat, email, or hotline.
  - **AR Camera Module for Virtual Try-On:** The core feature of the application, this module utilizes the device camera in combination with ARCore to allow users to virtually try on piercing jewelry. It includes real-time object rendering, accurate landmark detection and material simulation to provide a lifelike preview
- The main objective of the project are as follows:

1. Accessory Positioning in Real Environments: Displaying small jewelry items requires precise and stable landmark detection, adaptable to lighting, angles, and camera quality. This raises the question of whether current techniques can deliver smooth and realistic AR performance.
2. Product Visualization through AR Interface: Customers often struggle to judge if jewelry suits them based on static images, especially with small accessories. Many AR apps lack clear visualization or intuitive interfaces. Showing the product directly on the user's body through AR, combined with a simple interface, can improve clarity and boost purchase confidence.
3. Technology Integration to Enhance User Experience: Current AR try-on applications often lack smooth interaction, stability, and practical features that support the full shopping process. Therefore, this project examines whether integrating Augmented Reality with Machine Learning can deliver a more interactive, stable, and user-friendly shopping experience. By improving visualization accuracy and system performance, the integration aims to enhance customer satisfaction, reduce hesitation during purchase, and increase engagement with the platform.

Based on the preceding analysis, the research team proposes three primary research questions: (1) Can landmark detection techniques ensure the accuracy and

stability required for positioning AR fashion accessories on body using mobile devices? (2) Can an AR interface that displays the product on the user's body clearly help customers imagine products in reality and make more confident buying decisions? (3) Can the integration of Machine Learning into an AR virtual try-on system improve interaction quality, system stability, and overall shopping experience, thereby increasing user satisfaction and engagement?

To ensure a clear and structured development process, this project adopts the Waterfall methodology - a linear model where each phase must be completed before moving to the next. This approach is especially suitable for projects with clearly defined goals and stable requirements, such as our mobile application that integrates augmented reality (AR) and personalized recommendation features for fashion accessories.



*Figure 1: Waterfall Development Lifecycle for AR-based Recommendation System (Source: Authors)*

Subsequently, the team conducts a literature review of relevant journal articles to establish the theoretical foundation and identify existing gaps. Based on these findings, the requirements collection phase gathers functional and non-functional needs through user surveys and interviews. These are further analyzed in the requirements analysis phase to ensure they align with technical feasibility and business constraints. Once the requirements are finalized, the team proceeds to develop UML diagrams, including use case and sequence diagrams, to model system behavior and user interaction. This supports the next stage, user interface design, where interactive mockups are created using design tools like Figma, emphasizing usability and visual coherence. Following the interface design, the system development phase involves actual implementation using development environments such as Android Studio and Visual Studio Code. Once the system is built, it undergoes testing and evaluation, including performance validation, functionality testing, and user experience assessment. Finally, the results and documentation phase ensures that the completed system is ready for deployment, accompanied by full documentation covering design decisions, development processes, and testing outcomes.

The structure of this project is organized into six chapters, each systematically addressing key aspects of the system development process

**Chapter 1:** Introduction: This chapter introduces the context and motivation for the project, highlighting the rising need for personalized AR solutions in mobile

commerce. It outlines the main objectives, scope, and research questions. The chosen methodology and project implementation plan are also described.

**Chapter 2:** Theoretical Background and Related Work: This chapter reviews relevant international and local studies on AR and recommendation systems in fashion and retail from the past five years. It also covers key theoretical foundations. Common modeling tools and the development technologies used are introduced.

**Chapter 3:** Proposed Solution: This chapter presents the proposed system design, starting with functional and non-functional requirements. It describes six core feature modules, user flows, and system modeling through DFDs, use case diagrams, BPMN, and ER diagrams. The chapter also explains the system architecture, database structure, and integration of ML techniques.

**Chapter 4:** Implementation Results: This chapter showcases the implementation outcomes of the system. It includes the sitemap, UI design standards, and visual content of each feature. High-fidelity mockups and real app screenshots are provided for all modules.

**Chapter 5:** Discussion: This chapter analyzes the strengths and limitations of the developed system, including platform-specific constraints and feature boundaries. It discusses the practical implications of the project, how it meets user needs, and potential areas for improvement in future versions.

**Chapter 6:** Conclusion and Recommendation: The final chapter summarizes the project's key achievements and how well the objectives were met. It acknowledges current limitations and proposes future enhancements. Recommendations are provided for further development and potential commercialization of the system.

## CHAPTER 2. THEORETICAL BACKGROUND AND RELATED WORK

This chapter reviews recent studies on AR and virtual try-on systems in fashion retail, both internationally and in Vietnam. It also introduces core concepts such as AR technology, VTO methods, machine learning, and user-centered UI/UX design. These elements form the theoretical and technical basis for the system. The chapter helps define how existing research and tools support the project's development.

### 2.1. Related Research

Recent advancements in Augmented Reality (AR) technology have catalyzed a surge of research across various industries, particularly in fashion and jewelry retail. These studies aim to enhance the user experience, increase personalization, and reduce uncertainty in online shopping. In this context, both international and domestic researchers have contributed valuable insights into how AR-powered virtual try-on (VTO) systems are being implemented, evaluated, and optimized for consumer use. The following section reviews representative studies conducted abroad and within Vietnam, laying the theoretical foundation for this project.

#### 2.1.1. Foreign Research

The growing application of Augmented Reality (AR) in the fashion and jewelry industries has led to significant research focused on improving the virtual try-on (VTO) experience. As consumers increasingly shop online, providing them with realistic previews of accessories and apparel becomes crucial in enhancing engagement and purchase intent.

A representative study by Prajapat et al. (2022) introduced a jewelry try-on system using AR and MediaPipe that allows users to visualize hand jewelry in real-time via mobile interfaces. The study emphasized that traditional 2D visuals fail to capture the nuances of jewelry design, which are critical in purchasing decisions. Their system overlays 3D models of hand jewelry onto the user's hand, providing a realistic simulation of product appearance and fit. The approach significantly enhances the user experience, enabling a more informed decision-making process for online jewelry shopping.

Another significant contribution comes from Liarokapis and colleagues, who developed an AR-based application specifically tailored for jewelry shopping. Their system allowed customers to view digital replicas of rings and necklaces in real-time through smartphone cameras. The study focused not only on the visual fidelity of the try-on process but also on usability evaluation, demonstrating that AR applications can influence perceived product quality and user trust in online platforms.

Similarly, in their review published by IRJET, Pandey et al. (2022) explored the integration of AR in e-commerce applications and proposed an architecture combining Unity 3D and Python-based image processing to deliver an interactive AR try-on system. Their implementation supports real-time detection of hand or face regions and overlays virtual items accordingly. The study showed that using lightweight frameworks

such as MediaPipe can allow efficient on-device performance, making it practical for commercial mobile AR systems.

Moreover, the research published in IEEE by Xiong et al. (2022) discussed 3D modeling and material simulation techniques that improve realism in virtual try-on systems. By combining 3D garment simulation and AR toolkits, their system could render highly accurate reflections and shadows, contributing to a more immersive try-on experience. They also emphasized the importance of markerless AR to avoid obtrusive elements in user interaction.

Collectively, these international studies highlight the transition from static product visualization to immersive, interactive systems that simulate real-world product usage. The integration of AR with machine learning, computer vision, and lightweight mobile frameworks demonstrates the potential for creating seamless and personalized shopping experiences. These works lay a solid foundation for developing more advanced systems like the one proposed in emphasized, an AR-based mobile app that not only renders accessories but also provides personalized recommendations based on user characteristics.

### **2.1.2. Domestic Research**

In Vietnam, the application of augmented reality (AR) in fashion retail and mobile commerce is gaining traction in both industry and academia. Recent studies have explored consumer behavior, organizational readiness, and technological adoption in the Vietnamese market, particularly in the context of AR-based virtual try-on (VTO) applications.

Le and Nguyen (2024), in their empirical study on the impacts of virtual try-on for online shopping, found that VTO significantly influences Vietnamese consumers' attitudes toward online fashion purchases. The study emphasized that perceived enjoyment and perceived usefulness strongly affect purchase intention and brand trust among Gen Z consumers. Furthermore, personalization and real-time interactivity were shown to be critical drivers of favorable behavior in the e-commerce environment.

In another relevant study, Nguyen (2022) investigated the motivations and barriers to adopting AR among Vietnamese SMEs in fashion retail. Surveying over 200 retail managers, the research concluded that internal organizational factors such as innovativeness and a positive attitude toward AR were the main drivers of adoption. Meanwhile, competitive pressure emerged as a major external barrier. Although financial constraints negatively impacted organizational attitudes, they were not found to directly prevent AR implementation. The findings suggest that internal readiness plays a more vital role than market pressure in the Vietnamese context.

Additionally, Tran and Phan (2023) examined consumer acceptance of mobile AR applications in fashion. Their mixed-method study identified perceived usefulness, perceived ease of use, and perceived enjoyment as the most influential factors shaping users' intentions. Notably, technological experience was found to moderate the

relationship between attitude and purchase behavior, highlighting the role of digital literacy in emerging markets like Vietnam.

Together, these studies reflect Vietnam's increasing readiness to explore and adopt immersive technologies such as AR in the fashion sector. While infrastructural and economic constraints remain, AR-based VTO systems demonstrate significant promise in enhancing personalization, consumer trust, and conversion rates in mobile shopping experiences.

## 2.2. Theoretical Background

### *Augmented Reality (AR)*

Augmented Reality (AR) is a technology that overlays computer generated content onto the real world, enhancing users' perception and interaction with their environment. Azuma (1997) defines AR through three core characteristics: a combination of real and virtual elements, real time interactivity, and accurate 3D registration of virtual objects with the physical world.

Unlike Virtual Reality (VR), which fully immerses users in digital environments, AR maintains the real world context while integrating digital enhancements. Azuma (1997) also notes that AR can be implemented through various devices such as head mounted displays, mobile devices, or spatial projectors, as long as the foundational principles are upheld.

AR has become a powerful tool in digital marketing and e-commerce, offering immersive alternatives to physical shopping experiences. Studies show that AR features, like virtual product previews, not only boost engagement but also enhance brand recall and customer loyalty, contributing to improved online conversion rates (Orús et al., 2021). Moreover, empirical findings have linked AR to increased brand advocacy and long term retention (Kim et al., 2023; Olson et al., 2020; Orús et al., 2021). Supporting this, Somlith (2024) reports that approximately 71% of surveyed consumers were more inclined to make purchases when AR tools were available.

Further advancing the conceptual understanding of AR, Milgram and Kishino (1994) introduced the Reality Virtuality Continuum. This framework situates AR between the real environment and fully virtual environments, illustrating its position within the broader spectrum of mixed reality technologies. It underscores AR's unique ability to seamlessly blend digital and physical content, setting it apart from other immersive technologies.

### *Virtual Try-On (VTO)*

The application of Augmented Reality (AR) technology in the jewelry industry, particularly for products such as rings and bracelets, is emerging as a prominent trend aimed at enhancing the consumer shopping experience (Kang et al., 2020). Virtual Try-On (VTO) systems utilizing AR enable users to "try on" jewelry items visually on their hands through a smartphone camera, without the need to physically touch the product (Kim & Forsythe, 2008). On mobile devices, AR technology leverages motion sensors, cameras, and touchscreens to display virtual models of jewelry in real time, allowing

users to rotate their hands, change viewing angles, and seamlessly try multiple designs (Prado et al., 2021). This not only increases user engagement but also contributes to building trust in the product and reducing return rates in e-commerce (Hilken et al., 2017). Additionally, mobile AR applications for jewelry often integrate hand tracking and 3D alignment technologies to ensure the product appears in the correct position and at realistic scale (Sanna et al., 2021). VTO systems have been shown to increase consumer engagement, satisfaction, and purchase intention due to their personalized and highly interactive experience (Kim et al., 2023; Orús et al., 2021). One study reported that 71% of users were more likely to make a purchase when VTO features were available (Somlith, 2024).

### ***Machine Learning***

Machine Learning (ML) is a subfield of artificial intelligence focused on developing algorithms that can learn from data and improve their performance on specific tasks without being explicitly programmed. As defined by Mitchell (1997), “A computer program is said to learn from experience E with respect to some class of tasks T and performance measure P, if its performance at tasks in T, as measured by P, improves with experience E.” In the context of augmented reality (AR) applications, ML plays a critical role in enabling real-time facial recognition, pose estimation, and dynamic object tracking, thereby enhancing the accuracy and interactivity of the user experience.

In this project, we implemented MediaPipe, an open-source framework developed by Google, which provides high-performance ML solutions optimized for mobile and embedded devices. One of its most notable components, Face Landmarker (formerly Face Mesh), is capable of detecting up to 468 facial landmarks in real time. This enables precise 3D facial geometry mapping, allowing virtual accessories such as earrings or glasses to be accurately rendered and positioned on the user’s face, even during movement or rotation. According to the official MediaPipe documentation, all computations are performed on-device, ensuring low latency and reducing dependence on internet connectivity—crucial for delivering seamless AR try-on experiences on mobile platforms (Google Developers, 2024).

MediaPipe’s combination of efficiency, robustness, and real-time performance makes it especially suitable for interactive fashion applications that require both visual fidelity and smooth user interaction. Its integration into this project allows for a practical and scalable implementation of AR-based virtual try-on technology in the fashion accessory domain.

#### **2.2.1. Application Design Concept**

##### ***User Interface/ User Experience***

In app design, User Interface (UI) and User Experience (UX) are closely related concepts. According to Pushpakumar et al. (2023), UI design concerns the visual and interactive elements—the screens, buttons, menus, icons, and layout that users see and touch. UX design refers to the overall experience and satisfaction a user has when

interacting with the product—including usability, usefulness, emotions, and pleasure. Good UI (e.g., clear navigation and visual consistency) contributes significantly to good UX, but UX also involves broader dimensions such as trust, emotional impact, and the “joy of use,” which go beyond mere functionality.

In the field of Human-Computer Interaction (HCI), enhancing UX is considered the ultimate goal of interface design (Pushpakumar et al., 2023). Quezada et al. (2021) further emphasize that User-Centered Design (UCD) methods are key to achieving high usability and a positive user experience. In practice, UI/UX design draws from both cognitive psychology and visual design principles—ensuring that screens are intuitive, feedback is immediate and clear, and interactions align with users’ mental models. Studies by Nielsen Norman Group have encapsulated these into widely adopted heuristics, including visibility of system status, user control, consistency, and error prevention.

In this project, UI/UX design plays a central role in creating a seamless and immersive interaction with key features such as AR try-on, product browsing, and booking. Design decisions are guided by principles of accessibility, visual clarity, and responsiveness across various devices, with an emphasis on reducing cognitive load and improving overall satisfaction. Prototypes were developed and tested iteratively to refine navigation flow and maximize ease of use.

### ***User-Centered Design (UCD)***

User-Centered Design (UCD) is a design philosophy and process that grounds application development in the end user’s needs. It involves the active participation of representative users throughout the entire design cycle to ensure that the resulting product is aligned with their expectations and behaviors. Quezada et al. (2021) describe UCD as “a framework used to improve or guarantee high usability and user experience” in interactive systems.

The ISO 9241-210 standard outlines a human-centered design process comprising four iterative phases: analyzing user context, specifying user requirements, developing design solutions, and evaluating them with real users. Methods such as interviews, surveys, focus groups, and usability testing are employed to gather insights at each stage (ISO, 2010). As noted by Pushpakumar et al. (2023), UCD promotes intuitive and easily understandable software by constantly involving users and refining design choices based on their feedback.

In this project, UCD was implemented through a cyclical process of research, prototyping, testing, and iteration. Initially, user research—including questionnaires and observational studies—was conducted to define user goals and challenges in AR-based fashion try-on experiences. The design team then developed wireframes and interactive prototypes of the core features, followed by usability evaluations (e.g., A/B testing, heuristic analysis). Based on these results, improvements were made and retested, continuing until user expectations were effectively met. UCD thus ensured that both interface and functionality remained closely aligned with real user needs.

## **2.2.2. Requirement Acquisition Method**

In software engineering, requirement acquisition is the process of gathering and defining what a system should do in order to meet user expectations and business objectives. Selecting appropriate techniques to capture these requirements is critical to ensuring that the final product aligns with real-world needs. This project adopts two primary methods for requirement acquisition: observation and document review.

### ***Observation***

Observation is a widely used technique in requirements engineering to identify user behaviors, usability issues, and real-world interactions with systems. It allows analysts to detect implicit pain points that may not be revealed in interviews or surveys (Nuseibeh & Easterbrook, 2000). In this project, observation sessions were conducted by analyzing how users interact with existing AR shopping applications—specifically how they browse items, align virtual accessories on their face or ears, and respond to visual feedback. These insights helped uncover issues related to user posture, lighting conditions, and product positioning, which directly influenced UI design and AR rendering choices.

### ***Document Review***

Document review involves analyzing existing literature, technical documentation, and market guidelines to extract relevant information for requirement definition. It is particularly useful in AR development, where system constraints and user expectations are tied closely to platform limitations (Preece, Rogers, & Sharp, 2015). For this study, official documentation from Google ARCore, Firebase, and MediaPipe was examined alongside academic publications on virtual try-on systems and mobile UX guidelines. This helped the team define realistic functional and non-functional requirements and ensured that the application aligned with both user needs and technical feasibility.

## **2.2.3. Concepts and Diagrams in System Modeling**

System modeling serves as a bridge between user requirements and technical implementation, offering a visual abstraction of system functionality, data flow, structure, and user interaction. Below are key modeling techniques used in this project.

### ***Unified Modeling Language Diagram***

Unified Modeling Language (UML) is a formalized visual language commonly employed in object-oriented software development to model the architecture, behavior, and interactions within a system. It offers a comprehensive set of standardized diagram types that support both structural and dynamic views of software components. One of UML's primary strengths is its ability to provide a common framework for communication among various stakeholders, including developers, designers, analysts, and end users. In this project, UML is utilized to model essential aspects of the application, including system functionalities and interaction flows. Diagrams such as use case, sequence, and class diagrams were employed to depict how users interact with

the system, how internal processes are coordinated, and how components are structured to support the AR-based mobile application.

### ***Use Case Modeling***

Use case diagrams are used to represent the functional requirements of a system by mapping out how users (actors) interact with system functionalities (use cases). Each use case represents a specific objective that a user aims to accomplish through the system. This modeling approach is particularly valuable during the early phases of system design, as it helps clarify user expectations and system boundaries from the user's point of view. In this project, use case diagrams were developed to define key interactions such as trying on accessories through AR, browsing the product catalog, booking appointments, and managing user profiles. These diagrams serve as a foundation for implementing features that prioritize usability and user experience.

### ***Data Flow Diagram***

A Data Flow Diagram (DFD) is a visual representation that depicts how data flows through a system and how it is processed at different stages. It shows the movement of data between external entities, processes, and data stores. DFDs are widely used in system analysis and design to illustrate the functional perspective of data usage and transformation (Gane & Sarson, 1979). In this study, Level 0 and Level 1 DFDs were created to model how user data, product information, and recommendation results move through the AR application. For example, the process of scanning a face and receiving accessory suggestions was broken down into clear data movements between user input, AR rendering engine, and recommendation module.

### ***Entity-Relationship Diagram***

An Entity-Relationship Diagram (ERD) is used to represent the logical structure of a database by defining entities, attributes, and the relationships between them. ERDs help ensure data is stored efficiently, avoids redundancy, and supports system functionality (Chen, 1976). Key components of an ERD include entities (e.g., User, Product), their attributes (e.g., user ID, product type), and their interconnections (e.g., one user can have multiple bookings). In this project, the ERD was designed to model the relationships between users, AR accessory items, recommendation history, and bookings. This ensured that the database was properly structured to support personalized experiences and system scalability.

### ***Business Process Modeling Notation***

Business Process Modeling Notation (BPMN) is a standardized graphical notation that is used to model business processes. It includes visual elements such as tasks, gateways, events, and swimlanes to describe the logical flow of business activities (OMG, 2022). BPMN is especially helpful in ensuring that technical implementations align with real-world business rules and workflows. In this project, BPMN diagrams were used to model user flows such as product selection, AR interaction, and checkout/booking. This enabled both business stakeholders and developers to

understand the process steps clearly and identify opportunities for automation or optimization.

### ***Sequence Diagram***

A sequence diagram is a type of UML behavioral diagram that shows how processes operate with one another and in what order. It focuses on the time sequence of messages exchanged between objects or components in a system (Fowler, 2003). These diagrams are useful for illustrating real-time interactions and detailing the behavior behind specific use cases. For the AR try-on system, sequence diagrams were constructed to demonstrate flows such as “User opens AR camera and selects a product” or “User confirms a booking.” These helped developers understand the communication between front-end elements, backend services, and external libraries (e.g., MediaPipe, Firebase).

## **2.3. Tool Used**

### ***Visual Studio Code***

Visual Studio Code (VS Code) is a lightweight, cross-platform code editor developed by Microsoft. It supports multiple programming languages and features built-in Git integration, a terminal, and an extensive extension library (Microsoft, 2021). In this project, VS Code was used to build the admin web system for managing products, orders, and user data. This system connects to Firebase and interacts with the mobile app developed in Android Studio. The separation between admin and client platforms improves system organization and maintainability.

### ***Android Studio Code***

Android Studio is a widely used integrated development environment (IDE) for Android application development. Beyond supporting Java and Kotlin programming, Android Studio offers powerful UI design tools such as the Layout Editor, enabling developers to build interfaces using a drag-and-drop visual approach. In this project, Android Studio was used not only to implement functionalities but also to design the user interface of the mobile application for AR-based fashion accessory try-on. It also supports integration with technologies like ARCore and Firebase. The platform allows real-time preview across different screen sizes and supports efficient debugging, making it an effective tool for rapid UI development and user experience testing.

### ***Figma***

Figma is an online interface design platform that facilitates collaborative work in real-time, enabling teams to co-edit wireframes, mockups, and high-fidelity UI designs directly in the browser. Its cloud-based nature eliminates the need for local installations and supports seamless communication between designers and developers. In this project, Figma was applied to prototype the mobile application's interface for virtual try-on experiences and personalized fashion recommendations. The interface was crafted using user-centered design (UCD) techniques, ensuring intuitive navigation and ease of use, and was iteratively improved through usability testing prior to implementation in Android Studio (Quezada, Cueva, & Paz, 2021).

### ***GitHub***

GitHub is a web-based platform built on the Git version control system, enabling collaborative code management. It provides centralized repositories where multiple contributors can store, track, and update code efficiently, while also supporting issue tracking and documentation. In this study, GitHub was used to manage the source code for both the mobile AR application and the admin website system. It ensured version control, supported team collaboration, and facilitated code consistency across development stages. GitHub also enabled backup and change tracking throughout the process (GitHub, 2025).

### ***Firebase***

Firebase is a powerful Backend-as-a-Service (BaaS) platform by Google that offers tools for building and scaling modern mobile applications. Key features include user authentication, real-time databases, cloud storage, and analytics, all seamlessly integrated into Android Studio. In this project, Firebase is used to manage user accounts, store AR-related product metadata, and track user behaviors via Firebase Analytics. These services support the personalized recommendation system in the mobile app and ensure secure, scalable performance. Its compatibility with Google Cloud also allows future development of AI-enhanced features (Firebase, 2024).

### ***Drawio***

Draw.io (now diagrams.net) is a free, browser-based diagramming tool used for designing system architecture and software documentation. It supports UML, ERD, DFD, and BPMN diagrams, and integrates easily with platforms like Google Drive and GitHub. In this project, Draw.io was used to create system diagrams such as use case models and data flow diagrams. These visuals helped clarify user interactions, database structure, and system logic, serving as a reference for both design and development stages (Diagrams.net, 2024).

## **2.4. System Requirement Method**

In system and software development, clearly defining system requirements is essential for ensuring that the final product aligns with both user needs and technical objectives. System requirements are generally divided into two main categories: Functional Requirements and Non-functional Requirements. Both types are critical to the overall success of a project and provide a foundation for system design, development, and testing.

### ***Functional Requirements***

Functional requirements specify what a system must do. These are explicit behaviors or functions that a software or hardware system is expected to perform. They describe features such as data processing, user interactions, and specific operations that the system needs to support.

These requirements are often validated through various testing methods, including unit testing and integration testing, to ensure that the system behaves as intended. Functional requirements can be oriented around either processes (what tasks the system performs) or information (what data the system manages or uses).

One well-known approach to crafting effective functional requirements is the EARS (Easy Approach to Requirements Syntax) method, developed by engineer Alistair Mavin. EARS helps structure requirement statements into clear, practical formats by classifying them into archetypes such as:

- Ubiquitous requirements
- State-driven requirements
- Event-driven requirements
- Optional requirements
- Unwanted behavior requirements
- Complex requirements

Using these formats ensures that requirement statements are concise, consistent, and easy to understand across teams.

### ***Non-functional Requirements***

Non-functional requirements define constraints and quality attributes of a system rather than specific behaviors. They refer to how the system performs rather than what it does. These include overall performance expectations, operational limitations, or technical qualities such as:

- Speed and response time (performance)
- System stability and fault tolerance (reliability)
- Ease of use (usability)
- Ease of maintenance and upgrades (maintainability)
- Platform compatibility (portability)
- System safety and data protection (security)

Unlike functional requirements, non-functional ones often apply across the entire system and are critical for ensuring a positive user experience and long-term sustainability of the product.

For this project, non-functional requirements are categorized into the following groups:

- Performance Requirements (PR)
- Platform Constraints (PC)
- Accuracy and Precision (AP)
- Adaptability (AD)
- Security (SC)

## **2.5. Theoretical Framework of Model**

### **2.5.1 The MediaPipe Framework Architecture**

MediaPipe's real-time perception capabilities are primarily driven by its efficient pre-trained models for landmark detection, notably in facial and hand tracking. These systems employ a two-stage architecture—detect-then-track or detect-then-refine—that ensures a balance between computational efficiency and high accuracy, particularly on mobile or resource-constrained devices (Lugaresi et al., 2019; Bazarevsky et al., 2020).

Rather than performing detection on every frame, MediaPipe alternates between full detection and lightweight tracking modes. It maintains tracking as long as confidence remains high, switching back to detection when necessary, thereby optimizing processing load (Zhang et al., 2020; Google, 2023a).

### ***Face Mesh Detection***

MediaPipe Face Mesh predicts 468 3D landmarks from a single RGB image without requiring depth sensors (Bazarevsky et al., 2020). It operates in two stages: BlazeFace for initial detection, followed by a MobileNetV2-based model for 3D landmark regression (Howard et al., 2019). An Attention Mesh variant improves precision in facial regions such as the eyes and lips by applying attention mechanisms, at the cost of increased latency (Google, 2023b). Outputs include 3D coordinates (468 or 478 points), blendshape parameters (52 expressions), and a  $4 \times 4$  transformation matrix for pose estimation.

### ***Hand Landmark Detection***

MediaPipe Hands detects 21 2D/3D keypoints per hand and determines handedness using a two-step pipeline: a palm detection model for region proposal and a lightweight regression model for keypoint estimation. Trained on around 30,000 real and synthetic samples, the system tracks hand motion efficiently by relying on previous frames and only triggering detection when confidence degrades (Zhang et al., 2020; Google, 2023a).

## **2.5.2 Physically Based Rendering with Google Filament**

Google Filament is a real-time, physically based rendering engine optimized for mobile and cross-platform performance. It uses physical units (e.g., lumens, Kelvin) and provides a minimal, developer-friendly API in C++ and Java/JNI (Google, 2019). Built on top of graphics APIs like OpenGL, Vulkan, and MoltenVK, Filament avoids runtime shader compilation by using *matc*, which pre-compiles materials into optimized binaries.

Key components include:

- Engine: Manages resources
- Renderer: Executes draw calls
- SwapChain: Output surface
- Scene: Contains entities
- View: Defines camera, effects
- Camera: Sets projection and exposure

Filament supports glTF 2.0 for seamless 3D model import from tools like Blender. Filament uses microfacet-based BRDFs to approximate realistic lighting. The total reflectance is:

$$f(v, l) = f_d(v, l) + f_r(v, l)$$

$f_d$ : Lambertian diffuse

$f_r$ : Microfacet specular, computed as:

$$f_r = \frac{D(h)F(v,h)G(l,v,h)}{4\langle n \cdot l \rangle \langle n \cdot v \rangle}$$

Where:

- $D$ : Normal distribution (controls glossiness)
- $F$ : Fresnel effect (angle-dependent reflectivity)
- $G$ : Geometry term (shadowing/masking)

Filament ensures realistic reflections through a physically based model that respects energy conservation and roughness-driven light scattering. Its standard lit material model uses intuitive parameters such as *roughness*, *metallic*, and *baseColor*, with the *metallic* parameter determining whether the base color represents diffuse reflection (for dielectrics) or specular reflection (for metals), thereby enforcing physically plausible results and consistent behavior under dynamic lighting (Google, 2023).

### 2.5.3 Hybrid Recommender Systems

Hybrid recommender systems aim to combine the strengths of both Content-Based Filtering (CBF) and Collaborative Filtering (CF) to enhance recommendation quality and address the limitations inherent in each individual method.

Content-Based Filtering (CBF) operates by analyzing the intrinsic attributes of items and aligning them with user preferences. This process generally involves three key stages:

- Item Profiling: Each item is represented as a feature vector. For text-based items, Natural Language Processing (NLP) techniques such as Term Frequency–Inverse Document Frequency (TF-IDF), Word2Vec, or BERT are commonly used to extract meaningful keywords and capture semantic relationships. In the case of non-textual data, metadata attributes (e.g., genre, director, brand) are utilized to construct item-feature matrices.
- User Profiling: User profiles are generated by aggregating the feature vectors of items the user has previously interacted with or expressed interest in. NLP-based enhancements, such as sentiment analysis or topic modeling, can offer a deeper understanding of user preferences, particularly in textual interactions.
- Similarity Matching: Algorithms such as cosine similarity, dot product, or Euclidean distance are employed to measure the closeness between item vectors and the user profile. The top-ranked items are then recommended based on these similarity scores.

Collaborative Filtering (CF), in contrast, makes recommendations by identifying patterns in user behavior without relying on the content of items. CF techniques typically use a user-item interaction matrix and fall into two main categories:

- Memory-Based Methods: These include User-Based CF, which recommends items favored by similar users, and Item-Based CF, which suggests items similar to those a user has liked, based on co-occurrence patterns.

- Model-Based Methods: These approaches utilize techniques such as matrix factorization to uncover latent factors that explain observed interactions. Incorporating NLP-derived features into such models can improve their effectiveness, particularly in sparse data environments.

Collaborative Filtering (CF) is highly effective in identifying serendipitous or novel items by leveraging patterns in user-item interactions. However, its performance deteriorates in cold-start scenarios, particularly when dealing with new users or items that lack sufficient interaction data. To mitigate these limitations, Hybrid Recommender Systems integrate both Content-Based Filtering (CBF) and CF, employing various strategies such as the *weighted hybrid* approach, which combines the outputs of each method using context-dependent or performance-based weighting schemes.

Such hybrid models have consistently demonstrated improved recommendation accuracy, enhanced diversity, and increased robustness. Their effectiveness is further amplified when supplemented with Natural Language Processing (NLP) techniques, which extract semantic insights from unstructured data such as product descriptions and user reviews (Burke, 2002; Zhang et al., 2019; Roy et al., 2024). In particular, recent advancements employ large language models (LLMs) and sentiment scoring to enhance content representation and capture nuanced user preferences, further improving the quality of recommendations in hybrid architectures (Roy et al., 2024).

## 2.6. Proposed Model

The proposed system architecture consists of four primary components: the User, Frontend (Mobile UI), Backend, and Model Training module. This architecture enables an interactive and intelligent virtual try-on experience for users, specifically tailored for jewelry products.

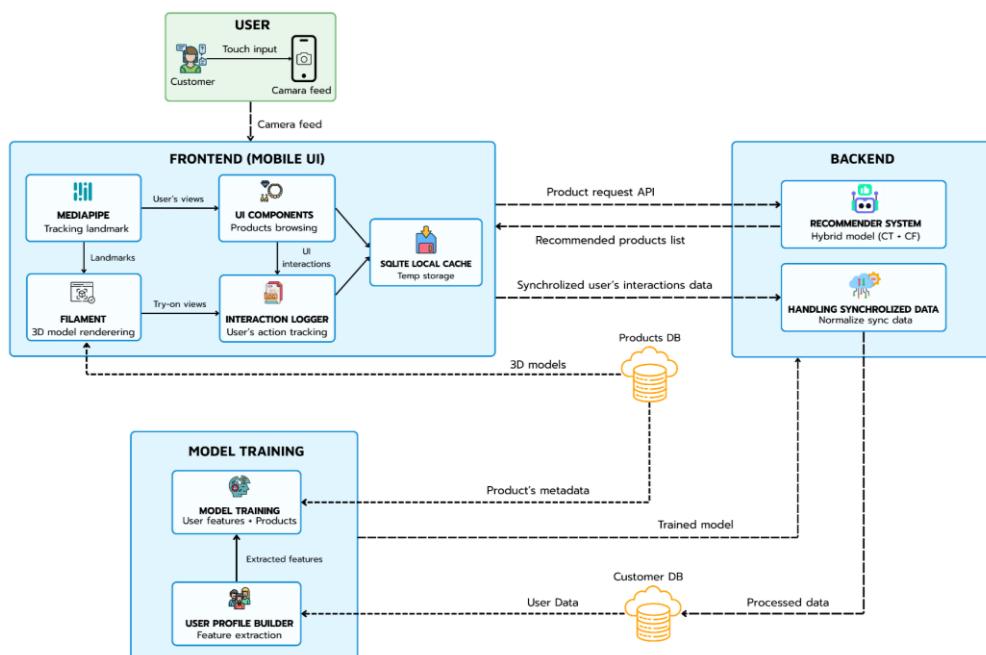


Figure 2: Proposed Model (Source: Authors)

## User Interaction

Users engage with the system through a mobile application interface. Interaction typically begins with a touch input that activates the device's camera. The live camera feed is then processed for landmark detection and augmented rendering, enabling the virtual try-on experience.

### ***Frontend (Mobile User Interface)***

The frontend module manages the user interface and processes real-time inputs from the mobile device. It includes several key subcomponents:

- MediaPipe: This framework detects and tracks facial and hand landmarks from the camera feed. These landmarks are essential for accurately positioning virtual jewelry items in 3D space.
- Filament: A real-time rendering engine that overlays 3D jewelry models onto the user's image based on the landmark coordinates provided by MediaPipe.
- UI Components: Allow users to navigate the product catalog, select jewelry items for try-on, and interact with the application.
- Interaction Logger: Captures user actions, such as product browsing and virtual try-on activities. These actions are temporarily stored using an SQLite cache for later synchronization with the backend.

### ***Backend System***

The backend is responsible for processing user interaction data and generating personalized product recommendations. It consists of two main modules:

- Recommender System: Utilizes a hybrid recommendation approach, combining content-based filtering with collaborative filtering (CF + CF). It processes product queries from the frontend and returns a tailored list of jewelry suggestions via an API.
- Data Handling and Synchronization: Normalizes interaction data received from the frontend and stores it in the Customer Database. This structured data serves as input for model training and system refinement.

### ***Model Training Module***

This module is tasked with building and training machine learning models to improve the recommendation system:

- User Profile Builder: Constructs detailed user profiles from the interaction data stored in the Customer Database. These profiles reflect user preferences and behavioral patterns.
- Model Training: Integrates user profiles with product metadata to train recommendation models. Once optimized, the models are deployed to the backend for real-time inference.

Product-related metadata and 3D models are sourced from the Product Database, while user behavior data is drawn from the Customer Database. This integrated data pipeline ensures the recommendation engine adapts to user preferences and continuously improves over time.

## CHAPTER 3: PROPOSED SOLUTION

This chapter presents the proposed system design, including key functional and non-functional requirements. It introduces six main feature modules, user flows and system models (DFDs, BPMN, Use Case, and ERD diagrams). The chapter also outlines the system architecture, database design, and integration of machine learning components.

### 3.1. System Requirement Document

This section outlines the main system features, including both functional and non-functional requirements, based on the proposed luxury jewelry e-commerce platform. The functional requirements focus on user interactions, services, and transaction management, while non-functional requirements define quality constraints for the overall system.

#### 3.1.1. Functional Requirement

##### *User Authentication Flow – Functional Requirements*

Table 1: Functional Requirements of User Authentication Flow (Source: Authors)

FR ID	Description
FR-LOGIN-01	The system shall allow users to register a new account using email or third-party login (Google, Apple).
FR-LOGIN-02	The system shall allow users to log in and out securely.
FR-LOGIN-03	The system shall support password reset using OTP verification.

##### *View & Reserve Service – Functional Requirements*

Table 2: Functional Requirements of View & Reserve Service (Source: Authors)

FR ID	Description
FR-BOOKING-01	The system shall allow users to book services (e.g., piercing, cleaning, styling) by selecting time, location, and technician.
FR-BOOKING-02	The system shall validate booking data and confirm via notifications.
FR-BOOKING-03	The system shall allow users to update or cancel booked appointments.
FR-BOOKING-04	The system shall allow users to view service booking history.

##### *Product Interaction Flow – Functional Requirements*

Table 3: Functional Requirements of Product Interaction Flow (Source: Authors)

FR ID	Description
FR-PRODUCT-01	The system shall allow users to browse products by category, filter, and keyword search.

FR-PRODUCT-02	The system shall display detailed product information including name, price, description, and AR preview.
FR-PRODUCT-03	The system shall allow users to add products to the cart or wishlist.
FR-CART-01	The system shall allow users to modify or remove products in the cart.

### ***Payment Flow – Functional Requirements***

*Table 4: Functional Requirements of Payment Flow (Source: Authors)*

<b>FR ID</b>	<b>Description</b>
FR-ORDER-02	The system shall allow users to place an order from the cart and proceed to checkout.
FR-PAYMENT-01	The system shall support multiple payment methods: card, COD, and bank transfer.
FR-PAYMENT-02	The system shall allow users to apply discount vouchers during checkout.
FR-PAYMENT-03	The system shall validate and confirm payment transactions securely.

### ***Account Settings & History – Functional Requirements***

*Table 5: Functional Requirements of Account Settings & History (Source: Authors)*

<b>FR ID</b>	<b>Description</b>
FR-ACCOUNT-01	The system shall allow users to update their profile, including avatar, email, phone, and password.
FR-ACCOUNT-02	The system shall allow users to manage multiple delivery addresses.
FR-ORDER-01	The system shall display users' past orders and service bookings.

### ***User Support Interaction – Functional Requirements***

*Table 6: Functional Requirements of User Support Interaction (Source: Authors)*

<b>FR ID</b>	<b>Description</b>
FR-SUPPORT-01	The system shall allow users to browse FAQs and access help topics.
FR-SUPPORT-02	The system shall allow users to submit inquiries via a contact form.
FR-SUPPORT-03	The system shall allow staff to view, reply to, and close support tickets.

### 3.1.2. Non-functional Requirement

Non-functional requirements (NFRs) define the quality attributes and constraints of the system, focusing on how the system should operate rather than what it should do. These requirements ensure performance, usability, scalability, and security, which are crucial for delivering a reliable and user-friendly experience, especially in the context of a luxury e-commerce platform.

*Table 7: Non-functional Requirement (Source: Authors)*

NFR ID	Description
PR-001	The system shall run in a mobile application environment to ensure accessibility for all users via their smartphones.
PR-002	The system shall respond to user requests within 2 seconds to provide a seamless experience during high-demand situations.
PR-003	The system shall be updated at least once a month to ensure that all features and security protocols are up to date.
PC-001	The system shall be compatible with Android and iOS operating systems for broader usability.
PC-003	The back end shall utilize a secure and scalable database system to store user and transactional data.
AP-001	The system shall differentiate between different users based on unique user credentials (username and password).
AP-002	User input shall be case-sensitive to prevent unauthorized access and ensure accurate data entry.
AP-003	The system shall inform the admin of any login failures after 3 unsuccessful attempts to prevent brute force attacks.
AD-001	The system shall allow admins to add, remove, or modify user accounts without requiring code changes or downtime.
AD-002	The system shall adapt to platform updates seamlessly, ensuring no disruption in service for users.
SC-001	The system shall require multi-factor authentication for users to enhance security during the login process.
SC-002	The system shall encrypt data exchange between the client and server using SSL to ensure data security.
SC-003	If a brute force hacking attempt is detected, the user's account shall be temporarily locked for 15 minutes.
SC-004	If a user forgets their password, the system shall provide a secure

password recovery process, including verification steps.

## 3.2. Data and Process Modeling

### 3.2.1. Context Diagram Data Flow Diagram

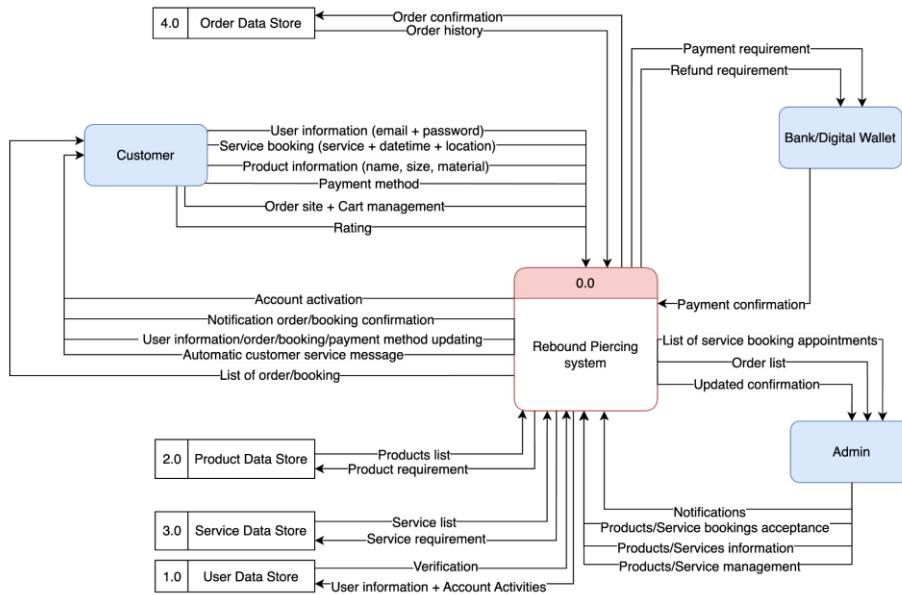


Figure 3: Context Diagram Data Flow Diagram (Source: Authors)

### 3.2.2. Customer Mobile Application Business Process Model and Notation Diagram

#### General User Flow

This BPMN diagram presents a comprehensive overview of the user interaction flow within a shopping application, covering the entire journey from app launch to order placement and tracking. The process begins when users open the app and are shown onboarding slides if they haven't viewed them previously; otherwise, they proceed to determine their account status. New users are directed to sign up, existing users to the sign-in interface, while others may opt to continue in Guest Mode. Regardless of login status, users can browse services, shop for products, read blog posts, or access FAQs. For advanced or personalized actions, the system re-checks the user's authentication status. Once logged in, users gain access to enhanced features such as booking services, managing their cart, updating personal information or passwords, and reviewing order history. After adding items to the cart, they can review, cancel, or proceed with payment and track their orders in real time. The process concludes once the system successfully processes the order. Overall, the BPMN diagram captures a seamless, intuitive flow that supports user engagement across all stages of the shopping experience—from onboarding to post-purchase management.

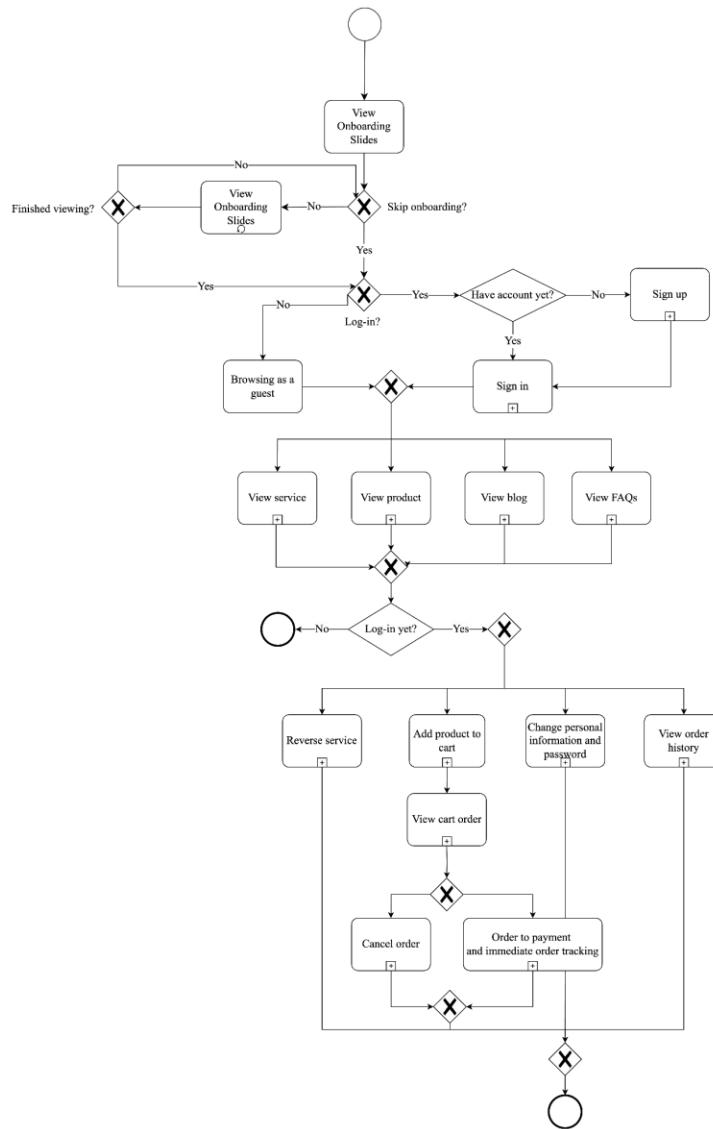


Figure 4: The General BPMN Diagram of The Customer Mobile Application (Source: Authors)

### 3.3. Authentication

#### 3.3.1 Business Process Model and Notation Diagram

This BPMN diagram outlines the complete flow of user registration, login, and password recovery within an application, organized across three main swimlanes: User Interface, System, and Authentication & Security Logic. The process begins with the user selecting the “Sign Up” option and entering personal details such as name, email, and password, while agreeing to the terms of service. The system validates the input, and if errors like a weak password or invalid email are detected, it prompts the user to correct them. Upon successful validation, the account is created in the database, and a confirmation message is displayed. Users can register using email or via third-party providers like Google. For login, users input their email and password, which the system verifies. If credentials are incorrect or improperly formatted, an error is shown; otherwise, the user is granted access and redirected to the homepage. In the event of a forgotten password, users can select “Forgot Password,” enter their registered email, and

receive a One-Time Password (OTP). If the OTP is not received, they can request a resend. After entering the correct code, users are prompted to set a new password. The system checks for validity and consistency between the new password entries. If valid, the update is saved and a success message is shown; if invalid, the user is asked to re-enter the information. Overall, the diagram provides a comprehensive view of the key authentication workflows, balancing user convenience with security protocols.

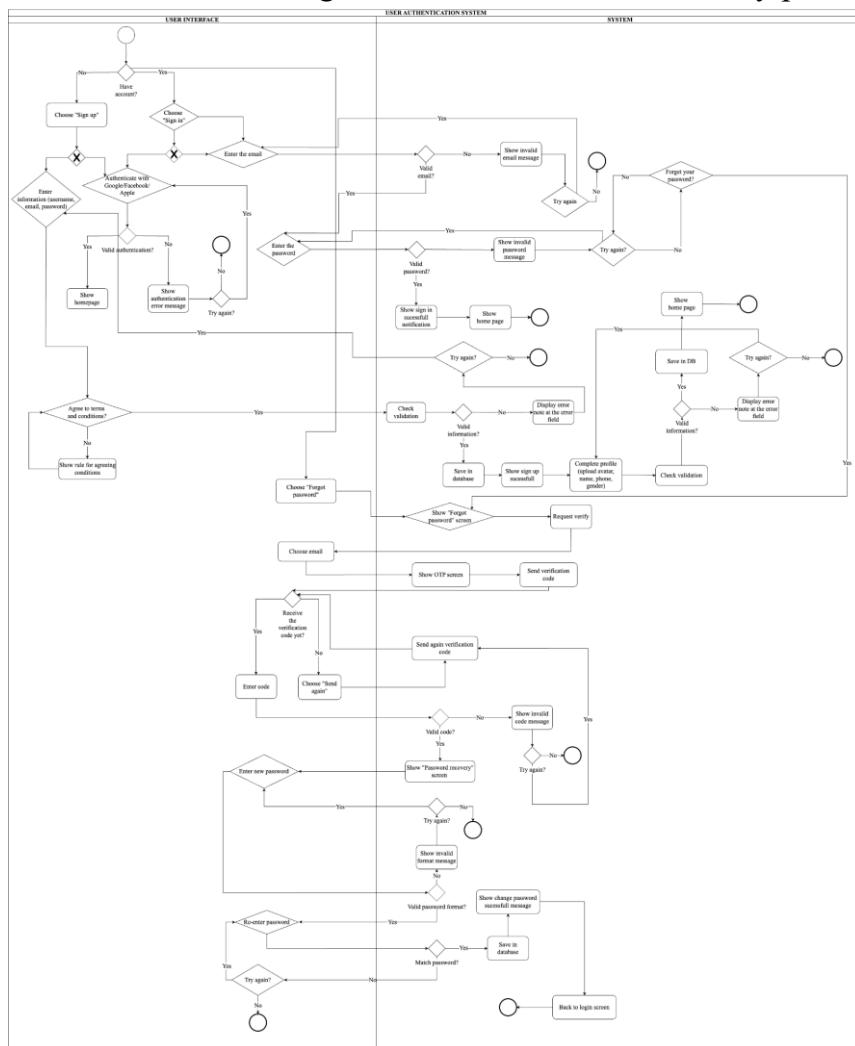


Figure 5: The BPMN Diagram of Authentication Function (Source: Authors)

### 3.3.2. Use Case Diagram

The Authentication module of the ReboundPiercing mobile app manages user access through three core use cases: Log in, Sign up, and Forget Password. It allows users to log in using either email/password or Google OAuth, verifies credentials, and handles error cases like invalid input or login failure. New users can sign up by providing a username, email, and password, with validation to prevent duplication and ensure input correctness. The Forget Password use case enables account recovery via OTP verification sent to the registered email, followed by a password reset. Supporting actions such as entering credentials and submitting OTPs are modularized for reuse across flows.

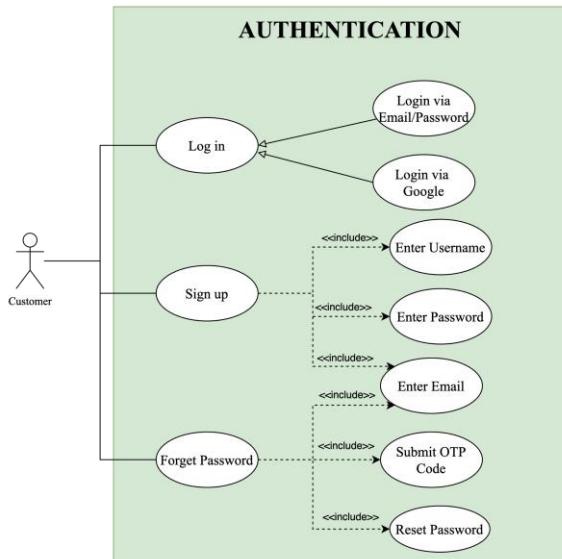


Figure 6: Authentication Use Case Diagram (Source: Authors)

### • Use Case Specification

#### *Use Case: Log in*

Table 8: Log in Use Case Specification (Source: Authors)

Attribute	Content
Use Case Name	Log in
Actor	Customer
Description	Allows users to authenticate using Email/Password or Google account
Successful Completion	User is authenticated and redirected to the app's home/dashboard screen
Basic Flow	<ol style="list-style-type: none"> <li>1. Customer opens app</li> <li>2. Selects “Log in”</li> <li>3. Chooses Email/Password or Google</li> <li>4. Provides credentials</li> <li>5. System verifies and logs in user</li> </ol>
Alternative Flow	<ol style="list-style-type: none"> <li>3a. If user selects Google → redirected to Google OAuth</li> <li>4a. If already signed in → skip credentials</li> </ol>
Exception Flow	<ol style="list-style-type: none"> <li>4b. Incorrect credentials → show error</li> <li>4c. Google authentication fails → display retry option</li> </ol>

Precondition	User must have a registered account
Post-condition	User is granted access and session is started

### **Use Case: Sign up**

*Table 9: Sign up Use Case Specification (Source: Authors)*

<b>Attribute</b>	<b>Content</b>
Use Case Name	Sign up
Actor	Customer
Description	Enables new users to register a ReboundPiercing account by providing credentials
Successful Completion	New account is created and user is logged in automatically
Basic Flow	<ol style="list-style-type: none"> <li>1. Customer selects “Sign up”</li> <li>2. Inputs username, email, and password</li> <li>3. System validates input</li> <li>4. Account is created</li> </ol>
Alternative Flow	<ol style="list-style-type: none"> <li>3a. If email already exists → notify and suggest login</li> <li>3b. Password is weak → show suggestions</li> </ol>
Exception Flow	3c. Invalid email format or missing fields → show error
Precondition	None
Post-condition	Account is created, and user is redirected to home screen

### **Use Case: Forget Password**

*Table 10: Forget Password Use Case Specification (Source: Authors)*

<b>Attribute</b>	<b>Content</b>
Use Case Name	Forget Password
Actor	Customer

Description	Allows users to recover their account by verifying email and submitting OTP to reset password
Successful Completion	User resets password and regains access to account
Basic Flow	<ol style="list-style-type: none"> <li>1. Customer selects “Forget Password”</li> <li>2. Enters registered email</li> <li>3. Receives OTP</li> <li>4. Inputs OTP</li> <li>5. Sets new password</li> </ol>
Alternative Flow	<ol style="list-style-type: none"> <li>4a. If OTP is expired → option to resend</li> <li>5a. New password is weak → prompt to re-enter</li> </ol>
Exception Flow	<ol style="list-style-type: none"> <li>2a. Email not registered → show error</li> <li>4b. OTP incorrect → block after multiple tries</li> </ol>
Precondition	User must have previously registered using that email
Post-condition	New password is saved; user can now log in

### 3.4. Product Browsing & Purchase

#### 3.4.1. Business Process Model and Notation Diagram

##### ***Product Interaction BPMN***

This BPMN diagram illustrates the user flow for searching, selecting products, managing wishlists, and handling the shopping cart within an e-commerce mobile application. The process begins when the user enters product-related keywords or filtering criteria and clicks the "Search" button. The system processes the request, queries the database, and displays either a "No products found" message or a list of relevant products. Upon selecting a product, the user chooses attributes such as size and material, and can tap the heart icon (♥) to manage their wishlist. The system checks if the item is already saved; if so, it removes it, otherwise, it adds the product to the wishlist and confirms the action. The user can also add the item to the shopping cart. If not logged in, the system prompts for authentication before proceeding. Once signed in, the item is added to the cart, where the user can adjust quantities or remove items. If an item is deleted and the remaining quantity is above zero, the system updates the cart accordingly; if the quantity reaches zero, the product is removed. Overall, this process supports a seamless and user-friendly experience for product discovery, personalization, and cart management.

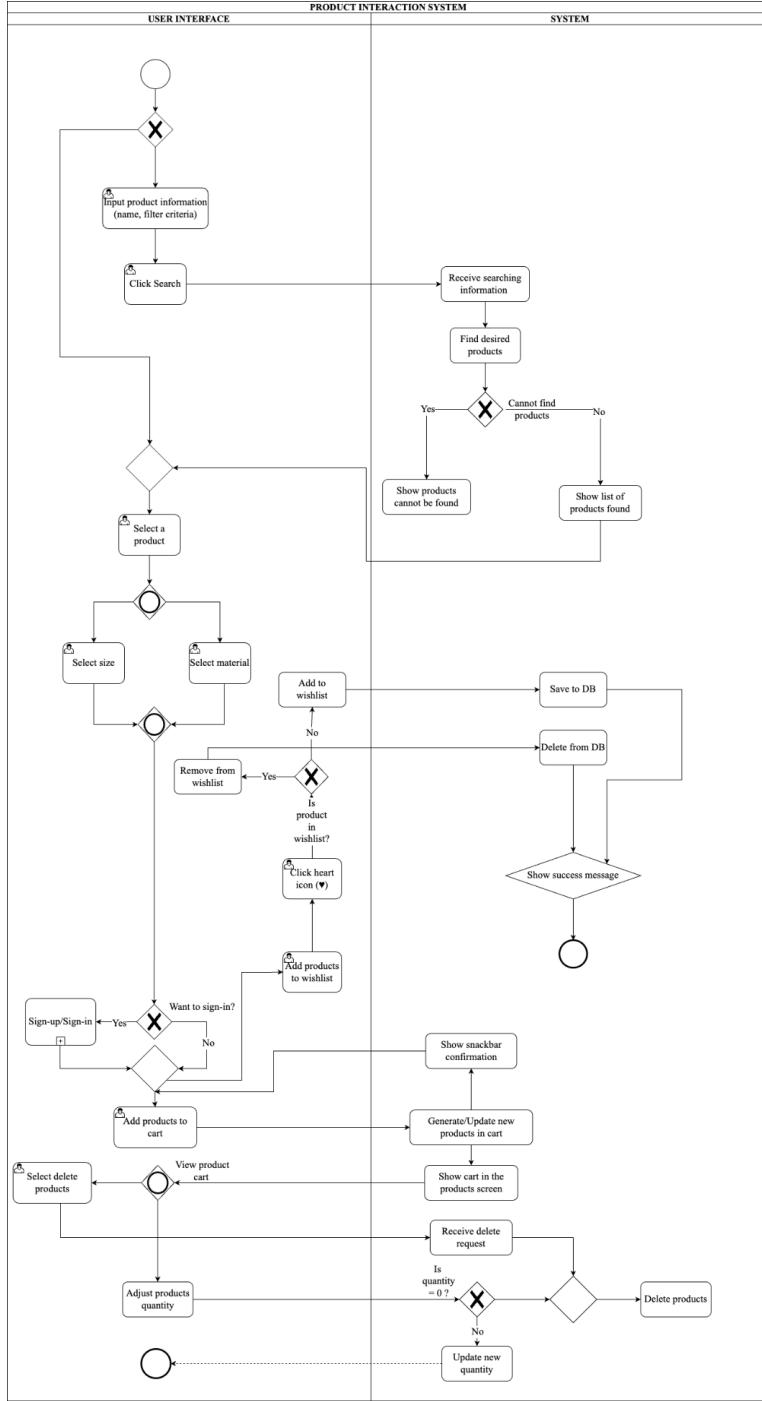


Figure 7: The BPMN Diagram of Product Interaction Function (Source: Authors)

### Payment Flow BPMN

This BPMN diagram illustrates the complete flow of how users complete payments and track orders within a shopping application. The process begins when the user accesses the cart; if it contains products, the system displays the cart page and updates the product list. The user proceeds by tapping the “Proceed to Checkout” button, entering a shipping address, and optionally applying discount vouchers. After confirming delivery details, the user selects a payment method—Cash on Delivery (COD), Credit/Debit Card, or Internet Banking via QR code. For COD, the system skips payment gateway verification, generates the order, saves it to the database, and offers

order tracking. If paying by Credit/Debit Card, the system collects card details and sends them for validation. On failure—due to incorrect details or insufficient funds—an error is displayed and the process ends; if successful, the transaction is recorded and tracking becomes available. With Internet Banking, the system either shows a QR code or redirects to the user's online banking interface, and verifies payment via API. Failed transactions lead to an error message, while successful ones transition to order tracking. In the final stage, users can track their order, with the system calling a tracking API to retrieve live delivery updates. If the data loads correctly, full order details are shown; if it fails, the user is still directed to the tracking page, though some information may be delayed or incomplete.

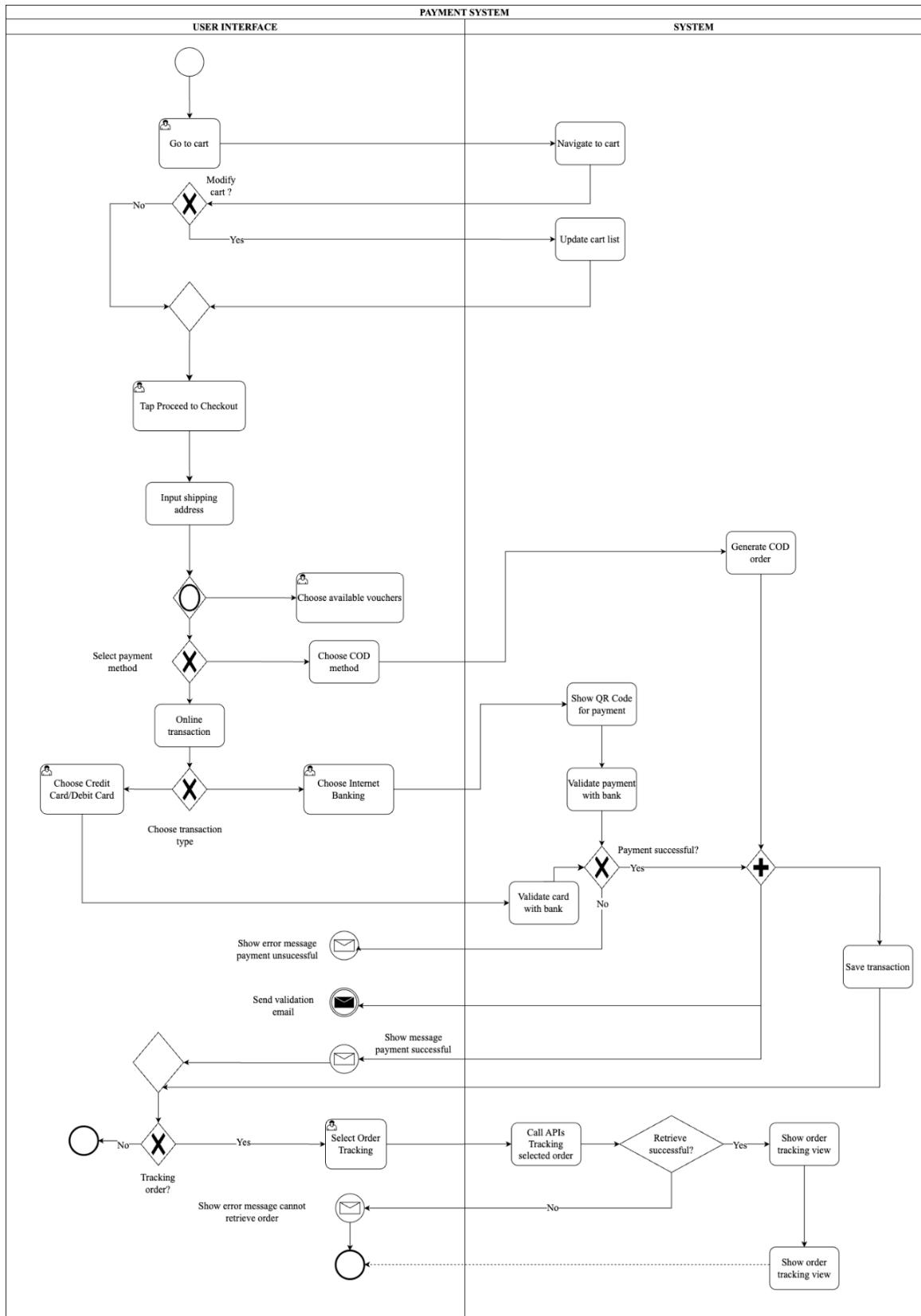


Figure 8: The BPMN Diagram of Payment Function (Source: Authors)

### 3.4.2. Use Case Diagram

The Product Browsing & Purchase module in the ReboundPiercing mobile app supports the full shopping journey of the customer, from discovering products to completing a transaction. Customers can search for products using keywords or explore

them by browsing categories. They can apply filters and view detailed information before deciding to add a product to the cart. When placing an order, users may apply discount codes, confirm or add a shipping address, choose a payment method, and finalize the order. After placing the order, customers proceed to make a payment, which the system processes. Once completed, users may optionally rate their experience.

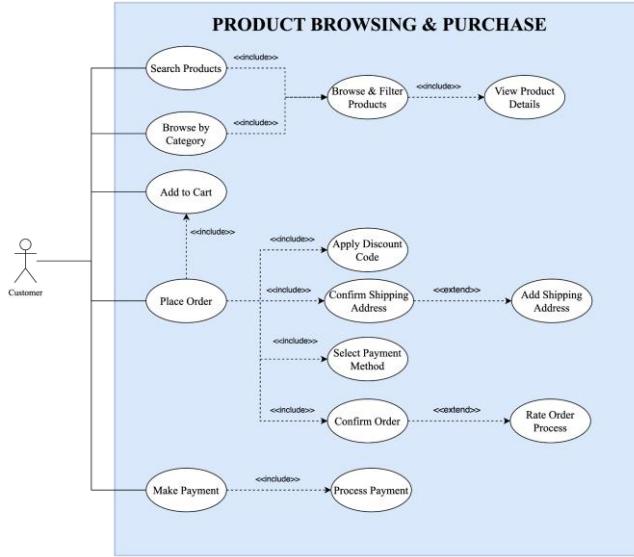


Figure 9: Product Browsing & Purchase Use Case Diagram (Source: Authors)

### ● Use Case Specification

#### *Use Case: Search Products*

Table 11: Search Products Use Case Specification (Source: Authors)

Attribute	Content
Use Case Name	Search Products
Actor	Customer
Description	Enables customers to find products by entering keywords
Successful Completion	Matching product results are displayed
Basic Flow	1. User types keyword into search bar 2. System displays matching results
Alternative Flow	1a. No results found → system suggests related items
Exception Flow	2a. Connection issue → show error message

Precondition	App is connected to internet
Post-condition	Results are presented and user can continue browsing

### **Use Case: Add to Cart**

*Table 12: Add to Cart Use Case Specification (Source: Authors)*

Attribute	Content
Use Case Name	Add to Cart
Actor	Customer
Description	Allows users to add selected products to the shopping cart
Successful Completion	Product is added to cart and cart count is updated
Basic Flow	<ol style="list-style-type: none"> <li>1. User views product</li> <li>2. Taps “Add to Cart”</li> <li>3. System updates cart</li> </ol>
Alternative Flow	2a. User is not logged in → prompt to sign in
Exception Flow	3a. Product out of stock → show notification
Precondition	Product must be available in stock
Post-condition	Cart contains the selected product

### **Use Case: Place Order**

*Table 13: Place Order Use Case Specification (Source: Authors)*

Attribute	Content
Use Case Name	Place Order
Actor	Customer
Description	Enables the customer to finalize an order after reviewing cart contents

Successful Completion	Order is successfully confirmed and marked for payment processing
Basic Flow	1. User opens cart 2. Applies discount code 3. Confirms shipping address 4. Selects payment method 5. Confirms order
Alternative Flow	2a. Discount code invalid → show error 3a. No address → redirect to add new address
Exception Flow	4a. No payment method selected → prompt 5a. Order confirmation fails due to timeout
Precondition	User must have valid items in cart
Post-condition	Order is created and ready for payment

### ***Use Case: Make Payment***

*Table 14: Make Payment Use Case Specification (Source: Authors)*

Attribute	Content
Use Case Name	Make Payment
Actor	Customer
Description	Finalizes the transaction by securely processing the selected payment method
Successful Completion	Payment is processed, and order is marked as completed
Basic Flow	1. User proceeds to payment 2. System invokes payment processor 3. Confirmation is returned
Alternative Flow	2a. User cancels before payment is processed → return to order summary
Exception Flow	3a. Payment fails → show error and option to retry or change method

Precondition	Valid order must exist and be confirmed
Post-condition	Payment is complete and order status is updated

### **Use Case: Rate Order Process**

*Table 15: Rate Order Process Use Case Specification (Source: Authors)*

Attribute	Content
Use Case Name	Rate Order Process
Actor	Customer
Description	Allows users to rate and provide feedback after order fulfillment
Successful Completion	Rating is submitted and stored in the system
Basic Flow	1. User accesses completed orders 2. Taps “Rate Order” 3. Selects stars, writes feedback
Alternative Flow	2a. User skips rating → no action
Exception Flow	3a. Submission error → prompt retry
Precondition	Order must be fulfilled or delivered
Post-condition	Feedback is saved to system and visible to admins

## **3.5. Booking Service System**

### **3.5.1. Business Process Model and Notation Diagram**

This BPMN diagram illustrates the process of booking, modifying, and canceling appointments through a web-based system. The process begins when the user selects the "Book Appointment" function, chooses a date and time, and enters the required information. The system validates the input; if invalid, the user is prompted to correct it. Once the information is valid, the system checks the user's login status. If the user is not logged in, they are redirected to the login page. After successful authentication, the system processes the booking, confirms the appointment, and redirects the user to the confirmation page. Following this, the user can either book additional appointments or view a list of existing ones. Within the appointment list, the user has the option to modify

the appointment time or delete an appointment. If deletion is selected, the system prompts the user to provide a cancellation reason. If the user cancels this action, the process ends. If confirmed, the system records the reason, deletes the appointment from the database, and concludes the process.

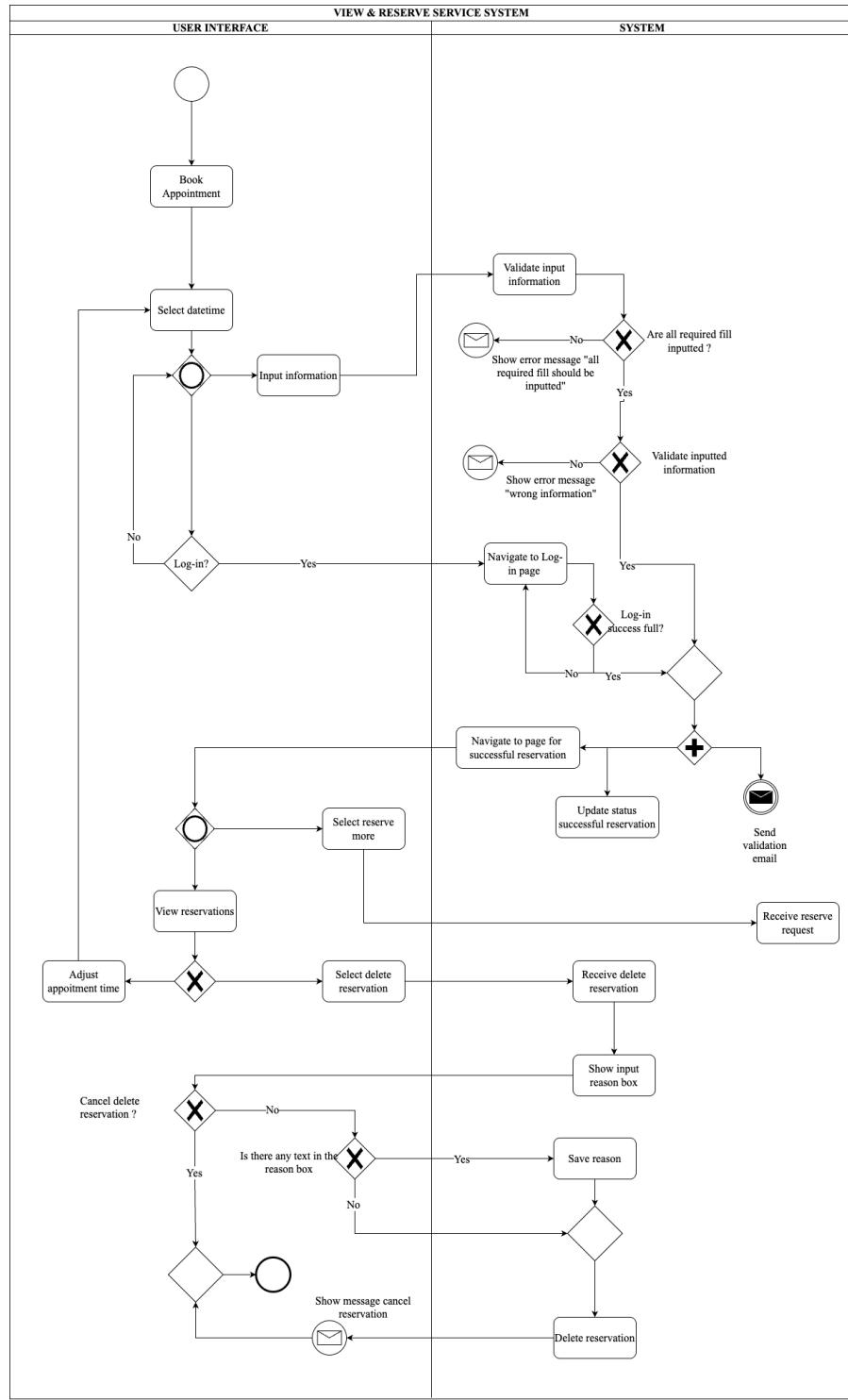


Figure 10: The BPMN Diagram of Booking Service Function (Source: Authors)

### 3.5.2. Use Case Diagram

The Booking Service System in the ReboundPiercing mobile app allows customers to schedule and manage piercing appointments. The core use cases include Book a Service and Cancel Booking, with the booking flow composed of sub-actions:

selecting a location, choosing services, picking a time slot, and confirming the appointment. These steps ensure users can conveniently reserve their preferred time and service. A cancellation option is also provided for users who already have an existing booking.

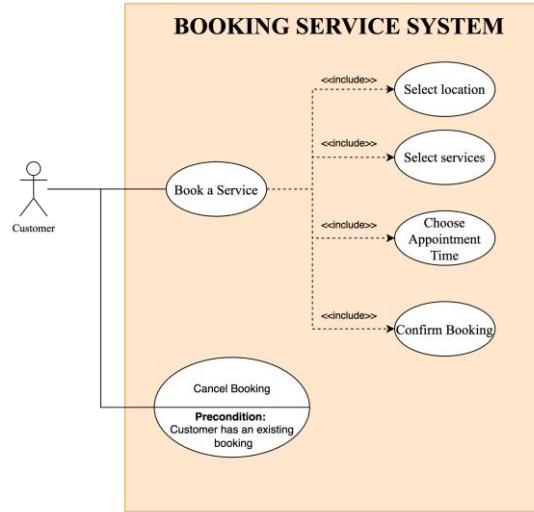


Figure 11: Booking Service System Use Case Diagram (Source: Authors)

### • Use Case Specification

#### **Use Case: Book a Service**

Table 16: Book a Service Use Case Specification (Source: Authors)

Attribute	Content
Use Case Name	Book a Service
Actor	Customer
Description	Allows users to schedule an appointment for piercing services
Successful Completion	A booking is created with selected location, service, and time slot
Basic Flow	<ol style="list-style-type: none"> <li>1. Customer selects location</li> <li>2. Chooses services</li> <li>3. Picks appointment time</li> <li>4. Confirms booking</li> </ol>
Alternative Flow	<ol style="list-style-type: none"> <li>2a. No services selected → show prompt</li> <li>3a. No available slots → suggest alternative times</li> </ol>
Exception Flow	<ol style="list-style-type: none"> <li>1a. Location data fails to load</li> </ol>

	4a. Booking conflicts → show error
Precondition	User must be logged in
Post-condition	Booking is saved to system; confirmation is shown

### ***Use Case: Cancel Booking***

Attribute	Content
Use Case Name	Cancel Booking
Actor	Customer
Description	Allows users to cancel an existing appointment
Successful Completion	The appointment is cancelled and removed from system
Basic Flow	<ol style="list-style-type: none"> <li>1. Customer opens booking history</li> <li>2. Selects appointment</li> <li>3. Confirms cancellation</li> </ol>
Alternative Flow	2a. User decides not to cancel → return to booking page
Exception Flow	1a. Booking not found or already cancelled → show error
Precondition	User must have an existing booking
Post-condition	Appointment is cancelled; status is updated

*Table 17: Cancel Booking Use Case Specification (Source: Authors)*

#### **3.5.3. Sequence Diagram**

The following sequence diagram depicts the appointment booking process within the mobile application. It covers both the main success scenario and an alternative flow in the case of a time slot conflict.

The process involves four primary actors and components:

- User: Initiates the booking process and interacts with the application interface.
- Front-end: Provides the user interface and transmits requests to the server.

- Back-end: Implements the business logic and handles interactions with the data layer.
- Database: Stores persistent data, including available time slots and confirmed bookings.

### **Main Flow – Successful Booking**

The process begins when the user selects a service, specifies a preferred date, and chooses a desired time slot. The front-end transmits this booking request to the back-end server. The back-end component then queries the database to verify the availability of the selected time slot. If the slot is available, the system proceeds to create a new appointment entry and stores it in the database. A booking confirmation is then sent back to the front-end, which displays the confirmation to the user.

### **Alternative Flow – Time Slot Conflict**

If the selected time slot is already occupied, the back-end detects the conflict and responds with an error message. The front-end then informs the user that the time slot is unavailable and provides a list of alternative available slots. At this point, the user may either select a different time—prompting the system to repeat the availability check—or cancel the process and return to the service selection step.

This sequence ensures that the booking system maintains data integrity and provides a responsive user experience through immediate feedback and available alternatives.

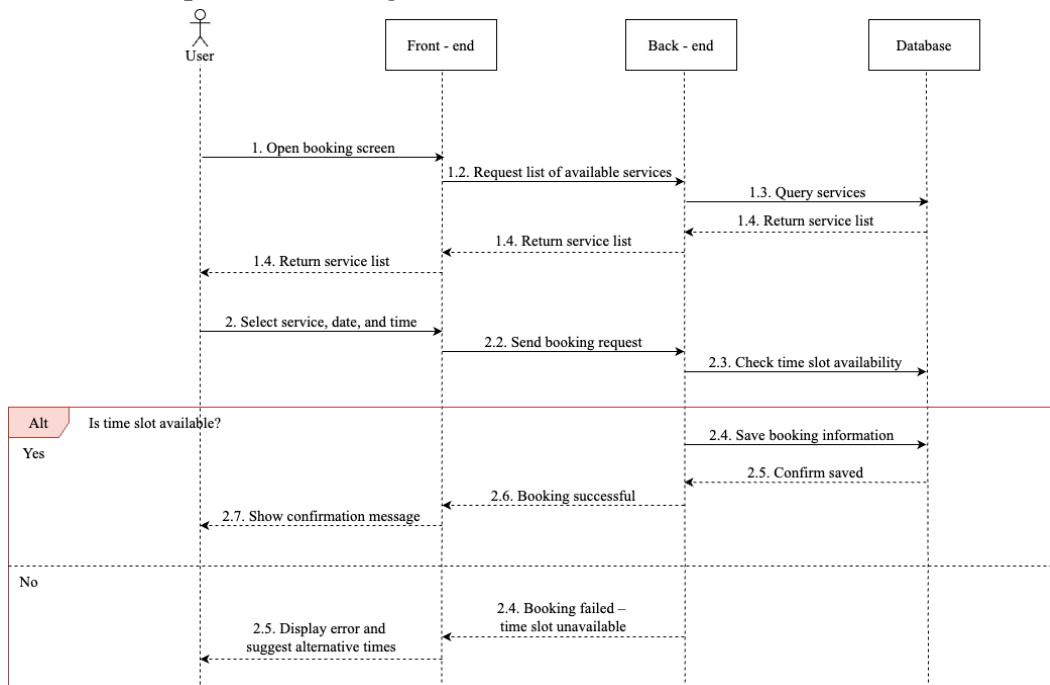


Figure 12: Sequence Diagram of Appointment Booking Flow (Source: Authors)

## **3.6. Customer Account Management**

### **3.6.1. Business Process Model and Notation Diagram**

#### **Account Settings & History**

The BPMN diagram illustrates the user's interaction flow with their personal profile and order history within the system. The process begins when the user selects the “Choose Profile” option, prompting the system to display their personal profile. From

there, the user can view their order history and select a specific order to access detailed information, which the system retrieves from the database. Users may also add products to their cart or delete existing orders; when an order is deleted, the system removes it from the database and confirms the action. Additionally, users can update their personal information by selecting the “Change Information” button. After entering new details—such as avatar, username, email, phone number, or password—they click “Update.” If the password is unchanged, the system directly updates the information. However, if a password change is requested, the system presents a dedicated password update screen requiring the current password, a new password, and its confirmation. The system verifies the inputs, and if valid, saves the new password and displays a confirmation message. If the inputs are invalid or the passwords do not match, the system prompts the user to re-enter the information until it is correct, at which point the update process concludes.

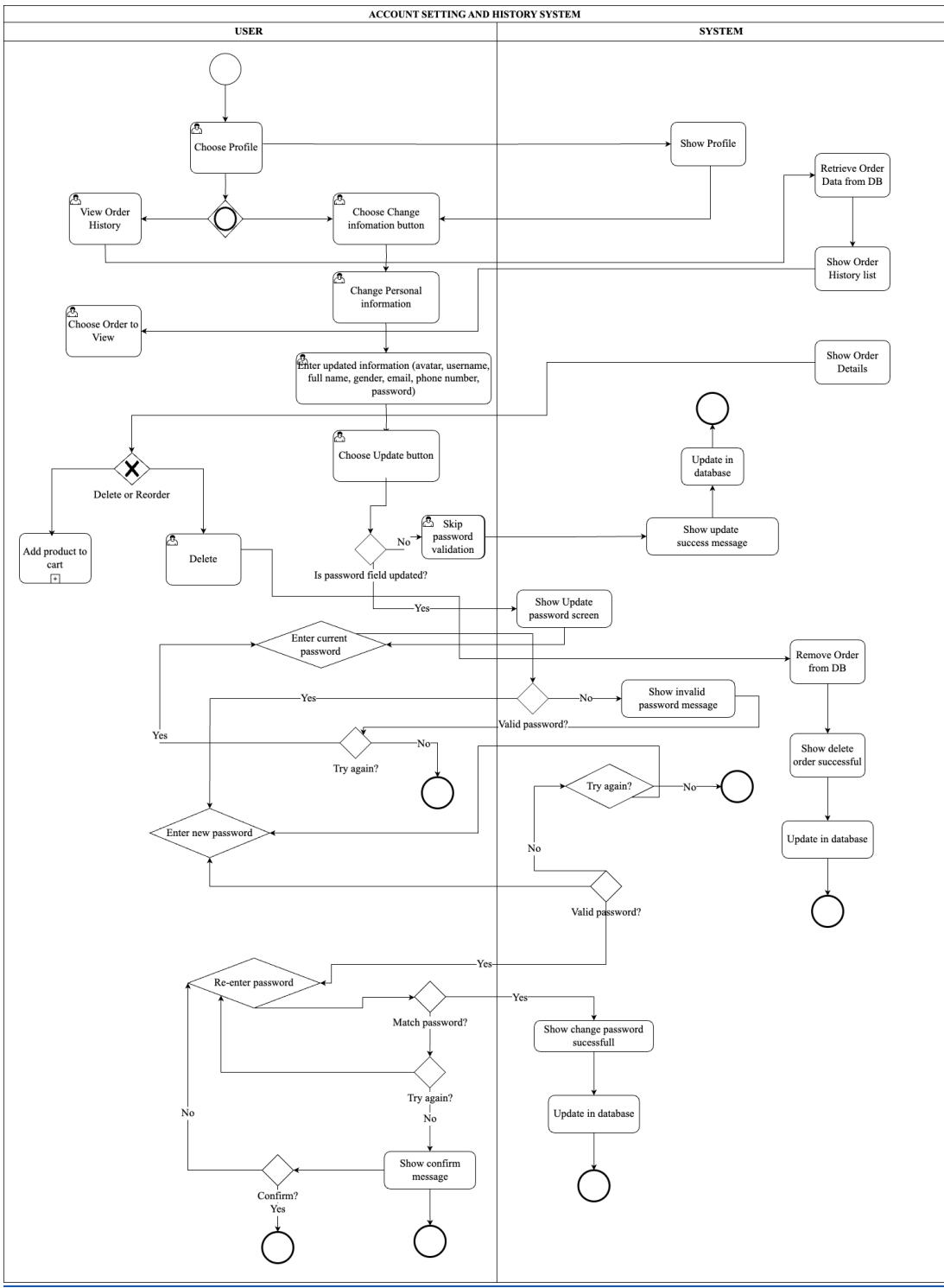


Figure 13: The BPMN Diagram of Account Settings & History Function (Source: Authors)

### 3.6.2. Use Case Diagram

The Customer Account Management module in the ReboundPiercing mobile app enables users to maintain and control various aspects of their personal profile, order activities, and system interactions. Customers can update their profile information, manage wishlists, add or remove payment methods, view past orders, and log out. Additional features include password changes, tracking order status, managing notification preferences, and reordering from previous purchases.

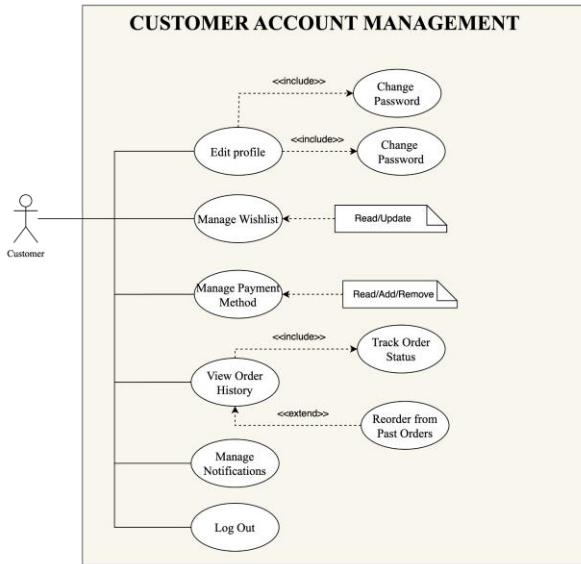


Figure 14: Customer Account Management Use Case Diagram (Source: Authors)

### ● Use Case Specification

#### **Use Case: Edit Profile**

Table 18: Edit Profile Use Case Specification (Source: Authors)

Attribute	Content
Use Case Name	Edit Profile
Actor	Customer
Description	Allows users to update profile information
Successful Completion	Profile is updated and changes are saved in the system
Basic Flow	<ol style="list-style-type: none"> <li>1. User opens profile page</li> <li>2. Makes changes</li> <li>3. Saves changes</li> </ol>
Alternative Flow	3a. User cancels changes → return to previous state
Exception Flow	2a. Invalid input format → show error message
Precondition	User must be logged in
Post-condition	Updated data is stored and visible on the profile page

#### **Use Case: Manage Wishlist**

Table 19: Manage Wishlist Use Case Specification (Source: Authors)

Attribute	Content
Use Case Name	Manage Wishlist
Actor	Customer
Description	Allows users to view, add, or remove items from wishlist
Successful Completion	Wishlist is updated as requested
Basic Flow	<ol style="list-style-type: none"> <li>1. User opens wishlist</li> <li>2. Adds/removes items</li> <li>3. Changes saved</li> </ol>
Alternative Flow	2a. User adds same item again → show already added message
Exception Flow	3a. Server error → show failure message
Precondition	User must be logged in
Post-condition	Wishlist reflects the latest user actions

### **Use Case: View Order History**

Table 20: View Order History Use Case Specification (Source: Authors)

Attribute	Content
Use Case Name	View Order History
Actor	Customer
Description	Displays user's previous and current orders
Successful Completion	List of orders is retrieved and shown
Basic Flow	<ol style="list-style-type: none"> <li>1. User accesses order history</li> <li>2. System fetches orders</li> <li>3. Orders displayed</li> </ol>

Alternative Flow	2a. No orders found → show empty state message
Exception Flow	2b. Network issue → show retry option
Precondition	User has placed at least one order
Post-condition	Orders are displayed with options to track or reorder

### **Use Case: Manage Payment Method**

*Table 21: Manage Payment Method Use Case Specification (Source: Authors)*

<b>Attribute</b>	<b>Content</b>
Use Case Name	Manage Payment Method
Actor	Customer
Description	Enables users to manage saved payment methods
Successful Completion	Selected method is added, updated, or deleted
Basic Flow	1. User opens payment settings 2. Adds/updates/deletes method 3. Save
Alternative Flow	2a. Attempt to delete primary method → show warning
Exception Flow	3a. Validation failure → show error message
Precondition	User is authenticated
Post-condition	System reflects current payment methods

### **Use Case: Log Out**

*Table 22: Log Out Use Case Specification (Source: Authors)*

<b>Attribute</b>	<b>Content</b>
Use Case Name	Log Out

Actor	Customer
Description	Ends the current user session
Successful Completion	User is logged out and redirected to login or home screen
Basic Flow	<ol style="list-style-type: none"> <li>1. User taps “Log out”</li> <li>2. System clears session data</li> </ol>
Alternative Flow	None
Exception Flow	2a. Log out fails → show retry option
Precondition	User must be logged in
Post-condition	User is logged out

### 3.7. Help & Info

#### 3.7.1. Business Process Model and Notation Diagram

##### *User Support Interaction*

This BPMN diagram illustrates the user support process through the system's Help Center, which involves interaction between the user interface, backend system, and support staff. The process begins when a user selects the “Help Center” option and is given two choices: browsing the Frequently Asked Questions (FAQs) or using the “Contact Us” form. If the user opts to view FAQs, they select a topic, prompting the system to retrieve and display relevant information from the database. The process ends once the answer is shown. Alternatively, if the user chooses the “Contact Us” option, a form appears for them to fill in their inquiry details. If submitted without content, the system redirects the user back to the main help page. If the form is properly filled out, the system forwards the inquiry to the support team. The support staff then reviews the message and responds, and the user receives the reply via the interface, concluding the process.

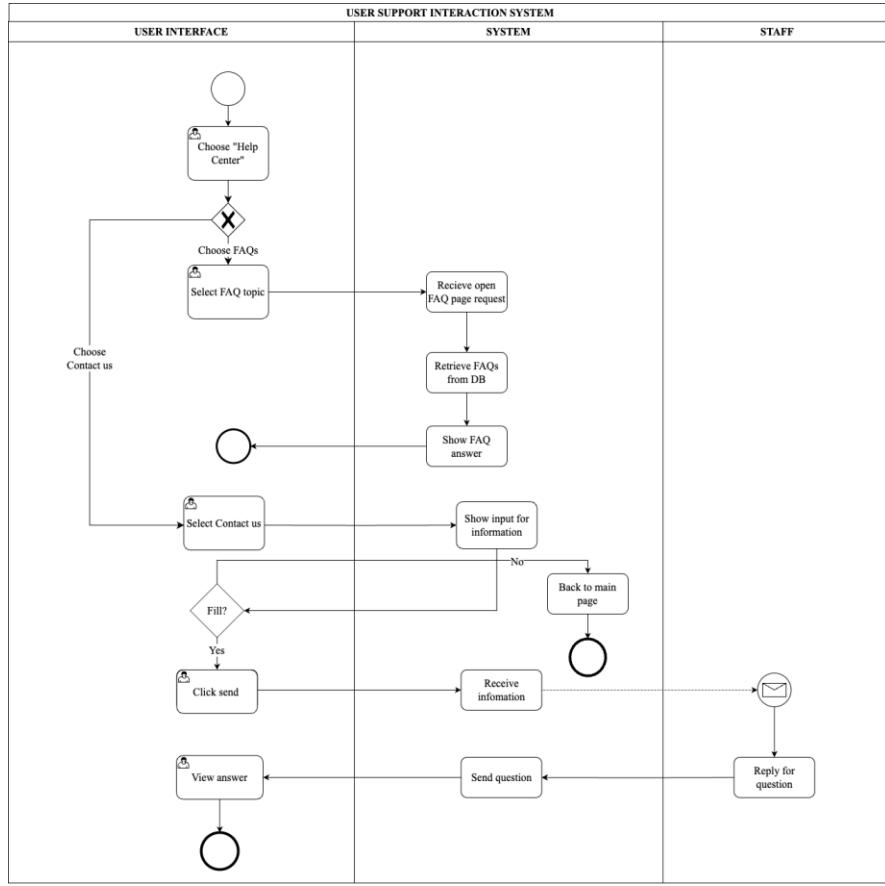


Figure 15: The BPMN Diagram of Help & Info Function (Source: Authors)

### 3.7.2. Use Case Diagram

The Help & Info module in the ReboundPiercing mobile app provides customers with self-service and support resources. Users can view the latest news and promotions, read frequently asked questions (FAQs), switch languages, and review terms and policies related to the app and services. If users require further assistance, they can contact support directly. The support request is forwarded to a staff member who receives and processes the inquiry.

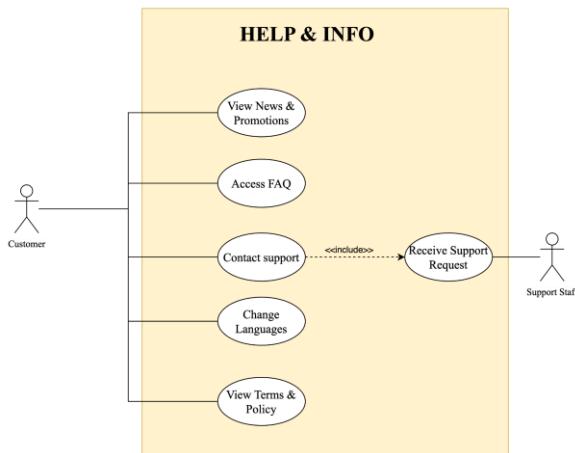


Figure 16: Help & Info Use Case Diagram (Source: Authors)

#### • Use Case Specification

##### **Use Case: View News & Promotions**

Table 23: View News & Promotions Use Case Specification (Source: Authors)

Attribute	Content
Use Case Name	View News & Promotions
Actor	Customer
Description	Displays current promotional campaigns, news, and app updates
Successful Completion	User can view and interact with the list of promotions
Basic Flow	<ol style="list-style-type: none"> <li>1. User opens news section</li> <li>2. Scrolls through content</li> <li>3. Taps for detail</li> </ol>
Alternative Flow	2a. No active promotions → show empty state or past promotions
Exception Flow	1a. Failed to load content → show retry button
Precondition	App must have access to news content
Post-condition	News viewed; user may proceed to take action (e.g. shop)

### **Use Case: Contact Support**

Table 24: Contact Support Use Case Specification (Source: Authors)

Attribute	Content
Use Case Name	Contact Support
Actor	Customer
Description	Allows users to submit a support inquiry to the helpdesk
Successful Completion	A support request is sent and acknowledged by the system
Basic Flow	<ol style="list-style-type: none"> <li>1. User opens support form</li> </ol>

	2. Fills in message 3. Submits request
Alternative Flow	2a. User cancels → no request sent
Exception Flow	3a. Network failure → show retry option
Precondition	User is logged in
Post-condition	Request is forwarded to support staff

### ***Use Case: Change Languages***

*Table 25: Change Languages Use Case Specification (Source: Authors)*

<b>Attribute</b>	<b>Content</b>
Use Case Name	Change Languages
Actor	Customer
Description	Allows users to switch the app's display language
Successful Completion	UI is updated to the selected language
Basic Flow	1. User navigates to settings 2. Selects language 3. App updates UI
Alternative Flow	2a. User exits before selection → no changes applied
Exception Flow	3a. Language resource not available → show error
Precondition	App supports multiple languages
Post-condition	Selected language is stored and applied

### ***Use Case: View Terms & Policy***

*Table 26: View Terms & Policy Use Case Specification (Source: Authors)*

<b>Attribute</b>	<b>Content</b>

Use Case Name	View Terms & Policy
Actor	Customer
Description	Lets users read the app's Terms of Service and Privacy Policy
Successful Completion	Legal content is displayed
Basic Flow	<ol style="list-style-type: none"> <li>1. User selects “Terms &amp; Policy”</li> <li>2. System loads the latest content</li> </ol>
Alternative Flow	None
Exception Flow	2a. Content fails to load → show retry message
Precondition	User is on an active session
Post-condition	Document is viewed

### ***Use Case: Access FAQ***

*Table 27: Access FAQ Use Case Specification (Source: Authors)*

Attribute	Content
Use Case Name	Access FAQ
Actor	Customer
Description	Enables customers to read frequently asked questions
Successful Completion	User views helpful information and possible solutions
Basic Flow	<ol style="list-style-type: none"> <li>1. User opens FAQ</li> <li>2. Browses or searches questions</li> <li>3. Views answer</li> </ol>
Alternative Flow	2a. User filters by category

Exception Flow	2b. FAQ list fails to load → show error
Precondition	FAQs are maintained in the backend
Post-condition	Information is shown to the user

### 3.8. AR Camera System

#### 3.8.1. Business Process Model and Notation Diagram

The BPMN diagram illustrates the interaction between the user interface and the system within the AR Camera System during a virtual jewelry try-on session. The process begins when the user initiates the session and selects a jewelry category. The system then validates the selection; if it is invalid, an error message is displayed and the process ends. If valid, the AR camera is activated. The system checks for camera permission—if denied, a warning is shown and the session is terminated; if granted, the system displays the AR overlay. The user can then optionally switch the camera, triggering the system to toggle the view. The process concludes when the user completes the try-on session. The diagram effectively captures the sequential and conditional flows between user actions and system responses.

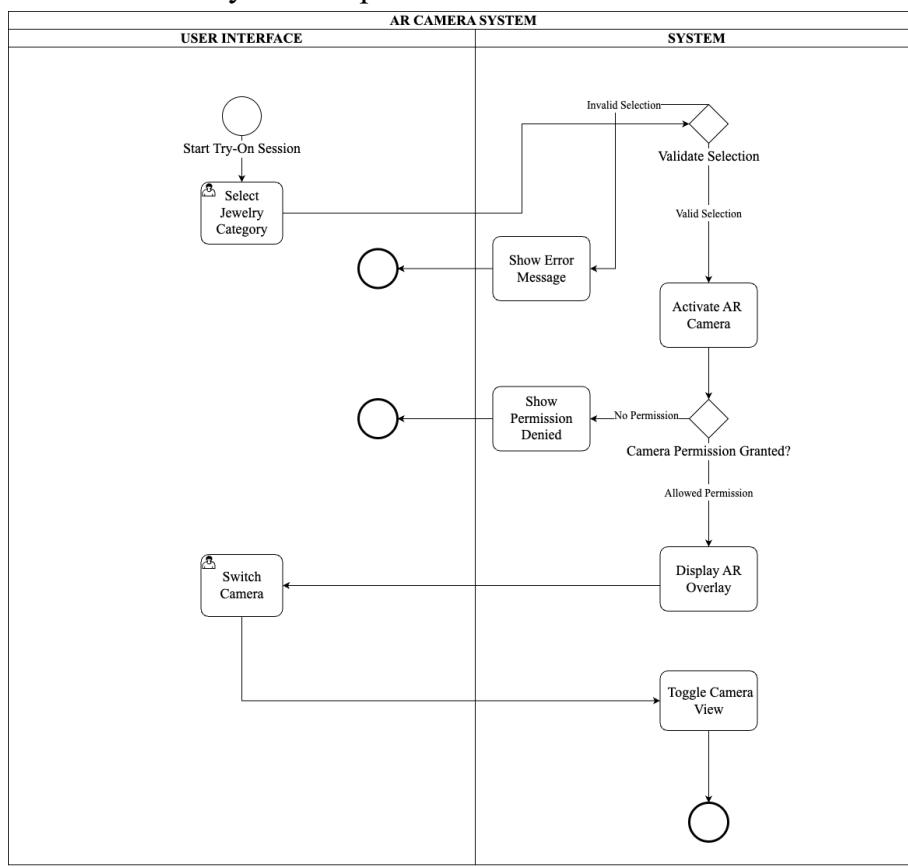


Figure 17: The BPMN Diagram of AR Camera System Function (Source: Authors)

#### 3.8.2. Use Case Diagram

The AR Camera System allows users to virtually try on jewelry items using augmented reality technology. Customers can start by selecting a jewelry category such

as earrings, rings, or bracelets. The AR camera is then activated, enabling real-time overlay of the selected item on the user's image. Users have the option to switch between front and back cameras depending on the type of product and angle needed. They can also take a snapshot of the try-on session for saving or sharing. This feature enhances customer experience by allowing visualization before purchase.

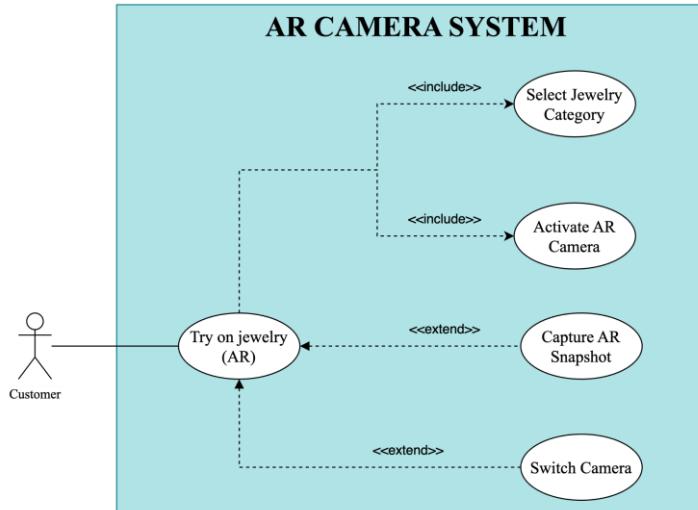


Figure 18: AR Camera System Use Case Diagram (Source: Authors)

- **Use Case Specification**

#### **Use Case: Try on Jewelry (AR)**

Table 28: Try on Jewelry (AR) Use Case Specification (Source: Authors)

Attribute	Content
Use Case Name	Try on Jewelry (AR)
Actor	Customer
Description	Enables customers to virtually try on jewelry using real-time AR overlay
Successful Completion	AR model is accurately displayed on user and interactive during session
Basic Flow	<ol style="list-style-type: none"> <li>1. User selects AR mode</li> <li>2. Chooses jewelry</li> <li>3. Camera opens</li> <li>4. Overlay is shown</li> </ol>
Alternative Flow	<ol style="list-style-type: none"> <li>2a. No category selected → show error</li> <li>3a. Permission denied → notify user</li> </ol>

Exception Flow	4a. Overlay not aligned → show adjustment option or restart
Precondition	Device has camera access and AR is supported
Post-condition	User experiences virtual try-on

### **Use Case: Capture AR Snapshot**

*Table 29: Capture AR Snapshot Use Case Specification (Source: Authors)*

Attribute	Content
Use Case Name	Capture AR Snapshot
Actor	Customer
Description	Lets user take a picture while trying on jewelry in AR mode
Successful Completion	Image is saved to gallery or shared externally
Basic Flow	<ol style="list-style-type: none"> <li>1. User taps snapshot icon</li> <li>2. System captures frame</li> <li>3. Saves or shares</li> </ol>
Alternative Flow	3a. User cancels save/share → discard image
Exception Flow	2a. Storage permission denied → show warning
Precondition	AR camera is active and overlay is functioning
Post-condition	Image is stored or shared based on user action

### **Use Case: Switch Camera**

*Table 30: Switch Camera Use Case Specification (Source: Authors)*

Attribute	Content
Use Case Name	Switch Camera
Actor	Customer

Description	Allows toggling between front and rear cameras during AR session
Successful Completion	Camera switches successfully, and AR overlay remains stable
Basic Flow	<ol style="list-style-type: none"> <li>1. User taps camera switch icon</li> <li>2. System toggles camera</li> <li>3. Overlay resumes</li> </ol>
Alternative Flow	2a. Switch delay → show loading spinner
Exception Flow	2b. Hardware error → show retry or fallback
Precondition	AR session is active
Post-condition	New camera view is active with AR model intact

### 3.9. Admin Website Unified Modeling Language Diagrams

#### 3.9.1. Business Process Model and Notation Diagram

##### *Management Service Reservation*

The reservation management process begins when the admin accesses the "Services Reservation Management" section, where the system displays a list of reservations including customer names, reservation dates, service types, and their statuses. The admin selects a specific reservation to review or update, prompting the system to retrieve and display detailed information about it. The admin can then make necessary changes, such as updating the reservation status, service type, or other relevant details. The system validates the modified information; if any data is invalid, an error message prompts the admin to make corrections. Once the information is verified as valid, the updated details are saved to the database. If applicable, the system also sends an updated confirmation email to the customer. The process concludes when the admin completes all required reservation management actions.

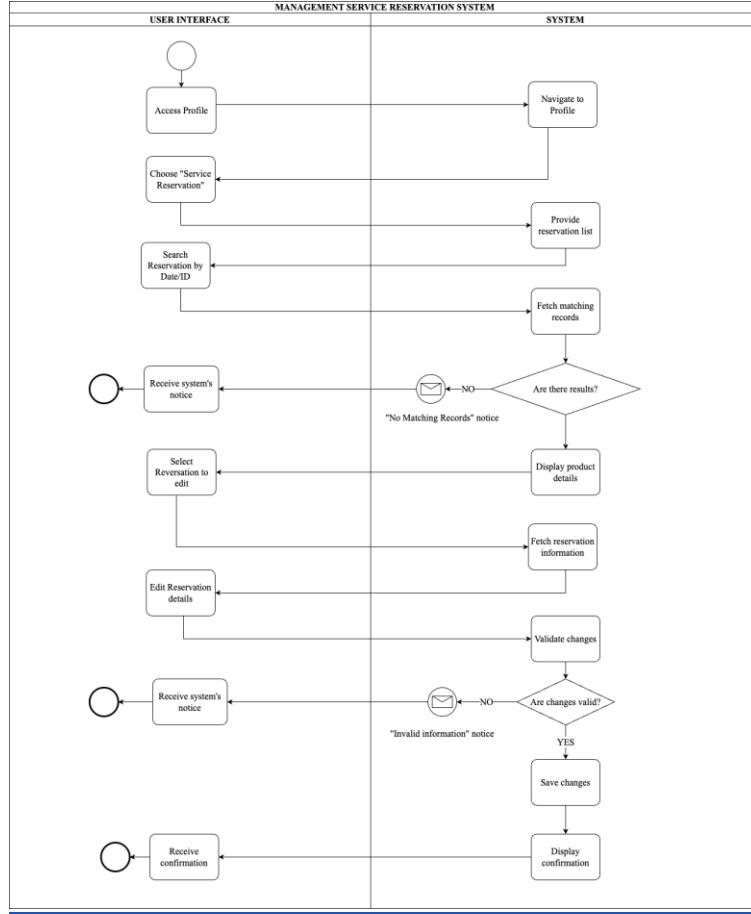


Figure 19: The BPMN Diagram of Management Service Reservation Function (Source: Authors)

### **Validate Orders**

The order management process begins when the admin accesses the "Order Management" section, where the system displays a list of all customer orders, including order ID, customer name, order date, total amount, status, and payment method. Upon selecting a specific order to manage, the system retrieves and shows detailed information such as the products ordered, their quantities and prices, the delivery address, and the payment status. The admin reviews the order to validate its accuracy, making updates if necessary—for example, confirming the payment or correcting the delivery address. The system then validates the updated information; if errors are detected, it prompts the admin to correct them. Once the data is valid, the changes are saved, the order status is updated accordingly (e.g., "Validated," "Pending Payment," or "Ready for Shipment"), and all modifications are logged. Optionally, a confirmation email may be sent to the customer. The process concludes when the admin finalizes all required validations and updates for the selected order.

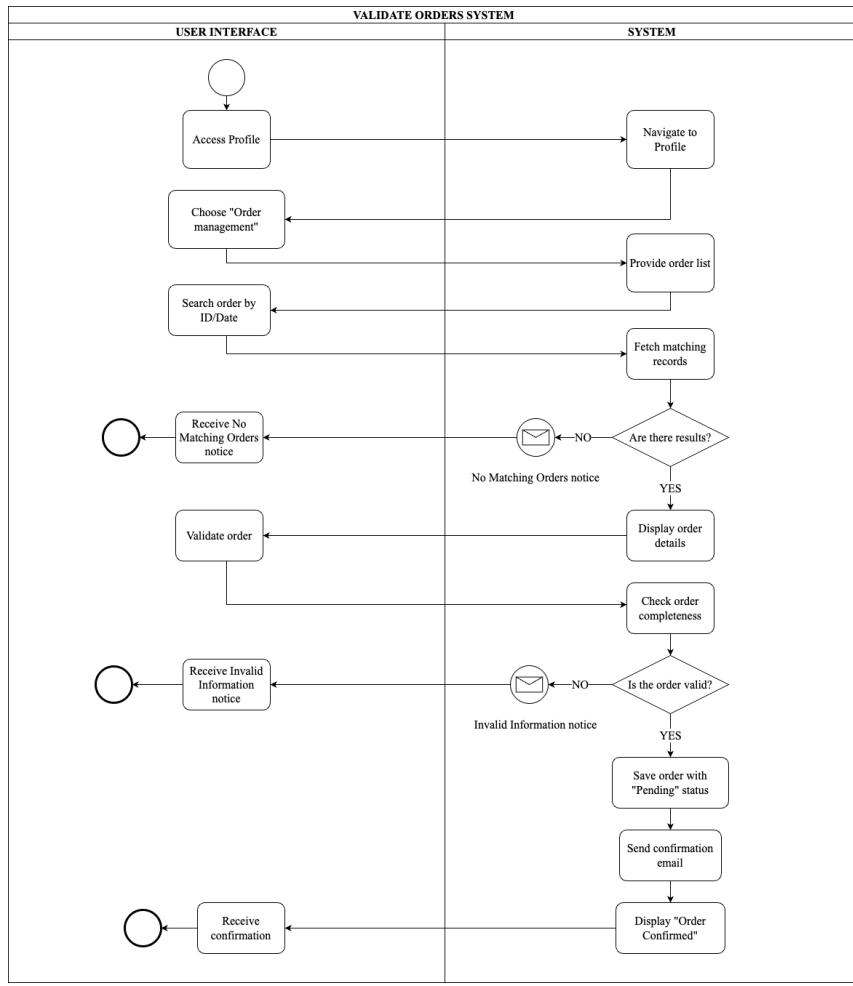


Figure 20: The BPMN Diagram of Validate Orders Function (Source: Authors)

### Customer Management

The customer management process begins when the admin accesses the "Customer Management" section, where the system retrieves and displays a list of customers along with their basic details. The admin selects a specific customer to manage, prompting the system to fetch and present detailed information about that individual. The admin then updates relevant customer information, such as contact details or account status. The system validates the updated data; if any information is invalid, an error message is displayed to prompt correction. Once the details are verified as valid, the changes are saved to the database. The process concludes when the admin completes all necessary updates and actions related to the selected customer.

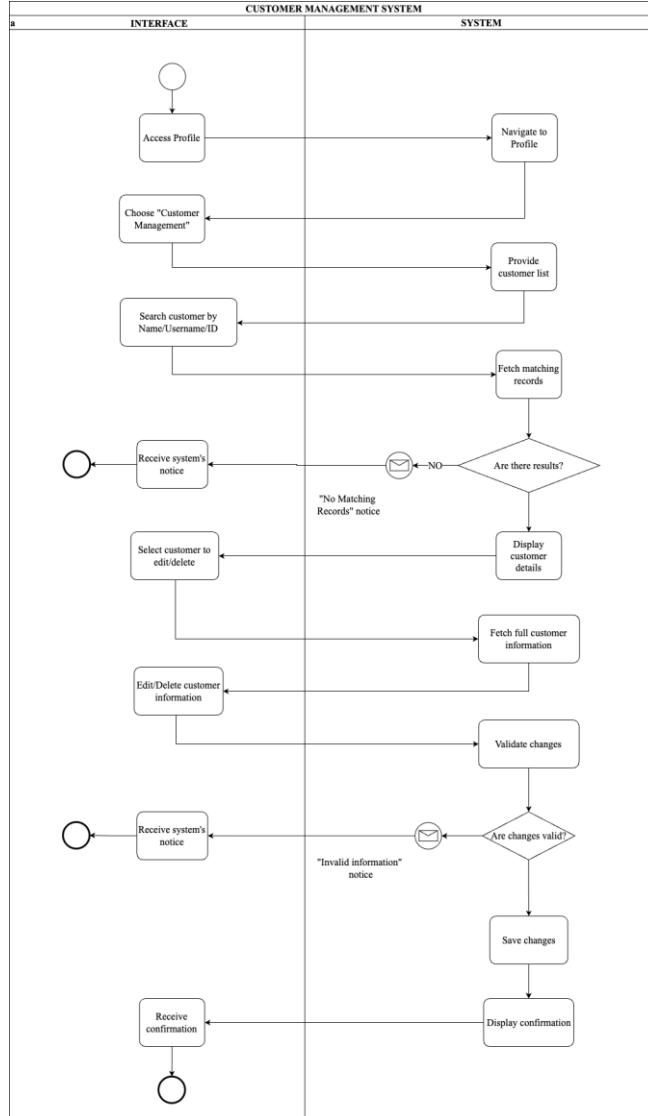
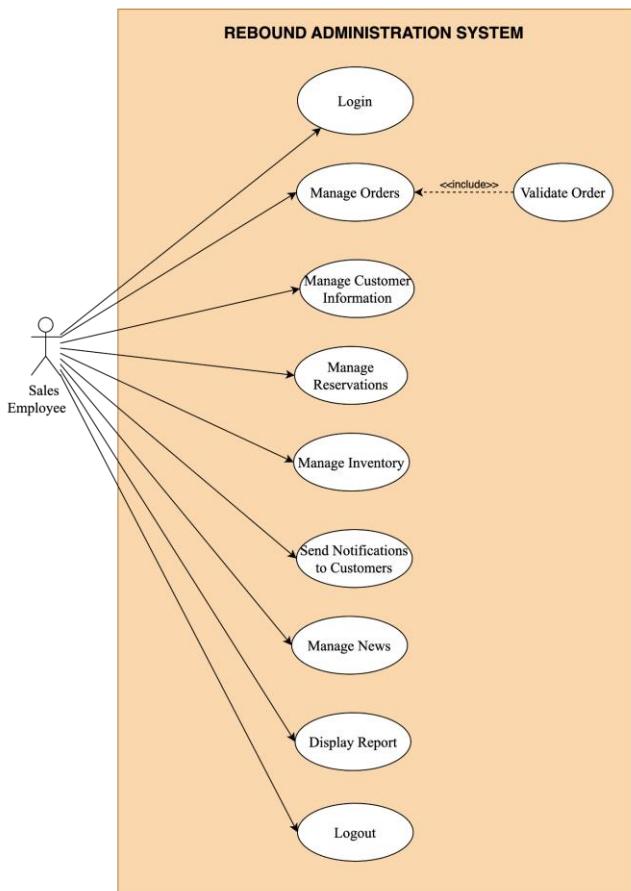


Figure 21: The BPMN Diagram of Customer Management Function (Source: Authors)

### 3.9.2. Use Case Diagram

The Rebound Admin Website provides administrative users (admin, staff) with web-based tools to manage and monitor key components of the ReboundPiercing platform. Through this interface, admins can manage customer accounts, product catalogs, orders, inventory, promotional campaigns, and user-generated content such as reviews or support tickets. The system supports real-time data updates, analytics viewing, and operational control over AR content and policies.



*Figure 22: Rebound Administration System Use Case Diagram (Source : Authors)*

- **Use Case Specification**

#### **Use Case: Manage Products**

*Table 31: Manage Products Use Case Specification (Source: Authors)*

Attribute	Content
Use Case Name	Manage Products
Actor	Admin
Description	Enables admins to add, update, or delete products from the online catalog
Successful Completion	Products are visible or updated in the customer-facing app
Basic Flow	<ol style="list-style-type: none"> <li>1. Admin logs in</li> <li>2. Opens product panel</li> <li>3. Adds or edits item</li> <li>4. Saves changes</li> </ol>

Alternative Flow	3a. Admin cancels → return to dashboard
Exception Flow	4a. Validation fails (e.g. missing image) → show error
Precondition	Admin is authenticated
Post-condition	Product list reflects new or updated item

### ***Use Case: Manage Orders***

*Table 32: Manage Orders Use Case Specification (Source: Authors)*

<b>Attribute</b>	<b>Content</b>
Use Case Name	Manage Orders
Actor	Admin
Description	Admin views and updates customer order statuses, handles cancellations or refunds
Successful Completion	Order status is correctly updated, refund processed if needed
Basic Flow	<ol style="list-style-type: none"> <li>1. Admin login</li> <li>2. Opens order panel</li> <li>3. Searches order</li> <li>4. Updates status or issues refund</li> </ol>
Alternative Flow	3a. No matching order found → show error message
Exception Flow	4a. Update fails due to invalid status → show warning
Precondition	Admin is authenticated
Post-condition	Order information is updated in the system

### ***Use Case: Manage Customers***

*Table 33: Manage Customers Use Case Specification (Source: Authors)*

<b>Attribute</b>	<b>Content</b>

Use Case Name	Manage Customers
Actor	Admin
Description	Search for and edit customer details, deactivate accounts, or reset passwords
Successful Completion	Customer record is modified or status updated
Basic Flow	<ol style="list-style-type: none"> <li>1. Admin opens customer panel</li> <li>2. Searches user</li> <li>3. Updates info</li> <li>4. Saves</li> </ol>
Alternative Flow	2a. No user found → notify admin
Exception Flow	3a. Password reset fails → display error
Precondition	Customer records exist
Post-condition	Updated data is saved and reflected in system

### 3.10. Database Design

#### 3.10.1. Entity Relationship Diagram

This Entity-Relationship Diagram (ERD) models the structure of a jewelry e-commerce platform with AR and service booking functionality. It contains key entities such as User, Product, Order, Payment, and Service along with their relationships. The schema supports functions including account management, product browsing, virtual try-on, order processing, and appointment scheduling.

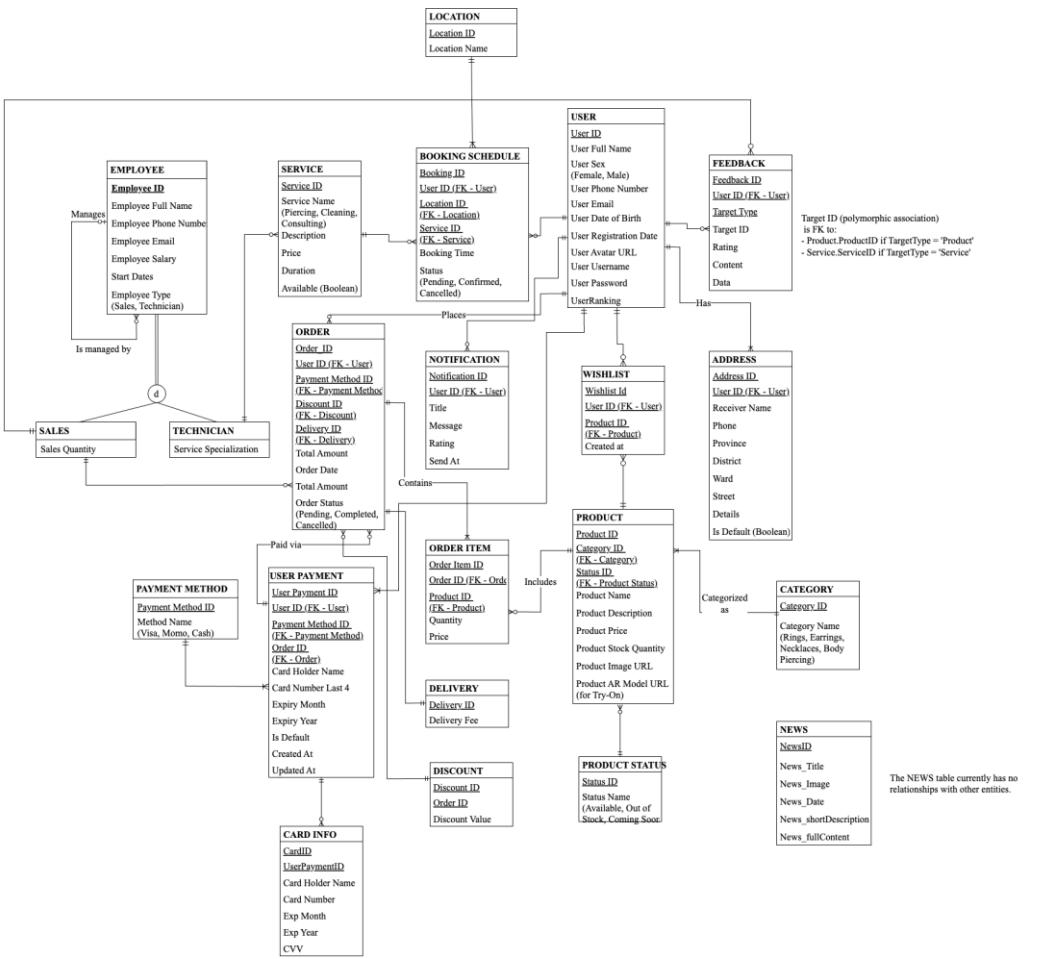


Figure 23: Entity-Relationship Diagram (ERD) of the Jewelry E-Commerce Platform with AR and Service Booking Features (Source: Authors)

### 3.10.2. Identify Entities, Attributes and Constraints

#### Main Entities

Table 34: Main Entities Description (Source: Authors)

Entity	Role / Description
User	Stores user information, including personal details, addresses, and user ranking.
Address	Stores the list of delivery addresses associated with a user.
Notification	Notifications sent to the user by the system.
Product	Represents jewelry products offered on the platform.
Category	Categories to which products belong.
ProductStatus	Status of the product (e.g., Available, Out of Stock).

Wishlist	User's list of favorite or saved products.
TryOnHistory	AR try-on history, including which products were tried and when.
Order	Orders placed by users.
OrderItem	Detailed information about individual products within an order.
PaymentMethod	Available payment methods for transactions.
UserPayment	Stores user payment details for orders.
Discount	Discount codes applicable to orders.
Delivery	Delivery fees applied to orders.
Feedback	User reviews and ratings for products.
FAQ	Frequently Asked Questions (extracted from Help Center).
Contact	User-submitted contact or support inquiries (Help Center).
Service	In-store services offered (e.g., piercing, styling, cleaning).
BookingSchedule	User bookings for specific services.
Employee	General employee entity (used for both sales and technicians).
Technician	Technical staff responsible for service execution.
Sales	Sales staff handling product sales and order support.

### **User**

*Table 35: Entity User (Source: Authors)*

Attribute	Description	Data Type
UserID	Primary Key	INT

FullName	Full name of the user	VARCHAR(100)
Sex	Gender	VARCHAR
PhoneNumber	Phone number	VARCHAR(15)
Email	User's email address	VARCHAR(100)
DateOfBirth	Date of birth	DATE
RegistrationDate	Registration date	DATETIME
AvatarURL	Profile image URL	VARCHAR(255)
Username	Username for login	VARCHAR
Password	User's password	VARCHAR
UserRanking	User level or rank	VARCHAR(50)

### ***Address***

*Table 36: Entity Address (Source: Authors)*

<b>Attribute</b>	<b>Description</b>	<b>Data Type</b>
AddressID	Primary Key	INT
UserID	Foreign Key referencing User	INT
ReceiverName	Name of the recipient	VARCHAR(100)
Phone	Recipient's phone number	VARCHAR(15)
Street	Detailed street address	VARCHAR(255)
District	District or area	VARCHAR(100)
City	City name	VARCHAR(100)

### ***Employee***

Table 37: Entity Employee (Source: Authors)

Attribute	Description	Data Type
EmployeeID	Primary Key	INT
FullName	Full name of the employee	VARCHAR(100)
PhoneNumber	Phone number	VARCHAR(15)
Email	Email address	VARCHAR(100)
Salary	Monthly salary	DECIMAL(10,2)
StartDate	Employment start date	DATE
EmployeeType	Type of employee	ENUM('Sales', 'Technician')

### Sales

Table 38: Entity Sales (Source: Authors)

Attribute	Description	Data Type
EmployeeID	Primary Key, Foreign Key referencing Employee	INT
SalesQuantity	Total number of sales made	INT

### Technician

Table 39: Entity Technician (Source: Authors)

Attribute	Description	Data Type
EmployeeID	Primary Key, Foreign Key referencing Employee	INT
ServiceSpecialization	Area of service specialization (e.g., piercing)	VARCHAR(100)

### Product

Table 40: Entity Product (Source: Authors)

Attribute	Description	Data Type

ProductID	Primary Key	INT
CategoryID	Foreign Key referencing Category	INT
StatusID	Foreign Key referencing ProductStatus	INT
Name	Name of the product	VARCHAR(100)
Description	Description of the product	TEXT
Price	Price of the product	DECIMAL(10,2)
StockQuantity	Quantity in stock	INT
ImageLink	URL of the product image	VARCHAR(255)
ARModelURL	AR model link for virtual try-on	VARCHAR(255)

### *Category*

*Table 41: Entity Category (Source: Authors)*

Attribute	Description	Data Type
CategoryID	Primary Key	INT
CategoryName	Name of the product category	VARCHAR(100)

### *Wishlist*

*Table 42: Entity Wishlist (Source: Authors)*

Attribute	Description	Data Type
WishlistID	Primary Key	INT
UserID	Foreign Key referencing User	INT
ProductID	Foreign Key referencing Product	INT
CreatedAt	Date and time the item was added to the wishlist	DATETIME

### *Order*

*Table 43: Entity Order (Source: Authors)*

Attribute	Description	Data Type
OrderID	Primary Key	INT
UserID	Foreign Key referencing User	INT
PaymentMethodID	Foreign Key referencing PaymentMethod	INT
OrderDate	Date and time the order was placed	DATETIME
TotalAmount	Total amount of the order	DECIMAL(10,2)
Status	Order status	ENUM('Pending', 'Completed', 'Cancelled')

### ***OrderItem***

*Table 44: Entity OrderItem (Source: Authors)*

Attribute	Description	Data Type
OrderItemID	Primary Key	INT
OrderID	Foreign Key referencing Order	INT
ProductID	Foreign Key referencing Product	INT
Quantity	Quantity of the product ordered	INT
Price	Price per unit at the time of purchase	DECIMAL(10,2)

### ***PaymentMethod***

*Table 45: Entity PaymentMethod (Source: Authors)*

Attribute	Description	Data Type
PaymentMethodID	Primary Key	INT

MethodName	Name of the payment method (e.g., Credit Card, PayPal, Bank Transfer)	VARCHAR(50)
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### **UserPayment**

*Table 46: Entity UserPayment (Source: Authors)*

Attribute	Description	Data Type
UserPaymentID	Primary Key	INT
UserID	Foreign Key referencing User	INT
PaymentMethodID	Foreign Key referencing PaymentMethod	INT
OrderID	Foreign Key referencing Order	INT
CardHolderName	Name of the cardholder	VARCHAR(100)
CardNumberLast4	Last 4 digits of the card number	VARCHAR(4)
ExpiryMonth	Expiration month of the card	INT
ExpiryYear	Expiration year of the card	INT
IsDefault	Indicates if this is the default payment method	BOOLEAN
CreatedAt	Record creation timestamp	DATETIME
UpdatedAt	Last updated timestamp	DATETIME

### **Discount**

*Table 47: Entity Discount (Source: Authors)*

Attribute	Description	Data Type
DiscountID	Primary Key	INT
DiscountValue	Value of the discount	DECIMAL(5,2)
Description	Description or conditions of the discount	TEXT

## *Delivery*

Table 48: Entity Delivery (Source: Authors)

Attribute	Description	Data Type
DeliveryID	Primary Key	INT
DeliveryFee	Shipping or delivery fee	DECIMAL(10,2)

## *Service*

Table 49: Entity Service (Source: Authors)

Attribute	Description	Data Type
ServiceID	Primary Key	INT
ServiceType	Type of service (e.g., Piercing, Cleaning, etc.)	VARCHAR(50)
Description	Description of the service	TEXT
Price	Price of the service	DECIMAL(10,2)
Duration	Duration of the service in minutes	INT
Available	Whether the service is currently available	BOOLEAN

## *BookingSchedule*

Table 50: Entity BookingSchedule (Source: Authors)

Attribute	Description	Data Type
BookingID	Primary Key	INT
UserID	Foreign Key referencing User	INT
ServiceID	Foreign Key referencing Service	INT
BookingTime	Date and time of the booking	DATETIME
Location	Location where the service will be performed	VARCHAR(100)

Status	Booking status	ENUM('Pending', 'Confirmed', 'Cancelled')
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### *CardInfo*

*Table 51: Entity CardInfo (Source: Authors)*

Attribute	Description	Data Type
CardID	Primary key	INT
UserPaymentID	Foreign key referencing UserPayment	INT
CardHolderName	Name of the cardholder	VARCHAR(100)
CardNumber	Full or masked card number	VARCHAR(16)
ExpMonth	Expiration month of the card	INT
ExpYear	Expiration year of the card	INT
CVV	Card Verification Value (3-digit security code)	INT

### *Feedback*

*Table 52: Entity Feedback (Source: Authors)*

Attribute	Description	Data Type
FeedbackID	Primary Key	INT
UserID	Foreign Key referencing User	INT
ProductID	Foreign Key referencing Product	INT
Message	Content of the user's feedback or review	TEXT
Rating	Rating score	INT
CreatedAt	Date and time the feedback was submitted	DATETIME

### *News*

*Table 53: Entity News (Source: Authors)*

Attribute	Description	Data Type
NewsID	Primary Key	INT
News_Title	Title of the news article	VARCHAR
News_Image	Date the news was published	VARCHAR
News_Date	Content of the user's feedback or review	DATE
News_shortDescription	Full content of the news article	TEXT
News_fullContent	Date and time the feedback was submitted	TEXT

### 3.10.3. Cardinality Constraints of Relationship Description

*Table 54: Cardinality Constraints of Relationship Description (Source: Authors)*

Relationship	Entities Involved	Cardinality	Description
User – Address	User to Address	1:N	A user can have multiple shipping addresses.
User – Wishlist	User to Wishlist	1:N	A user can add multiple products to their wishlist.
Wishlist – Product	Wishlist to Product	N:1	Each wishlist item refers to one product.
User – Order	User to Order	1:N	A user can place multiple orders.
Order – OrderItem	Order to OrderItem	1:N	An order contains multiple products.
Product – OrderItem	Product to OrderItem	1:N	A product can appear in many order items.
Product – Category	Product to Category	N:1	Each product belongs to one category.

Product – ProductStatus	Product to ProductStatus	N:1	Each product has one availability status.
User – Feedback	User to Feedback	1:N	A user can leave feedback on multiple products.
Product – Feedback	Product to Feedback	1:N	A product can have many feedback entries.
User – BookingSchedule	User to BookingSchedule	1:N	A user can make multiple service bookings.
BookingSchedule – Service	BookingSchedule to Service	N:1	Each booking is for one specific service.
Technician – BookingSchedule	Technician to BookingSchedule	1:N	A technician can handle multiple bookings.
Service – Technician	Service to Technician	N:1	A service is performed by a specific technician.
Employee – Technician/Sales	Employee to Technician/Sales	1:1	Each employee is either a technician or a sales rep (specialized subtypes).
User – Notification	User to Notification	1:N	A user can receive multiple system notifications.
User – TryOnHistory	User to TryOnHistory	1:N	A user can have multiple AR try-on sessions.
Product – TryOnHistory	Product to TryOnHistory	1:N	Each try-on session is linked to one product.
Order – UserPayment	Order to UserPayment	1:1	Each order is paid with one user payment method.
PaymentMethod – UserPayment	PaymentMethod to UserPayment	1:N	One payment method can be used in multiple transactions.

User – UserPayment	User to UserPayment	1:N	A user can save multiple payment methods.
UserPayment – CardInfo	UserPayment to CardInfo	1:1	Each user payment has one associated card info.

### 3.11. Sitemap

#### 3.11.1. Mobile Application for Customer Sitemap

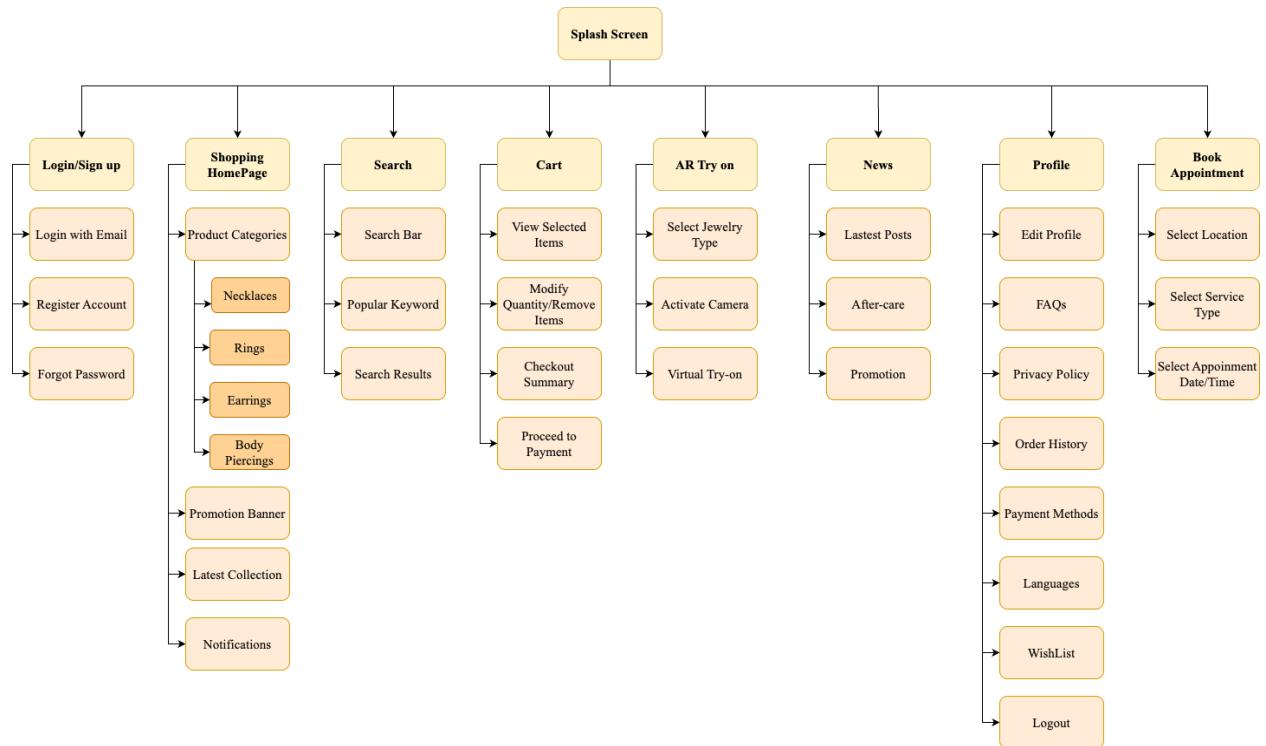


Figure 24: ReboundPiercing Mobile Application Sitemap (Source: Authors)

The sitemap of the ReboundPiercing mobile application presents a clear and structured flow tailored to enhance the customer experience in shopping and booking piercing services. Starting from the splash screen, users can log in, register, or recover passwords through the Login/Sign-up section. The Shopping Homepage showcases product categories such as necklaces, rings, earrings, and body piercings, along with promotional banners, the latest collections, and notifications. A dedicated Search function allows users to explore products using a search bar, trending keywords, and detailed search results. The Cart section enables viewing selected items, modifying quantities, and proceeding to checkout and payment. One of the app's standout features is the AR Try-on, which lets users select jewelry types, activate the camera, and experience virtual try-on using augmented reality. The News section provides updates through the latest blog posts, after-care tips, and promotional content. Within the Profile section, users can edit personal information, view order history, manage payment methods, access FAQs and privacy policies, change languages, manage their wishlist, and log out. Finally, the Book Appointment function allows customers to select service locations, types, and preferred date and time for piercing sessions. Altogether, the

sitemap reflects a user-centric, interactive, and end-to-end journey designed to support modern jewelry shopping and piercing experiences.

### 3.11.2. Admin Website Sitemap

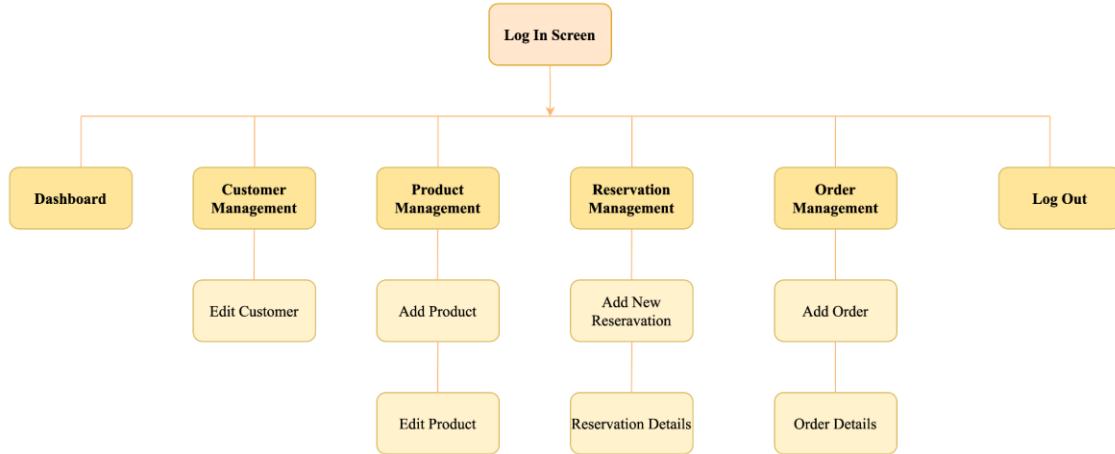


Figure 25: Admin Website Sitemap (Source: Authors)

The Admin Website Sitemap outlines the structure of the ReboundPiercing web-based management system, designed to support administrators in efficiently handling business operations.

After logging in via the Log In Screen, administrators are directed to the main dashboard with access to six core modules:

- Dashboard: Provides an overview of platform activities, key metrics, and system status.
- Customer Management: Allows admins to manage user information, including the ability to edit customer details for account maintenance or support purposes.
- Product Management: Supports adding and updating product listings. Admins can add new products and edit existing ones, ensuring the catalog remains accurate and up to date.
- Reservation Management: Enables the creation and tracking of piercing appointments. Admins can add new reservations and view reservation details to monitor service schedules.
- Order Management: Facilitates sales operations by allowing admins to add new orders and review order details, supporting inventory and fulfillment processes.
- Log Out: Ends the admin session securely.

## CHAPTER 4. IMPLEMENTATION RESULTS

This chapter presents the implementation of the system, including the sitemap for both the customer app and admin dashboard. It showcases high-fidelity UI mockups for all main features. All components are designed for usability, functionality, and consistency across the app.

### 4.1. Design Settings

#### 4.1.1. Brand Logo

The logo design uses a modern, minimalist serif font with fine lines, reinforcing a luxurious and elegant brand identity suitable for fashion accessories.



Figure 26: Rebound Piercing Logo (Source: Authors)

#### 4.1.2. Color Library

The color palette includes neutrals (beige, cream, brown), sophisticated blacks, and soft accent tones (pale pink, gold, navy blue), creating a refined and consistent visual experience throughout the app.



Figure 27: Color Library (Source: Authors)

#### 4.1.3. Typography

The selected font family is Montserrat, known for its clean and professional look. The font hierarchy includes distinct sizes and weights for headers (H1, H2...) and body text, ensuring clarity and aesthetic alignment across all screens.



Figure 28: Mobile Application Font (Source: Authors)

Typography				
Typeface	Weight	Size	Line	Spacing
<b>H1. Headline</b>	Semi Bold	48	28	0
<b>H2. Headline</b>	Semi Bold	40	28	0
<b>H3. Headline</b>	Semi Bold	32	28	0
<b>H4. Headline</b>	Semi Bold	28	24	0
<b>H5. Headline</b>	Semi Bold	24	28	0
<b>B1. Subtitle</b>	Semi Bold	16	28	0
<b>B2. Subtitle</b>	Semi Bold	16	28	0
<b>B3. Body</b>	Regular	16	24	0
<b>B4. Body</b>	Medium	16	28	0
<b>B5. Body</b>	Regular	14	20	0
<b>B6. Body</b>	Medium	14	28	0
<b>C1. Caption</b>	Regular	12	16	0
<b>C2. Caption</b>	Medium	12	16	0
<b>C3. Caption</b>	Medium	12	14	0
<b>LABEL</b>	Medium	12	16	0
Button Font				
Typeface	Weight	Size	Line	Spacing
Giant	Semi Bold	16	24	0
Large	Semi Bold	16	20	0
Medium	Semi Bold	14	16	0
Small	Semi Bold	12	16	0
tiny	Semi Bold	12	12	0

Figure 29: Typography Settings (Source: Authors)

#### 4.1.4. Assets Setting

Screenshots show consistent use of spacing, icons, and layout structures. Button styles, card layouts, and navigation elements follow a uniform design system, reinforcing usability and visual cohesion.



Figure 30: Assets Settings (Source: Authors)

### 4.2. Mobile Application User Interface

#### 4.2.1. User Interface



Figure 31: Introduction and Splash Screens User Interface (Source: Authors)

When first opening the app, users see the Welcome screen (screen 1). New users can tap “Register” to create an account. After successful registration, three splash screens (screens 2–4) introduce the app’s key features and usage.

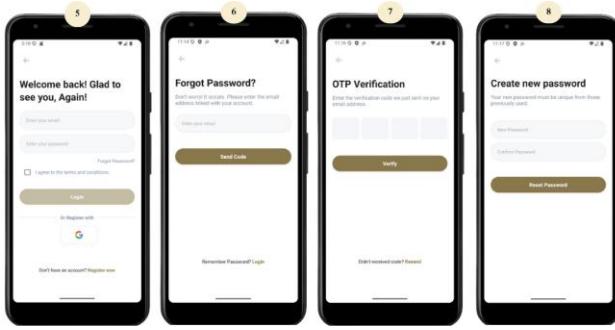


Figure 32: Login and Reset New Password Process User Interface (Source: Authors)

Users with an account can tap “Login” to access screen 5, then sign in via email/password or Google. If they forget their password, tapping “Forgot Password?” starts the recovery process. After email input (screen 6) and OTP verification (screen 7), they can set a new password on screen 8.

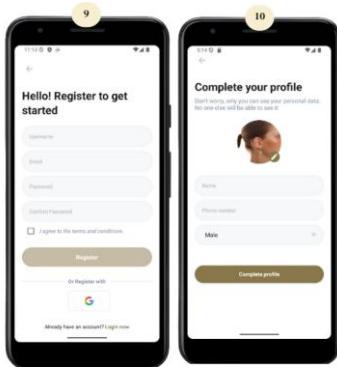


Figure 33: Register Account Process User Interface (Source: Authors)

If users choose to register, they are directed to screen 9 to enter their details. After submitting the form, their profile is successfully created and shown on screen 10.



Figure 34: Main Page/Shopping Page User Interface (Source: Authors)

After login, users are directed to the Shopping Page (screens 11–11.1) featuring the logo, notification icon, search bar, categories, banners, and product collections in a top-down layout. A fixed navigation bar at the bottom provides access to Shop, Schedule, AR Camera, News, and Profile sections.

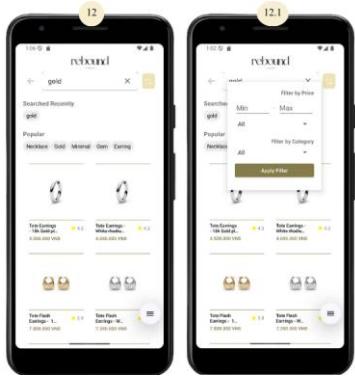


Figure 35: Search and Filter User Interface (Source: Authors)

With the search and sorting bar, users can not only look for the item they want by entering a keyword (Screen 12), but also filter the product list by price and category (Screen 12.1).

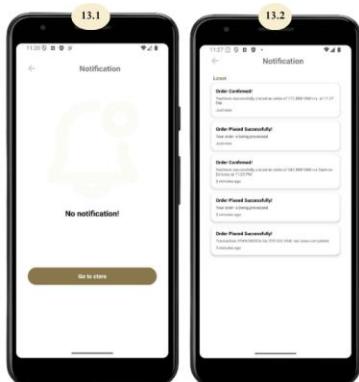


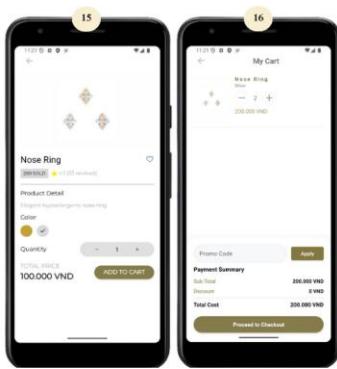
Figure 36: Notification User Interface (Source: Authors)

After tapping the notification icon on the main page (Screen 11), users are directed to the Notification screen (13). If there are no updates, a message saying “No notifications!” is displayed (Screen 13.1). When notifications are available, they are listed in screen 13.2, showing relevant system messages or promotional updates.



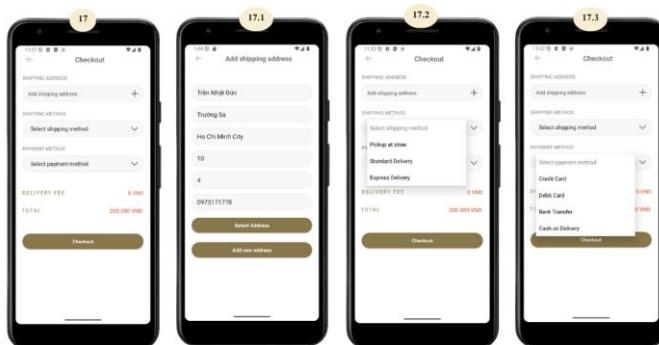
Figure 37: Product List Filtered by Categories User Interface (Source: Authors)

When a user selects a product category from the main shopping page (Screen 11), they are taken to the Product List screen, filtered by the selected category. Screens 14.1 to 14.4 display items under categories such as Necklaces, Earrings, Rings, and Body Piercing, respectively.



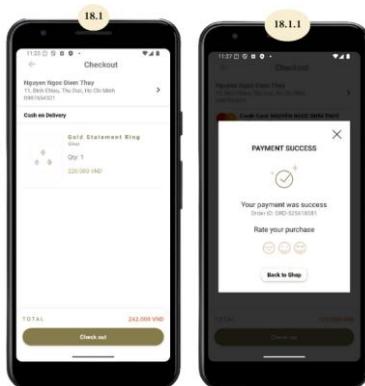
*Figure 38: Product Details and Cart User Interface (Source: Authors)*

After selecting a product, users are directed to the Product Details screen (15) to view information and choose options. Tapping “Add to Cart” leads to the Cart screen (16), where they can adjust items and proceed to checkout.



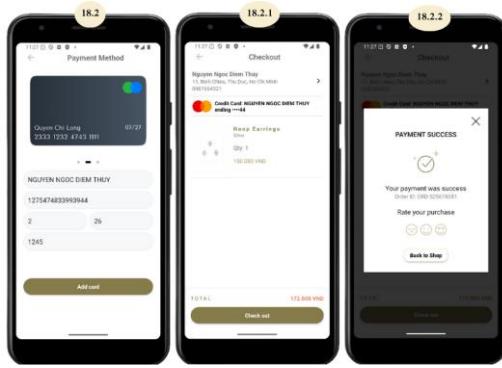
*Figure 39: Checkout and Input Field Completion User Interface (Source: Authors)*

In the Checkout screen (17), users provide a shipping address, select a delivery method (screen 17.2), and choose a payment option (screen 17.3). If no address is saved, they can add one via screen 17.1.



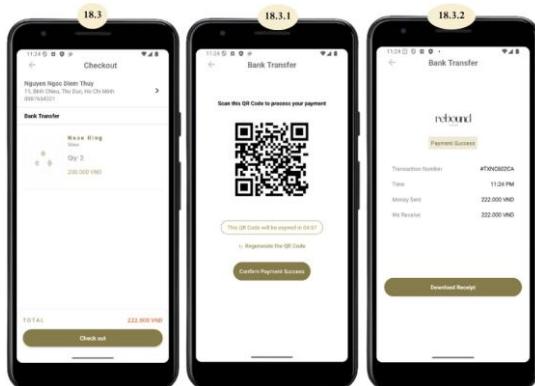
*Figure 40: Checkout via “Cash on Delivery” Payment Method Process User Interface (Source: Authors)*

When selecting Cash on Delivery, users confirm the order (screen 18.1) and are shown a success screen (18.1.1) indicating payment will be made upon delivery.



*Figure 41: Checkout via “Credit Card” or “Debit Card” Payment Method Process User Interface (Source: Authors)*

For Credit/Debit Card payments, users enter card details (screen 18.2) or select a saved card (18.2.1). After processing, a confirmation appears on screen 18.2.2.



*Figure 42: Checkout via “Bank Transfer” Payment Method Process User Interface (Source: Authors)*

For Bank Transfer, users review their order (screen 18.3), scan a QR code or use bank details (18.3.1), then confirm the transfer via screen 18.3.2.



*Figure 43: Booking Service Process User Interface (Source: Authors)*

In the Schedule section, users can book a service by selecting a date (19.1) and time (19.2), then tapping “Book Appointment”. A confirmation and optional reminder appear on screen 20.



Figure 44: AR Camera Function User Interface (Source: Authors)

By tapping the AR Camera section, users are brought to a virtual try-on interface (screens 21 and 22), where they can preview how different piercing accessories would look on their face in real time using augmented reality.



Figure 45: News Function and News Details User Interface (Source: Authors)

Selecting the News section opens the latest updates and articles related to piercing trends and tips. On screen 23, users can browse news headlines, and by tapping a specific item, they can read the full content in detail on screen 24.

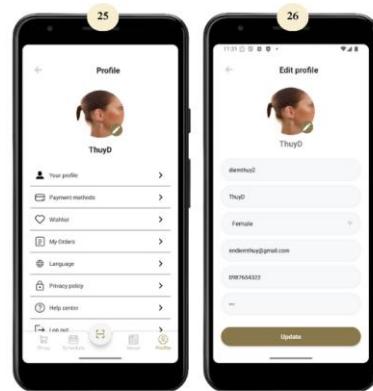


Figure 46: Profile Page and Edit Profile User Interface (Source: Authors)

In the Profile section (screen 25), users can view their personal info and access settings like address, language, orders, and wishlist. Tapping “Edit Profile” opens screen 26, where they can update their details.

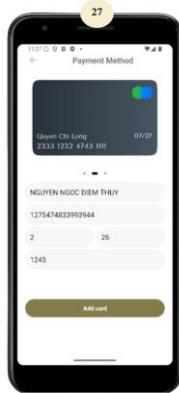


Figure 47: Payment Method Management User Interface (Source: Authors)

In the Payment Method section (screen 27), users can add or manage their saved card details, including cardholder name, card number, expiration date, and CVV code, to streamline the checkout process.

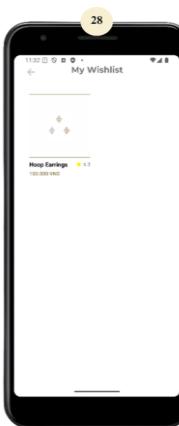


Figure 48: Wishlist User Interface (Source: Authors)

The Wishlist page (screen 28) displays a list of products that users have marked as favorites for future reference or purchase. If no items have been added yet, a message is shown indicating that the wishlist is currently empty.

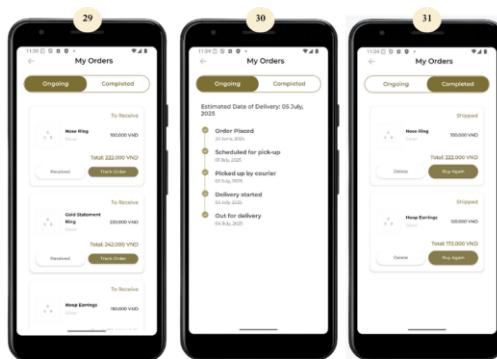


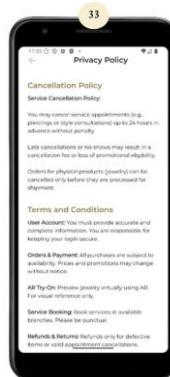
Figure 49: My Orders User Interface (Source: Authors)

In the My Orders section, users can view ongoing (screen 29) and completed orders (screen 31), as well as track delivery progress in detail (screen 30).



*Figure 50: Language User Interface (Source: Authors)*

The Language screen (screen 32) allows users to switch between available languages, such as English and Vietnamese.



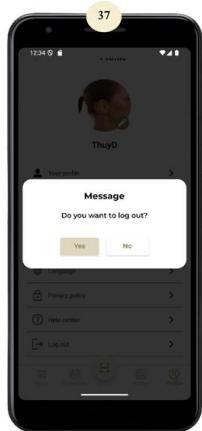
*Figure 51: Privacy Policy User Interface (Source: Authors)*

The Privacy Policy screen (screen 33) displays key policies, including cancellation terms, service conditions, and refund information.



*Figure 52: Help Center User Interface (Source: Authors)*

The Help Center interface provides support through two main sections: FAQs and Contact Us. Screens 34–35 display categorized questions and answers about delivery and orders, while screen 36 shows multiple contact options, including customer service phone number and social media channels.

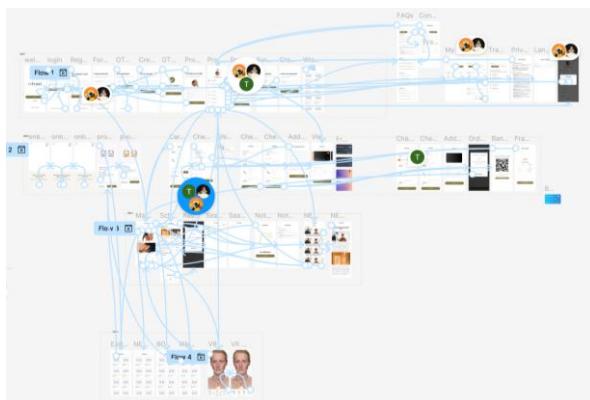


*Figure 53: Log Out User Interface (Source: Authors)*

When users choose to log out, a confirmation message appears (screen 37) with “Yes” or “No” options. Selecting “Yes” redirects to the Login screen (5), while “No” returns to the Profile page.

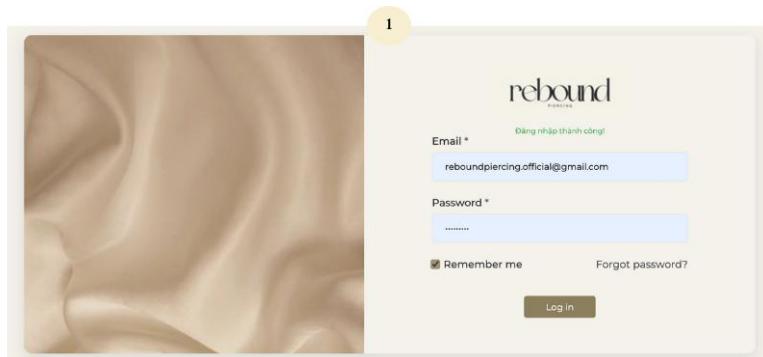
### 4.2.2 Prototype

To visualize the overall user flow and interaction logic of the application, we created a prototype using Figma. This prototype maps out all major screens and transitions, helping to ensure a smooth and consistent user experience.



*Figure 54: UX/UI Implementation on Figma (Source: Authors)*

### **4.3. Admin Website User Interface**



*Figure 55: Login Successfully User Interface (Source: Authors)*

This is the Login Interface (Screen 1) for the admin website. Admins enter their email and password to log in. Upon successful login, a confirmation message appears above the form.

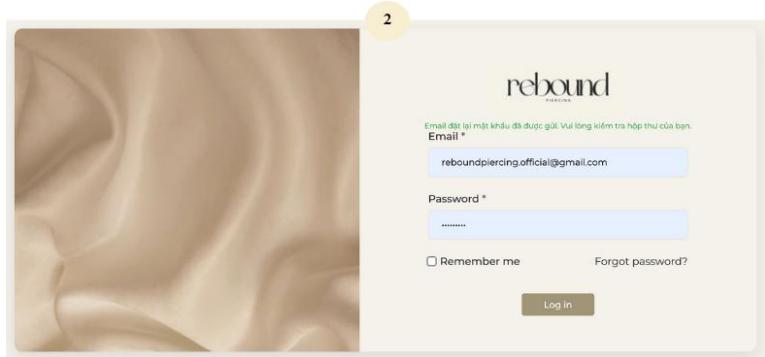


Figure 56: Forgot Password User Interface (Source: Authors)

If the admin selects “Forgot password?” (Screen 2), a notification appears confirming that a reset link has been sent to the entered email address.

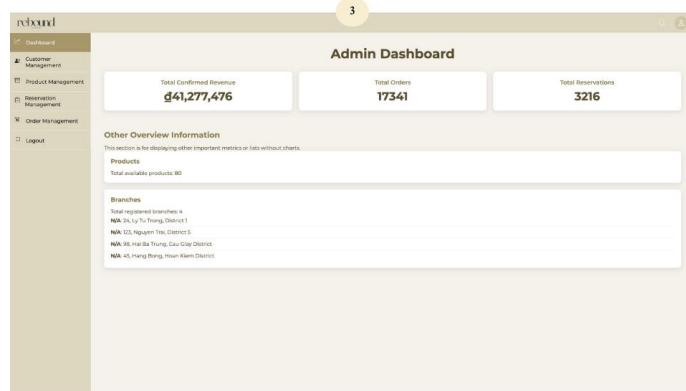


Figure 57: Admin Dashboard User Interface (Source: Authors)

After a successful login, the admin is directed to the main interface, where a left-hand sidebar provides navigation to key sections including Dashboard, Product Management, Order Management, Customer Management, and Logout. By default, the Dashboard (Screen 3) is displayed first, offering an overview of total revenue, number of members, total transactions, and important system notices.

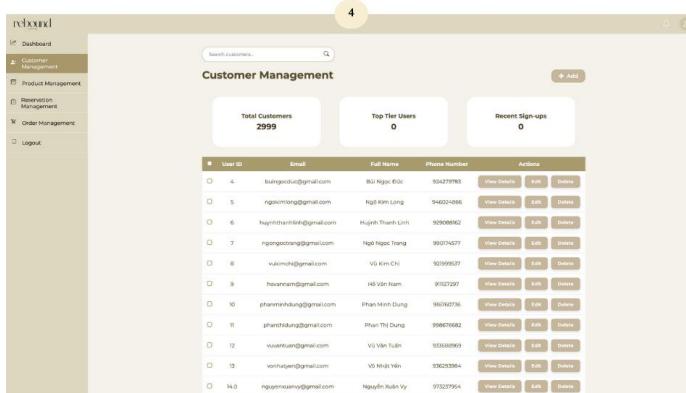


Figure 58: Customer Management User Interface (Source: Authors)

From the sidebar, selecting Customer Management (screen 4) opens a searchable table listing all users, including their email, name, phone number, and account status. Admins can view or manage individual accounts directly from this page.

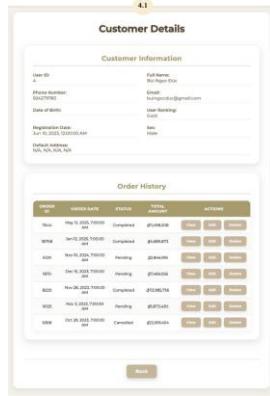


Figure 59: Customer Details User Interface (Source: Authors)

By selecting “View Detail” for a customer in screen 4, the admin is taken to the Customer Details screen (screen 5), which displays the user’s personal information along with their complete order history for review and management purposes.

The screenshot shows the 'Product Management' screen (Screen 5). On the left is a sidebar with navigation options: Dashboard, Customer Management, Product Management (selected), Reservation Management, Order Management, and Logout. The main area has a header 'Product Management' and 'Total Products: 80'. It includes search and filter functions ('Search products...', 'Category: All Categories', 'Status: All statuses'). Below is a table titled 'Product Management' with columns: Image, Product Name, Product ID, Price, Stock, Status, Category, and Actions. The products listed are:

Image	Product Name	Product ID	Price	Stock	Status	Category	Actions
	Tote Earrings - 18k Gold plated	1	\$4,500.00	50	Available	Earrings	<button>Edit</button> <button>Delete</button>
	Tote Flash Earrings - White gold plated	2	\$4,000.00	50	Available	Earrings	<button>Edit</button> <button>Delete</button>
	Tote Flash Earrings - 18k Gold plated	3	\$7,800.00	100	Available	Earrings	<button>Edit</button> <button>Delete</button>
	Tote Flash Earrings - White medium plate	4	\$7,300.00	50	Available	Earrings	<button>Edit</button> <button>Delete</button>
	Weekender Flash Earrings - 18k Gold plated	5	\$7,300.00	50	Out of Stock	Earrings	<button>Edit</button> <button>Delete</button>
	Weekender Flash Earrings - White medium plate	6	\$7,000.00	50	Coming soon	Earrings	<button>Edit</button> <button>Delete</button>
	Dolphin Earrings - 18k gold plated	7	\$6,000.00	100	Available	Earrings	<button>Edit</button> <button>Delete</button>
	Dolphin Earrings - White medium plated	8	\$5,000.00	100	Available	Earrings	<button>Edit</button> <button>Delete</button>
	Meno Huggie - 18k gold plated	9	\$5,000.00	200	Available	Earrings	<button>Edit</button> <button>Delete</button>

Figure 60: Product Management User Interface (Source: Authors)

The Product Management interface (screen 5) displays a list of products with image, name, quantity, price, status, and category. It supports search and filter functions to help admins manage inventory efficiently.

The screenshot shows two side-by-side product management screens. On the left is 'Edit Product' (Screen 5.1) and on the right is 'Add Product' (Screen 5.2). Both share a common header 'Product Information'.

**Edit Product (Screen 5.1):** This screen allows editing of existing product details. Fields include Product Name (Tote Earrings - 18k Gold plated), Category (Earrings), Price (\$4,500.00), Stock Quantity (50), and Status (Available). It also includes a 'Product Image' section with a placeholder image and a note about file requirements, and a 'Product Description' section with a note about file requirements and a rich text editor.

**Add Product (Screen 5.2):** This screen provides input fields for creating new products. It includes 'Product Information' fields for Product Name (with an 'Enter product name' placeholder), Product Image (with a placeholder image and note about file requirements), and Product Category (Earrings). It also includes 'Product Details' fields for Price, Origin, Stock, and Status.

Figure 61: Edit and Add Product User Interface (Source: Authors)

The Edit Product screen (screen 5.1) allows admins to update product details, while the Add Product screen (screen 5.2) provides similar input fields for creating new items.

Order ID	Order Date	Subtotal	Total	User ID	Status	Actions
20042	Jun 30, 2025, 7:00:00 AM	\$2,500.00	\$2,500.00	62	Completed	<span>View</span> <span>Edit</span> <span>Delete</span>
20043	Jun 30, 2025, 7:00:00 AM	\$1,522.00	\$1,522.00	10	Pending	<span>View</span> <span>Edit</span> <span>Delete</span>
20044	Jun 30, 2025, 7:00:00 AM	\$9,022.00	\$9,022.00	10	Pending	<span>View</span> <span>Edit</span> <span>Delete</span>
20045	Jun 30, 2025, 7:00:00 AM	\$5,030.00	\$5,030.00	10	Pending	<span>View</span> <span>Edit</span> <span>Delete</span>
20046	Jun 30, 2025, 7:00:00 AM	\$5,030.00	\$5,030.00	10	Pending	<span>View</span> <span>Edit</span> <span>Delete</span>
20047	Jun 30, 2025, 7:00:00 AM	\$2,530.00	\$2,530.00	10	Pending	<span>View</span> <span>Edit</span> <span>Delete</span>
20048	Jun 30, 2025, 7:00:00 AM	\$5,030.00	\$5,030.00	10	Pending	<span>View</span> <span>Edit</span> <span>Delete</span>
20049	Jun 30, 2025, 7:00:00 AM	\$9,022.00	\$9,022.00	-4	Pending	<span>View</span> <span>Edit</span> <span>Delete</span>
20050	Jun 30, 2025, 7:00:00 AM	\$2,530.00	\$2,530.00	-3	Pending	<span>View</span> <span>Edit</span> <span>Delete</span>
20001	Jun 29, 2025, 7:00:00 AM	\$2,000.00	\$2,000.00	N/A	Pending	<span>View</span> <span>Edit</span> <span>Delete</span>

Figure 62: Order Management User Interface (Source: Authors)

The Order Management interface (screen 6) shows all customer orders with details like order ID, date, amount, user ID, and status. Admins can filter orders and use buttons to view, edit, or delete them.

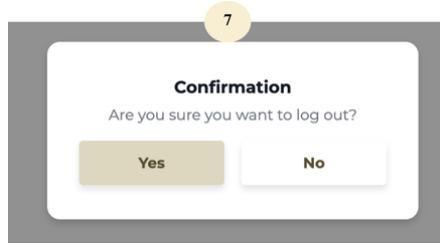


Figure 63: Log Out Pop Up User Interface (Source: Authors)

The Log Out confirmation (screen 7) displays a prompt with “Yes” and “No” options to confirm the admin’s intent before logging out.

## CHAPTER 5. DISCUSSION

This chapter evaluates how the project meets its objectives by delivering an AR-based virtual try-on system for body piercing accessories. It highlights key achievements in landmark detection, user interface design, and system functionality. The strengths include improved visualization, real-time try-on, and personalized recommendations. Limitations involve platform restriction, limited accessory types, and brand-specific design, suggesting directions for future improvement.

### 5.1. Discussion

The outcomes of this project demonstrate that all three research objectives have been effectively addressed through the design and implementation of a mobile application integrating Augmented Reality (AR) and Machine Learning (ML) technologies for virtual try-on of body piercing accessories.

The first objective focused on the accurate positioning of accessories in real environments using mobile devices. This requirement was met by incorporating machine learning-based landmark detection techniques capable of identifying key body features with high precision. The system maintains stability and accuracy across varying lighting conditions, camera angles, and device qualities. As a result, the application can display small items such rings in real time, ensuring that users receive a consistent and convincing virtual try-on experience. The second objective aimed to improve product visualization through an intuitive AR interface. To address this, the application allows users to view jewelry items directly on their own body through the live camera view. This feature helps overcome the limitations of traditional static images, which often fail to convey how an item will appear when worn. The AR interface was designed to be simple and user-friendly, enabling customers to clearly visualize the product in context and make more confident purchase decisions. The third objective examined whether the integration of AR and Machine Learning could enhance the overall user experience by improving interaction quality, system performance, and usability. The resulting application supports not only virtual try-on but also other essential features, including secure user authentication, product browsing, account management, booking services, AR system and customer support. These components are supported by a Firebase-based backend, which ensures reliable data handling and system scalability. The integration of AR and ML has shown to improve system responsiveness, reduce purchase hesitation, and create a more engaging and enjoyable shopping process.

### 5.2. Project Strengths and Limitations

This project offers an innovative solution to a common challenge faced in online shopping, which is the difficulty of visualizing fashion accessories before making a purchase. By integrating real-time augmented reality (AR), users can search for products and instantly try them on, making the shopping experience more interactive and personalized. The system also uses precise landmark detection to place jewelry accurately on the user's body, allowing for a clear and realistic visualization. More

importantly, this virtual try-on feature reduces hesitation and uncertainty, boosts buyer confidence, and makes the purchasing process more enjoyable.

Despite these strengths, the project also has several limitations. At this stage, the system is only available on Android devices, restricting access for iOS users and thereby limiting the potential user base. Furthermore, the virtual try-on feature currently supports only rings. It does not yet support items like necklaces, bracelets, or earrings, which reduces its appeal for users seeking a broader virtual try-on experience. Another limitation is that the application is built specifically for the Rebound Piercing brand. All data, product entries, and design elements are customized for that retailer, making it difficult to scale the system for use by other brands without substantial modifications.

## **CHAPTER 6. CONCLUSION AND RECOMMENDATIONS**

This chapter summarizes the project's key achievements in developing an AR and ML-powered mobile app for virtual try-on in fashion accessories. It highlights the system's value in improving online shopping experiences and customer engagement. The chapter also discusses the practical significance of the project and its potential for wider adoption. Lastly, it outlines future directions, including cross-platform expansion, broader accessory support, and enhanced personalization.

### **6.1. Conclusion**

This project successfully developed a mobile application that integrates Augmented Reality (AR) and Machine Learning to enhance the online shopping experience for fashion accessories, with a particular focus on the body piercing segment. The application was designed to address challenges of product visualization in e-commerce. By allowing users to virtually try on jewelry in real time through the AR camera module, the system helps bridge the gap between digital browsing and the physical shopping experience.

The system offers a wide range of features to support user interaction and satisfaction. These include user authentication, enabling individuals to register and log in with confidence; a comprehensive product catalog that allows browsing by type, material, size, and price; and detailed product listings with high-quality images and descriptions. Users can also schedule appointments for in-store services through the booking system. The customer account management module allows users to personalize their profiles and save relevant information for future use. In addition, the Help & Information section offers useful resources and multi-channel customer support options. From a technical standpoint, the project showcases how the integration of AR and ML technologies can deliver a more interactive and intelligent shopping environment. It not only enhances user engagement but also lays a foundation for future expansion, such as supporting a wider variety of accessories, improving recommendation algorithms, or enabling cross-platform compatibility.

### **6.2. Value of the project**

This project plays an important role in improving the online shopping experience for fashion accessories, especially body piercings. One of the biggest challenges for online shoppers is not being able to see how a product will actually look when worn. By using Augmented Reality (AR), the application allows users to try on accessories virtually in real time. This helps them make better purchase decisions and reduces disappointment after buying.

The system also makes online shopping more engaging and personalized. With features like product recommendations, real-time previews, and easy appointment booking, users feel more supported throughout their shopping journey. These features are especially valuable for younger users who are familiar with technology and expect modern, interactive experiences. Beyond solving a practical problem, the project shows

how new technologies like AR and Machine Learning can be used to improve real-world e-commerce. It offers added value not just for customers, but also for businesses looking to attract and retain more tech-savvy consumers.

### **6.3. Future Works**

Due to the current limitations of the project, there are several directions for future development that could help improve both the functionality and practicality of the application. One important improvement is expanding the system's compatibility to include iOS devices. This would help increase accessibility and allow the application to reach a broader user base across different platforms. Another promising direction is broadening the range of supported accessories. Currently limited to earrings and nose rings, the system could be upgraded to include items like necklaces, bracelets, or glasses by integrating upper-body or full-face detection techniques, offering a more complete virtual try-on experience. Additionally, the backend architecture could be redesigned to support multiple brands instead of being restricted to Rebound Piercing. A more flexible and customizable system would enable wider commercial adoption and cross-brand deployment. Finally, although advanced personalization features are not included in the current version, future enhancements may explore machine learning techniques to analyze user preferences and improve product suggestions, further enriching the shopping experience.

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## APPENDIX

### **Appendix 1. Project Related Materials**

#### **1. Submission Link**

<https://drive.google.com/drive/u/2/folders/1ZqhQbMv1tCLPeENtD-MXELueSmNjIdDX>

#### **2. Design Of Mock-Ups (User Interface) Of Application**

<https://www.figma.com/design/dqYdTIqh0DwLrAVQ0lDwWT/REBOUND-PIERCING-MOBILE-APP?node-id=18-3288&t=EUvvijOldeMdf8p5->

#### **3. Diagrams For Project (Drawio.nets)**

<https://drive.google.com/file/d/1wGJ4ur0wizMYwJyW29HriXGT82cIIoVt/view?usp=sharing>

#### **4. Endpoints**

<https://docs.google.com/spreadsheets/d/1SJzdn8g-NwsUeOwN972slfB3N-qxPskz1B-9Fi3eVmg/edit?usp=sharing>

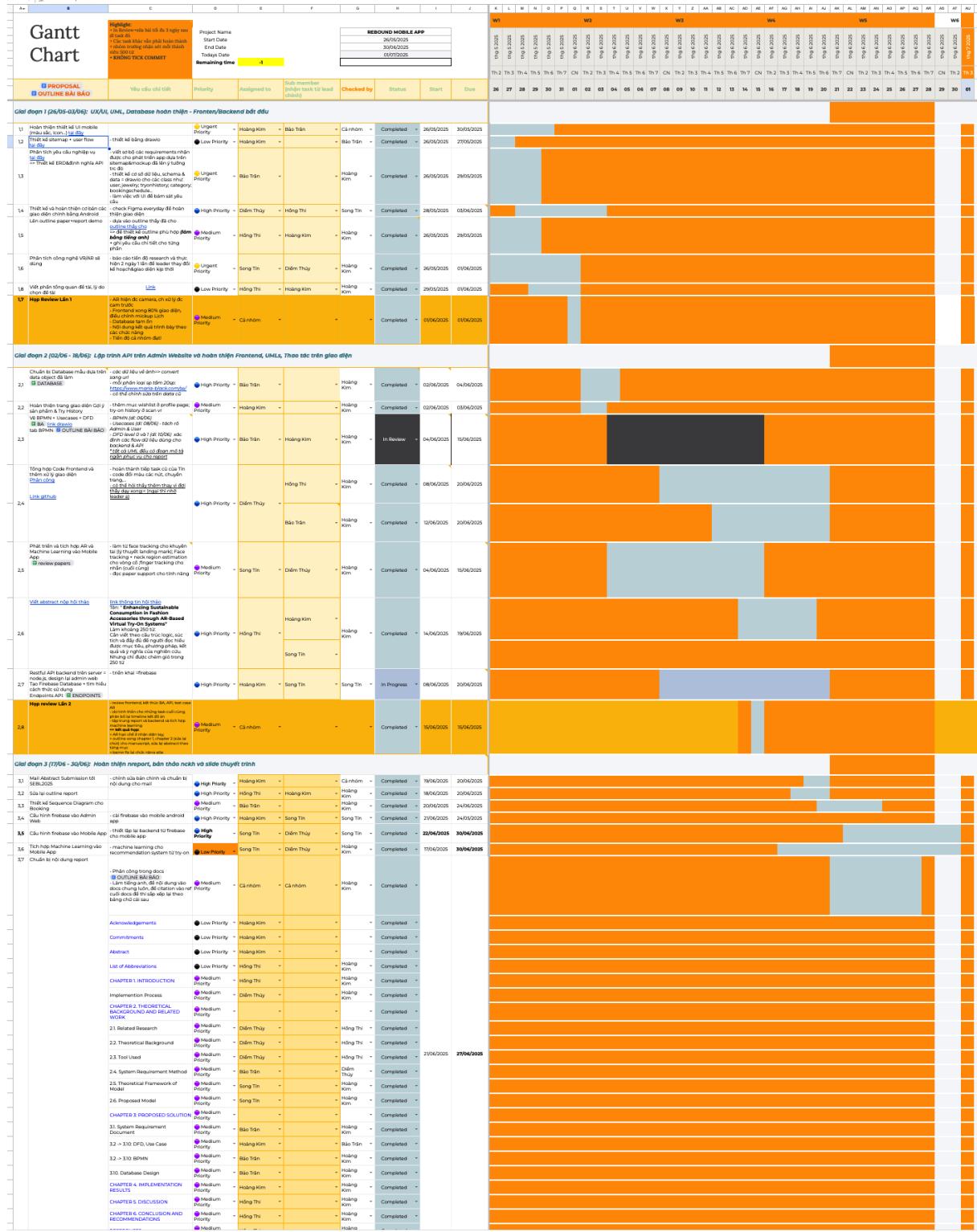
#### **5. Database of the project**

<https://docs.google.com/spreadsheets/d/1cbanww5gS4kjn5EELPOV0PbepX-3B0C3y9MIZNpGWrY/edit?usp=sharing>

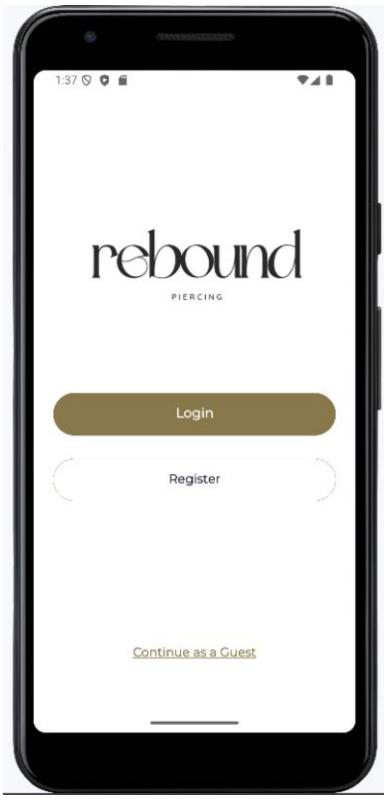
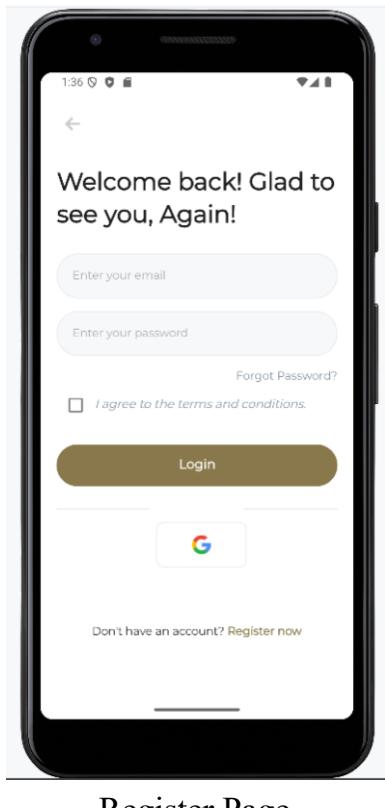
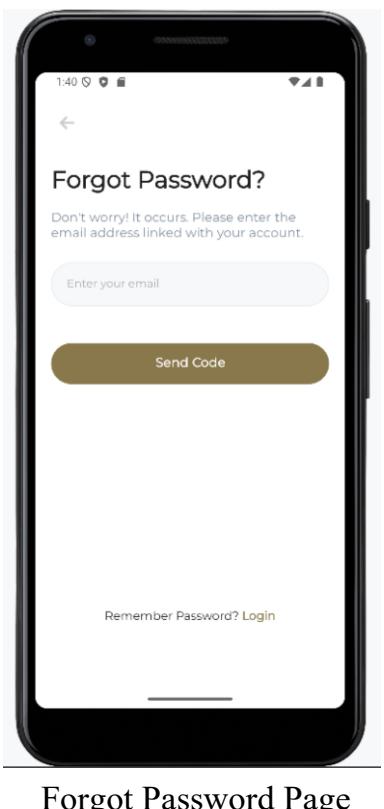
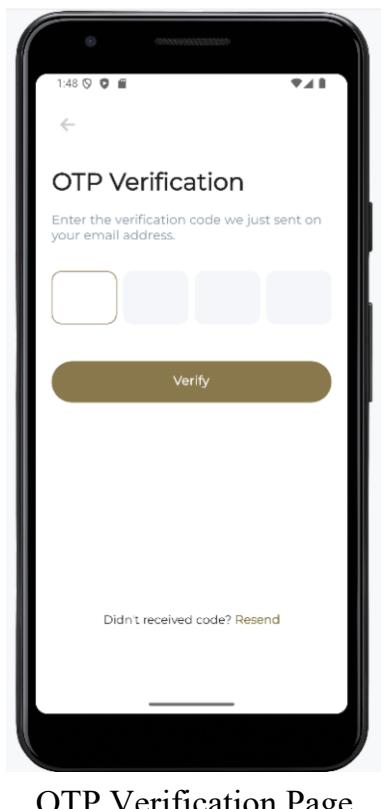
#### **6. Github repository**

[https://github.com/hoaloken61998/REBOUNDGroup5\\_Submissions/tree/main#](https://github.com/hoaloken61998/REBOUNDGroup5_Submissions/tree/main#)

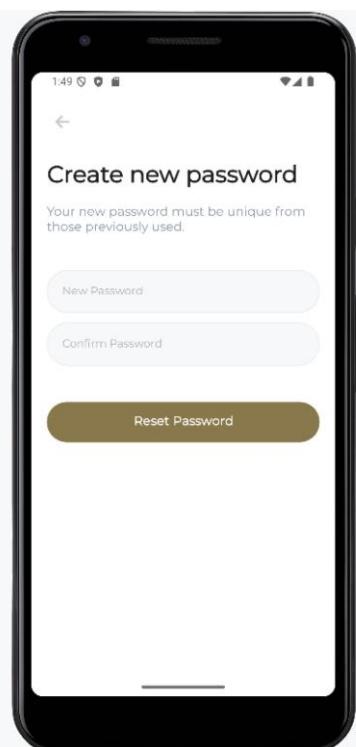
## **Appendix 2. Project Implementation Plan (Gantt Chart)**



### Appendix 3. User Flow Description

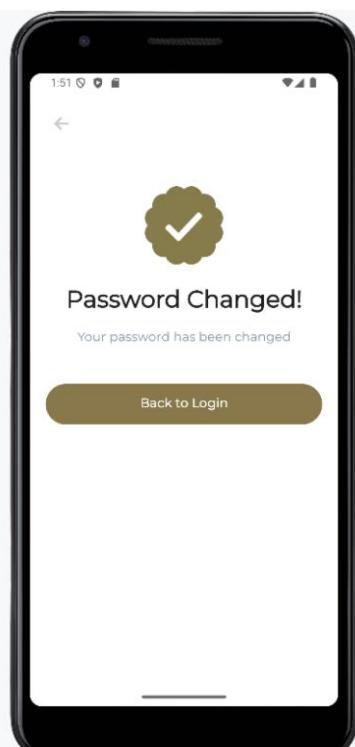
<p>Primary Flow - Authentication → Click to Login</p>	 <p>Welcome Page</p>	<p>Filling out email and password → Click to Login</p>	 <p>Welcome back! Glad to see you, Again!</p> <p>Enter your email</p> <p>Enter your password</p> <p>Forgot Password?</p> <p>I agree to the terms and conditions.</p> <p>Login</p> <p>Don't have an account? Register now</p> <p>Google icon</p> <p>Register Page</p>
<p>Alternative Flow 1: Forgot Password → Click Send code</p>	 <p>Forgot Password?</p> <p>Don't worry! It occurs. Please enter the email address linked with your account.</p> <p>Enter your email</p> <p>Send Code</p> <p>Remember Password? Login</p> <p>Forgot Password Page</p>	<p>User verify their account → Click verify</p>	 <p>OTP Verification</p> <p>Enter the verification code we just sent on your email address.</p> <p>Verify</p> <p>Didn't received code? Resend</p> <p>OTP Verification Page</p>

Users  
renew their  
password  
→ Click  
Reset  
Password



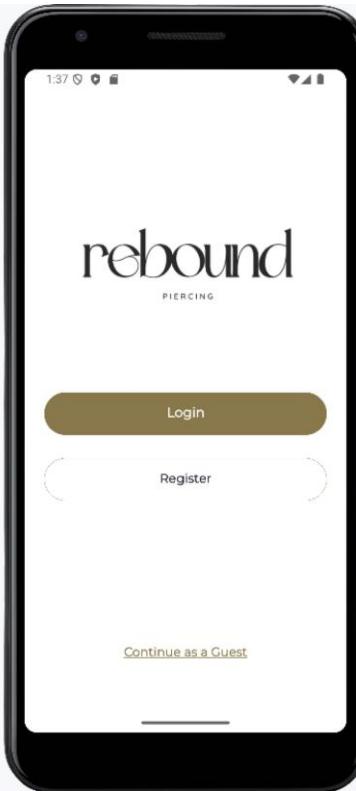
Create New Password Page

Click Reset  
Password



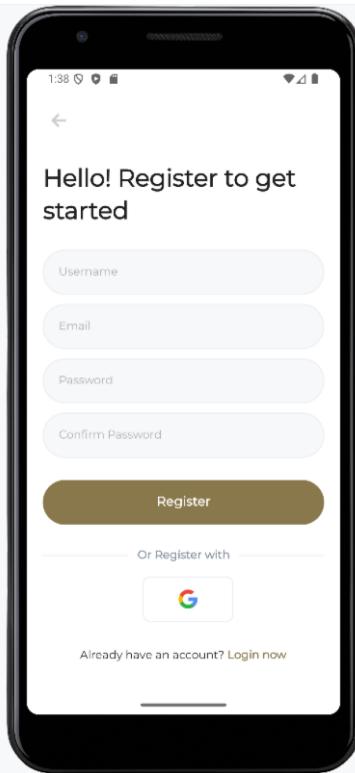
Create New Password  
Page

Alternative  
2: Register  
→ Click to  
register



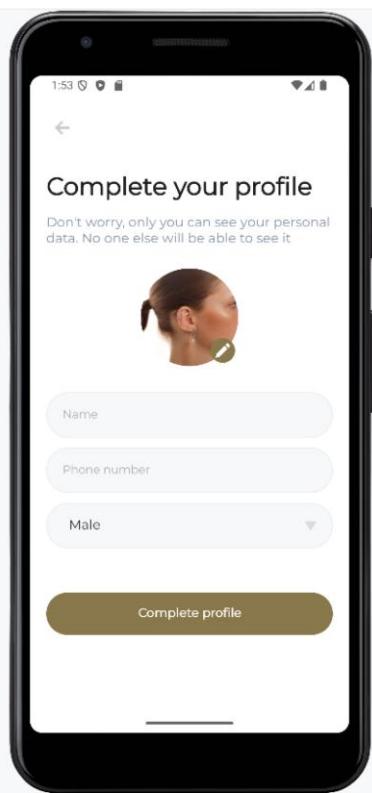
Welcome Page

User fill out  
information  
→ Click  
Register



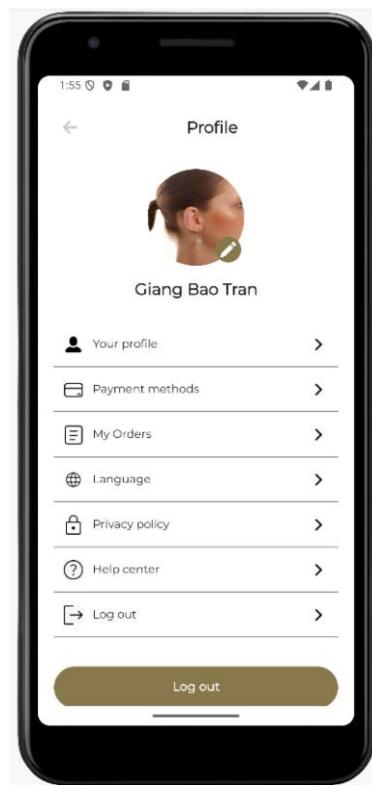
Register Page

Complete profile →  
Click to Complete profile



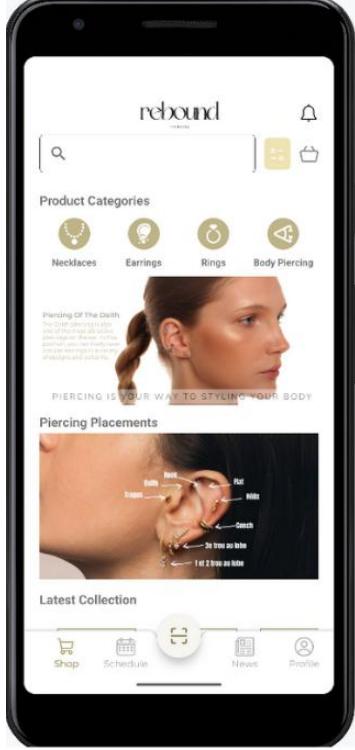
Profile Page

Click complete profile



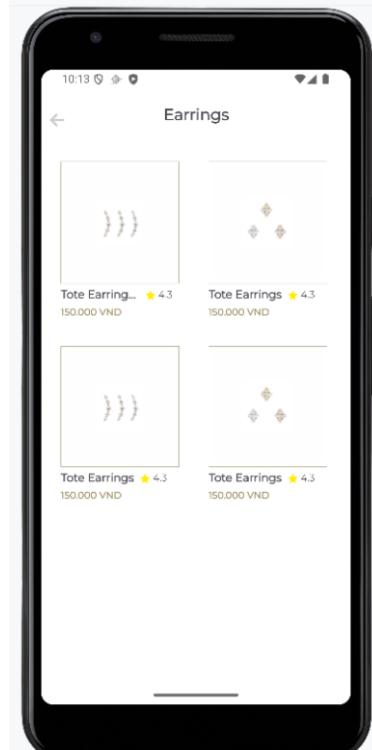
Profile Page

Primary Flow:  
Product Browsing &  
Purchase → Click to Shop



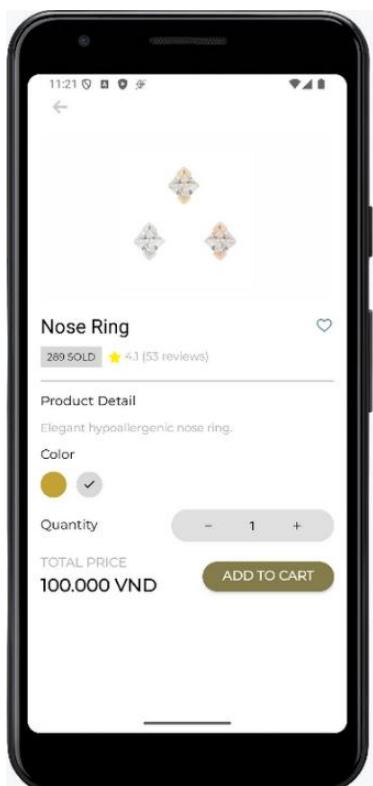
Shop Page

Click to choose Products category



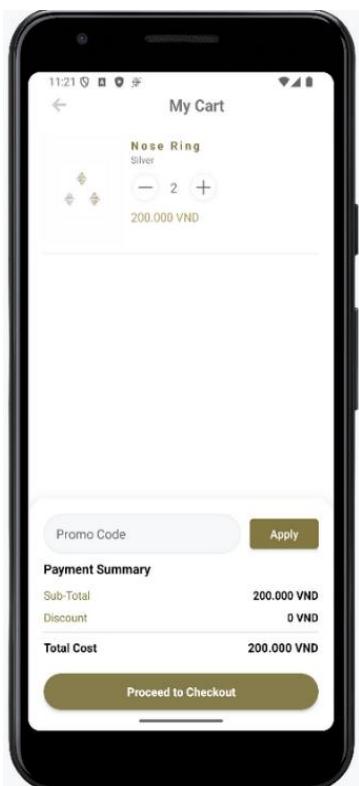
Product Category Page

Select Product Details → After checking, click Add to Cart



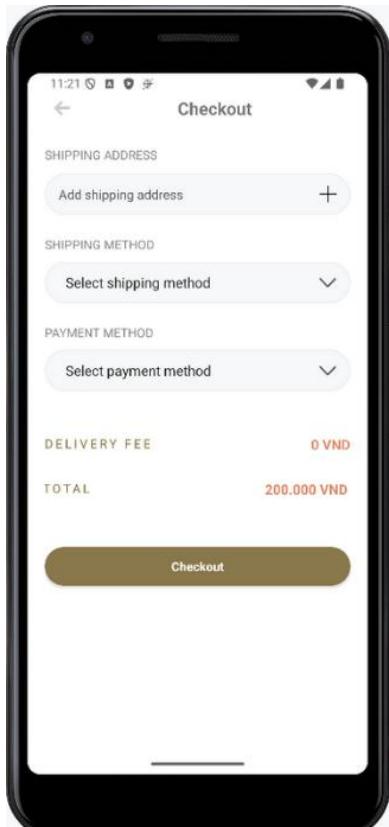
Product Details Page

View Product Orders → Click to Proceed to check out



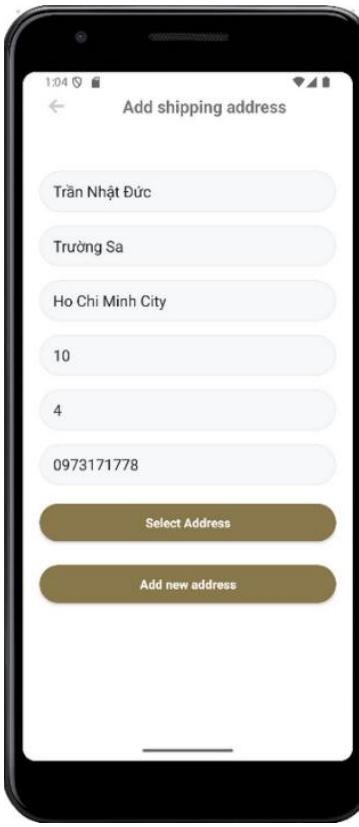
My Cart Page

Check Order Information



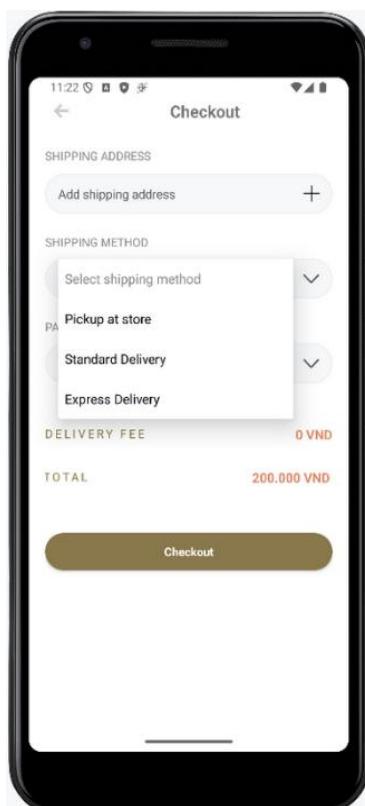
Checkout Page

If customer does not have shipping address → Add shipping address



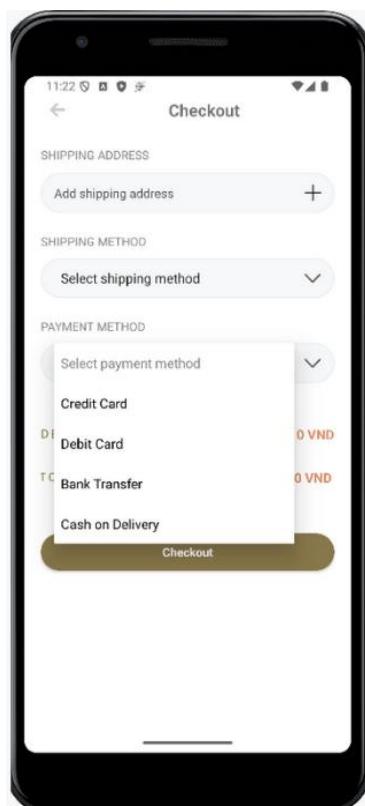
Add Shipping Address Page

Select  
Shipping  
Method



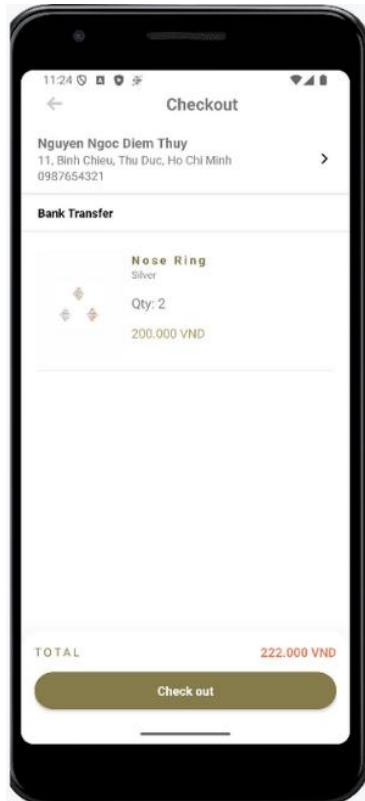
Checkout Page

Select  
Payment  
Method



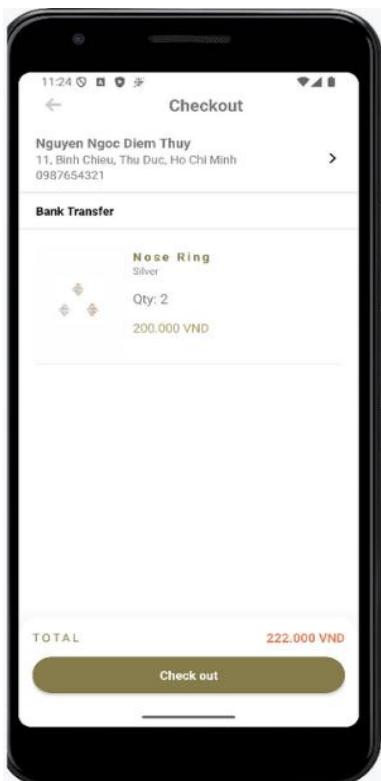
Checkout Page

After  
checking  
order  
informatio  
n → Click  
to  
checkout



Checkout Page

Alternative  
Flow 1:  
Checkout  
with bank  
transfer →  
Click  
check out



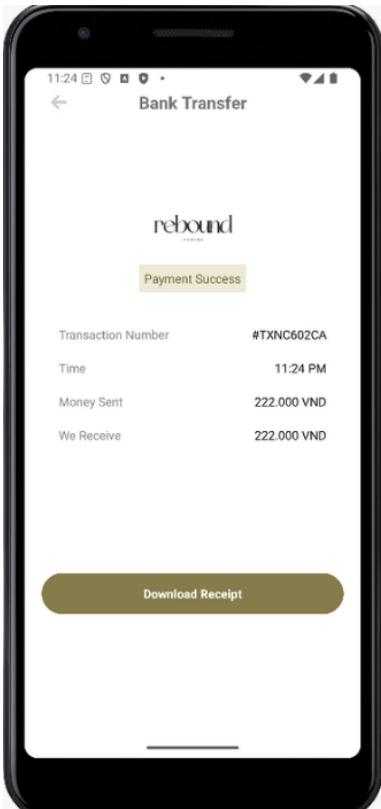
Checkout Page

Paying with  
bank  
transfer →  
Click to  
Confirm  
Payment  
Success



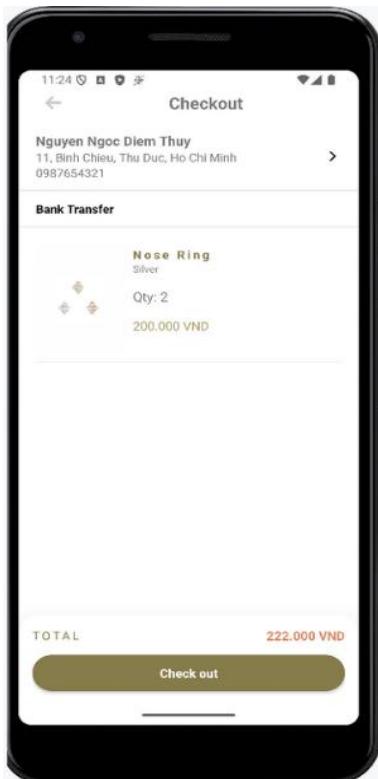
Bank Transfer Page

Checking  
receipt



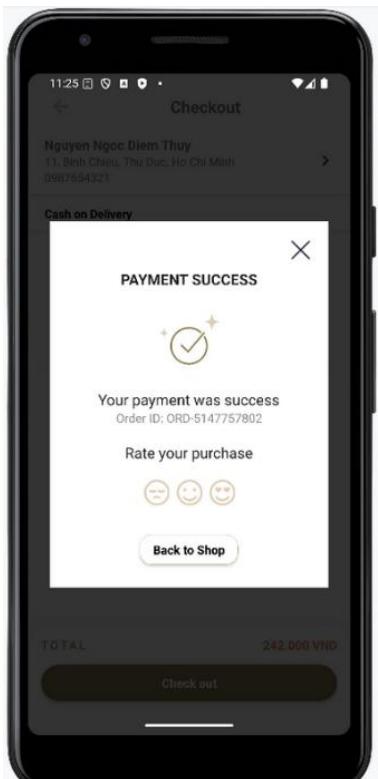
Bank Transfer Page

Alternative Flow 2:  
Checkout with cash on delivery  
→ Click check out



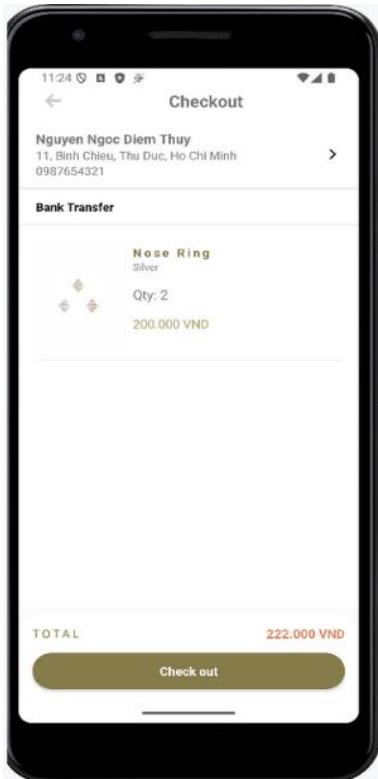
Checkout Page

Checkout with cash on delivery confirmation



Checkout Page

Alternative Flow 3:  
Checkout with card  
→ Click check out



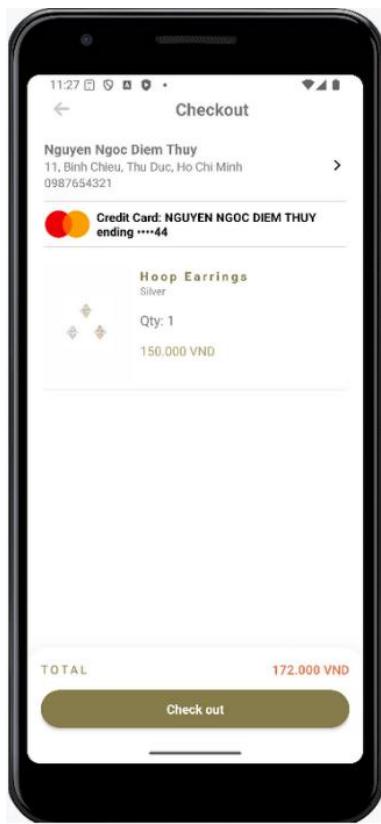
Checkout Page

Adding card information  
→ Click to Add card



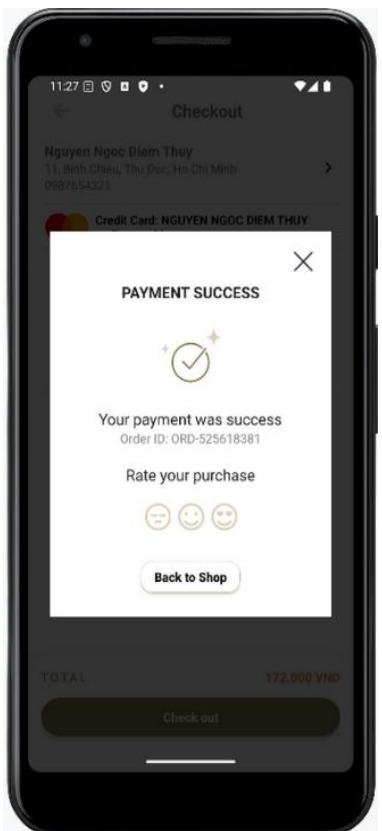
Payment Method Page

After  
checking  
order →  
Click to  
Checkout



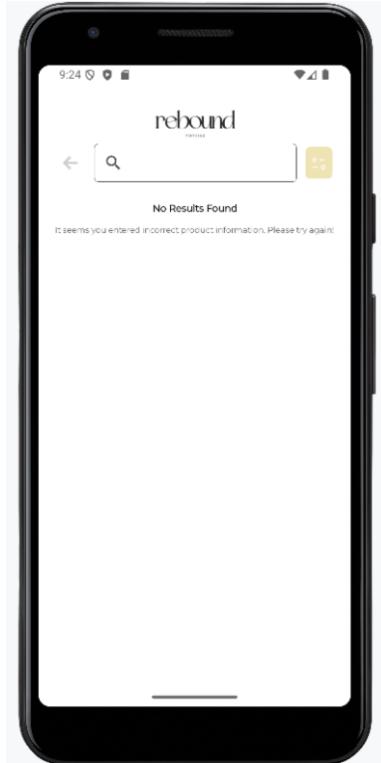
Checkout Page

Payment  
with card  
confirmatio  
n



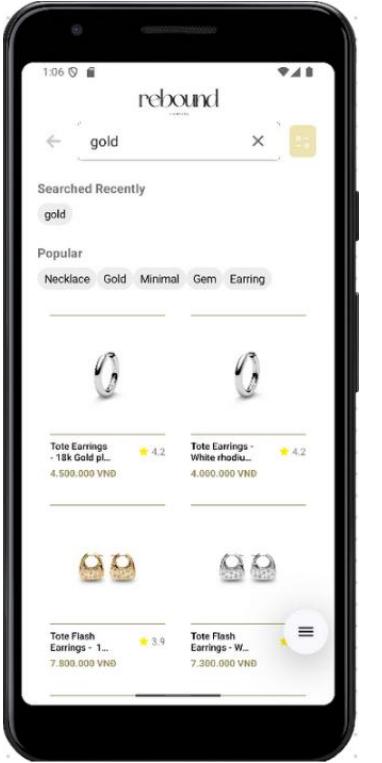
Checkout Page

Alternative  
Flow 4:  
Search  
Product



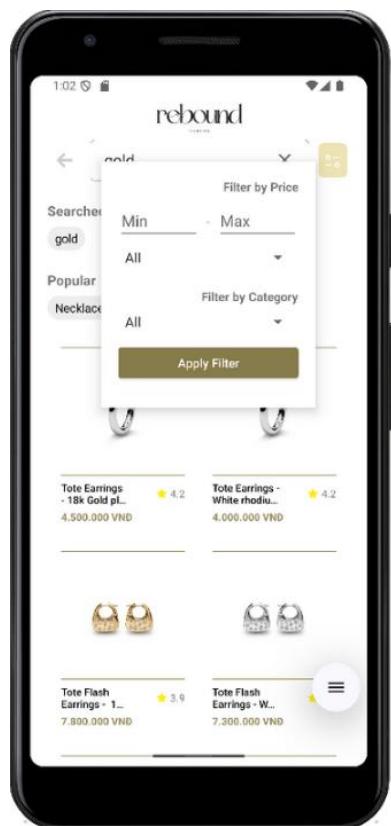
Search Page

User enter  
product  
category →  
Click find  
icon



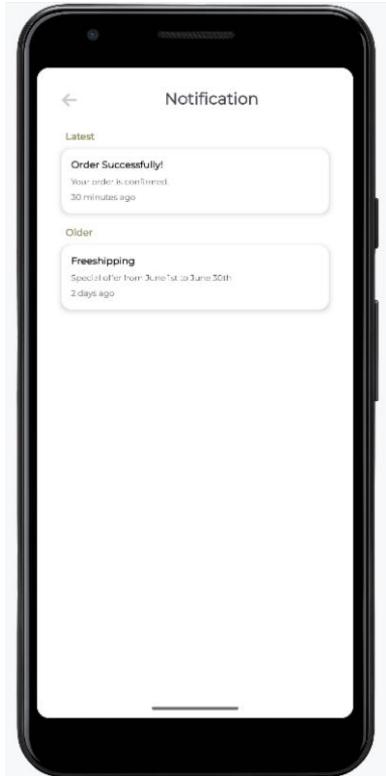
Search Result Page

User to filter product → Click to icon filter at the right top of the screen



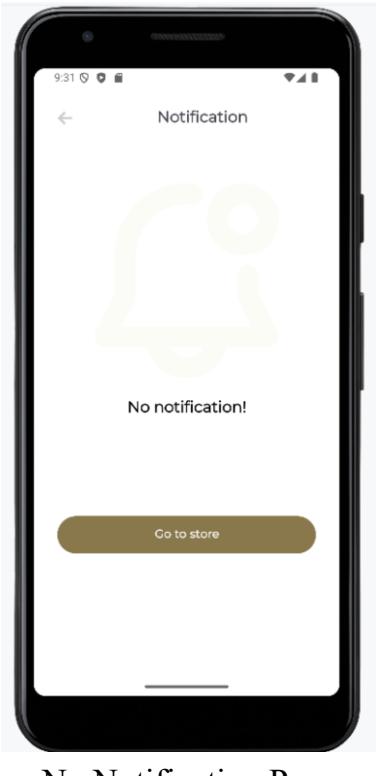
Search Result Page

Alternative Flow 5: Notification → Click to icon notification on the top left of the screen



Notification Page

If there is no notification



No Notification Page

Primary Flow:  
Booking system -  
Click to Schedule



Schedule Page

Select appointment date



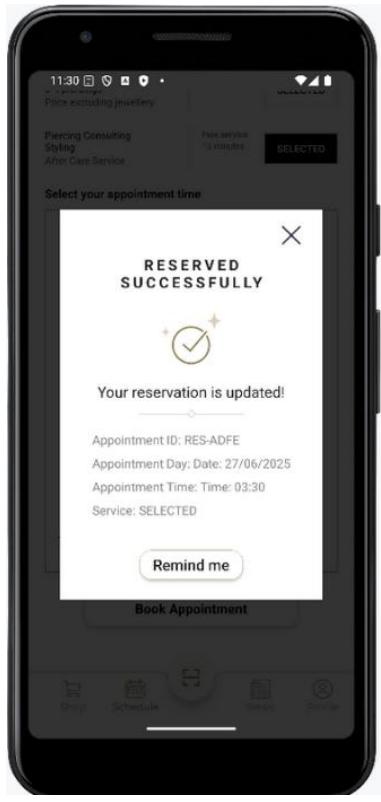
Schedule Page

Select Appointment Time



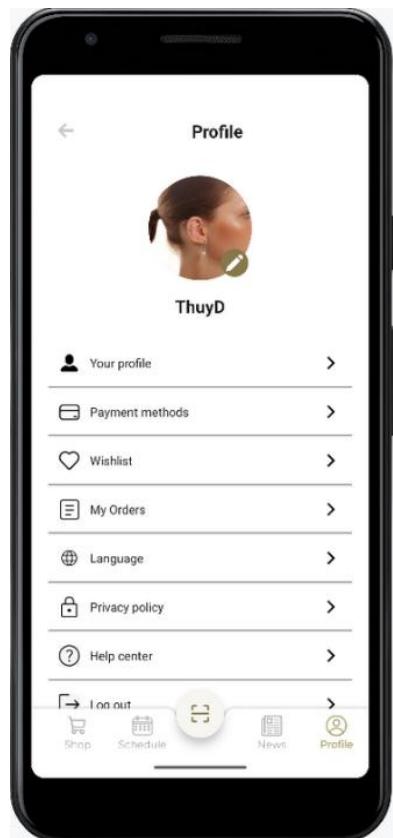
Schedule Page

After finish appoint date and time → Click to Book Appointment



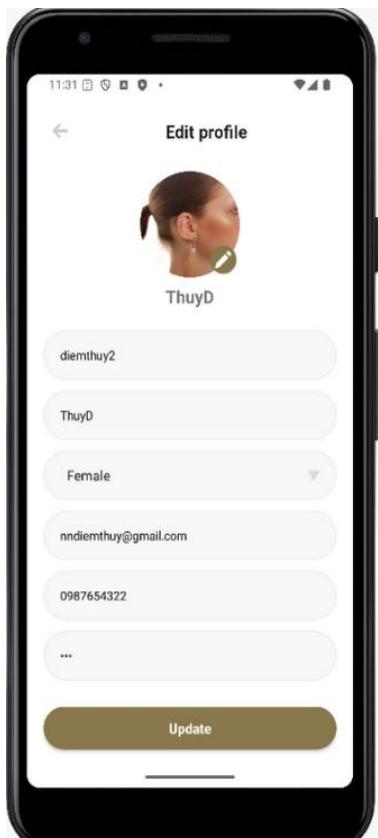
Appointment Confirmation Page

Primary Flow:  
Customer Account Management - Click to Profile



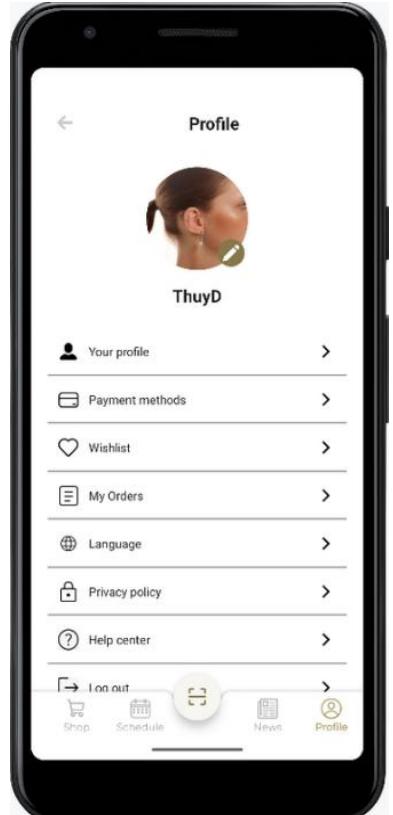
Profile Page

Once users finish editing their profiles → Click to update



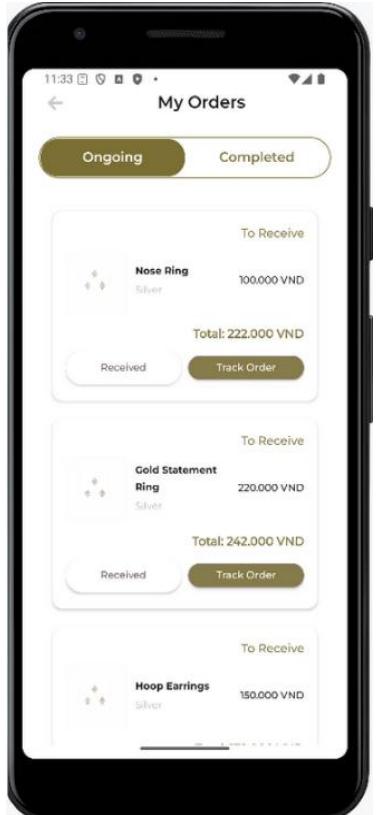
Edit Profile Page

Alternative Flow 2;  
Tracking orders → Click to My Orders



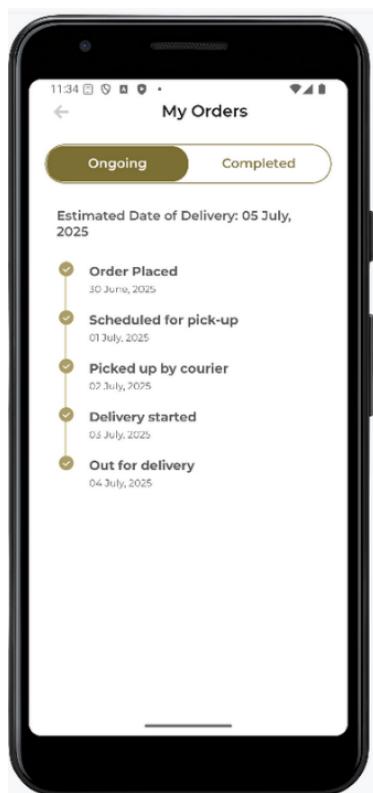
Profile Page

Click to Ongoing



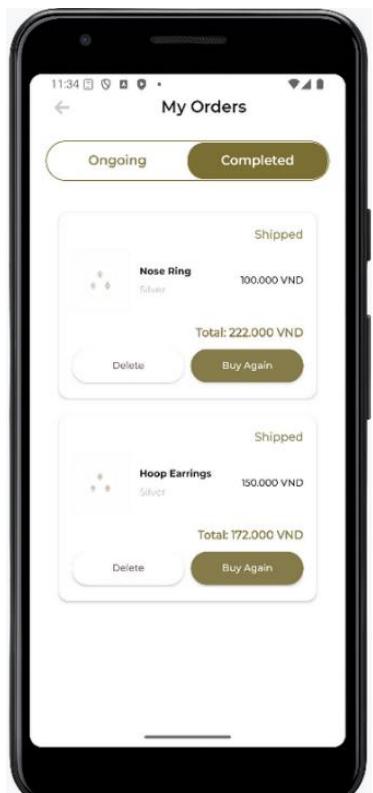
My Orders Page

If users want to check for orders status → Click to Track Order



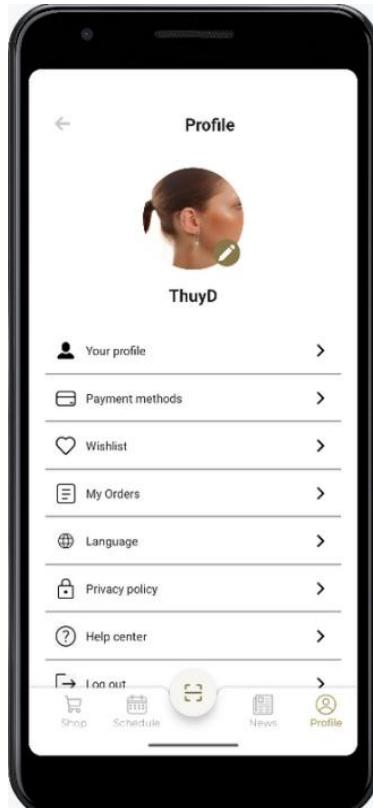
My Orders Page

User to track order completed  
→ Click to Completed



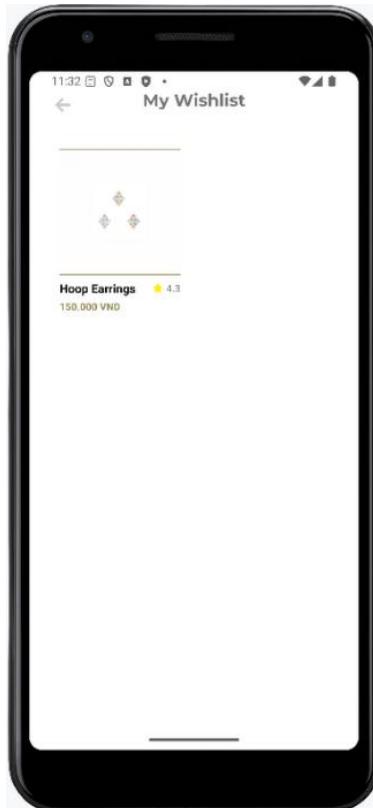
My Orders Page

Alternative Flow 3:  
Wishlist → Click to Wishlist



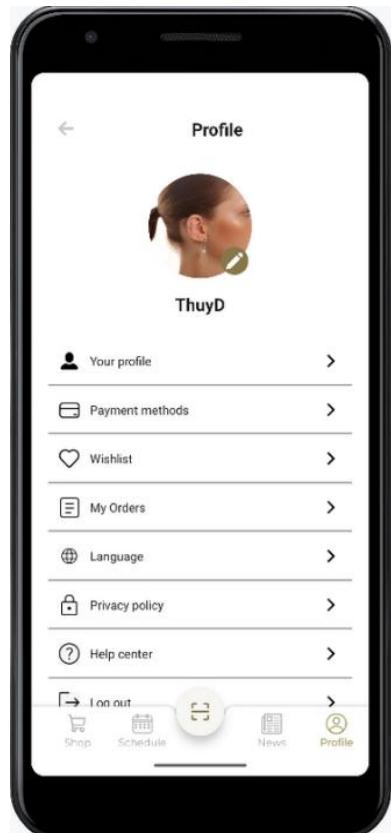
Profile Page

User check their wishlist



Wishlist Page

Alternative Flow 3: Set up language  
→ Click to Language



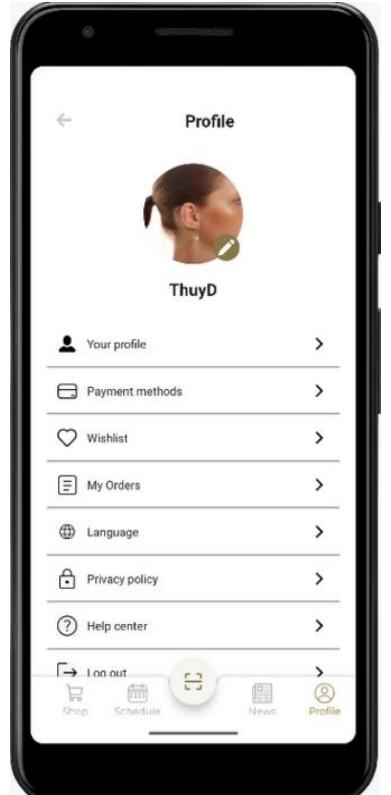
Profile Page

User to select Language  
→ Click to choose language



Select Language Page

Alternative Flow 4:  
Logout →  
Click to Logout



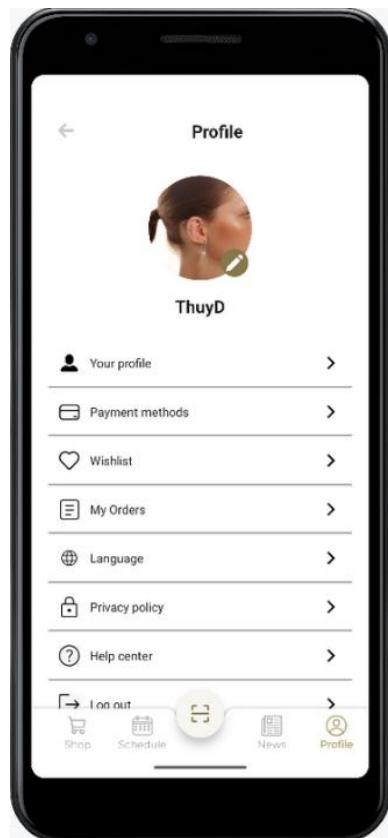
Profile Page

User logout →  
Click to Yes



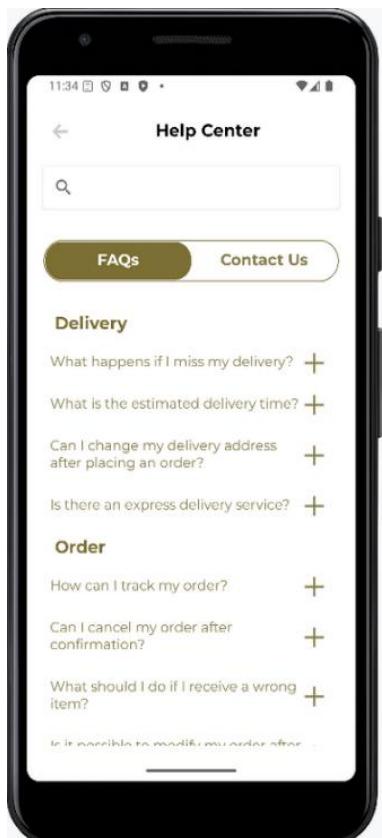
Logout Page

Primary Flow: Help and Info - Click to Help Center



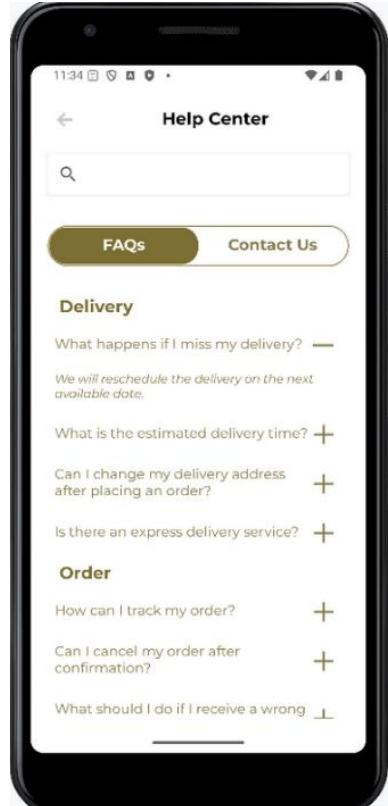
Profile Page

Click to FAQs



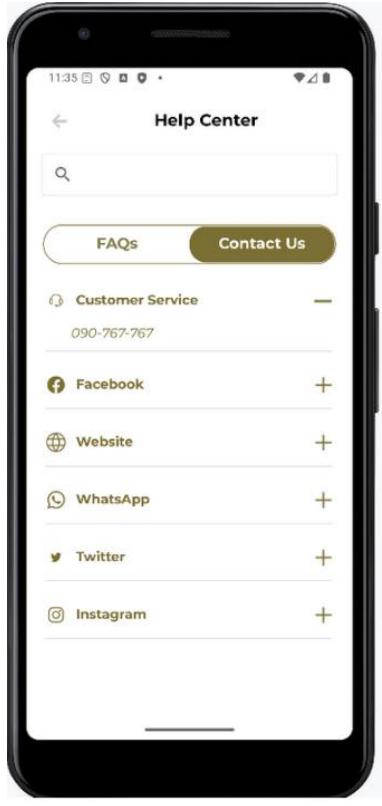
Help Center Page

Users to read frequently asked question → Click add icon

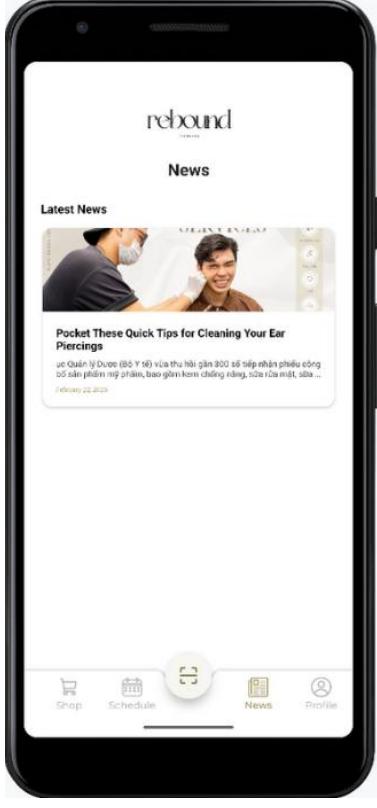
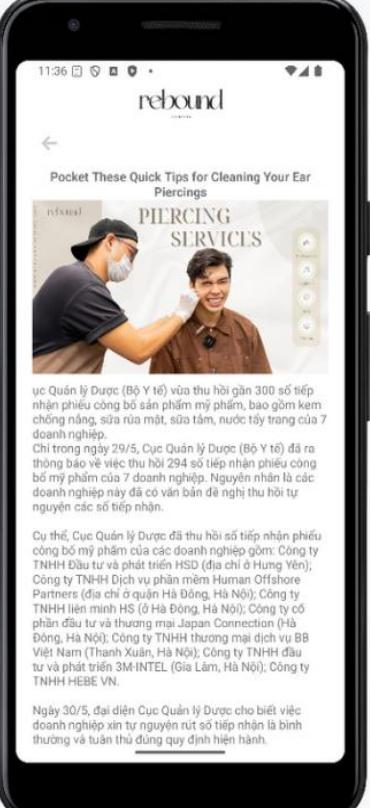
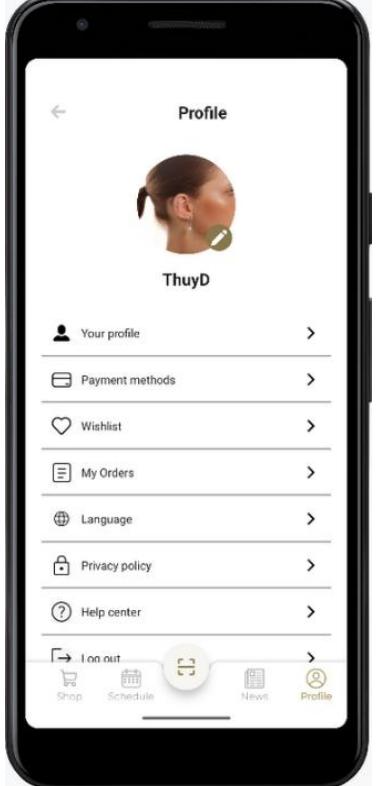
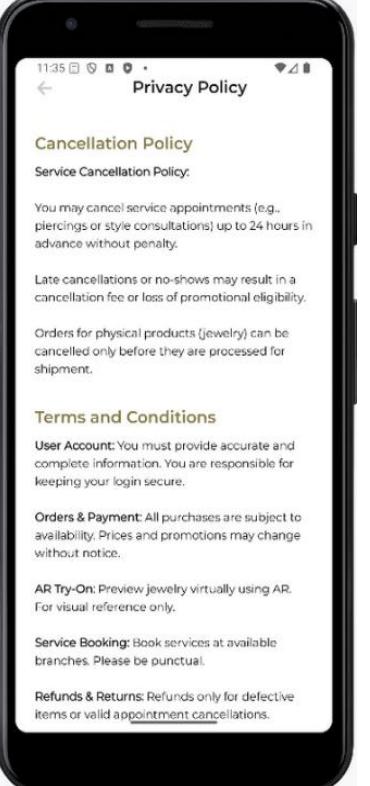


Help Center Page

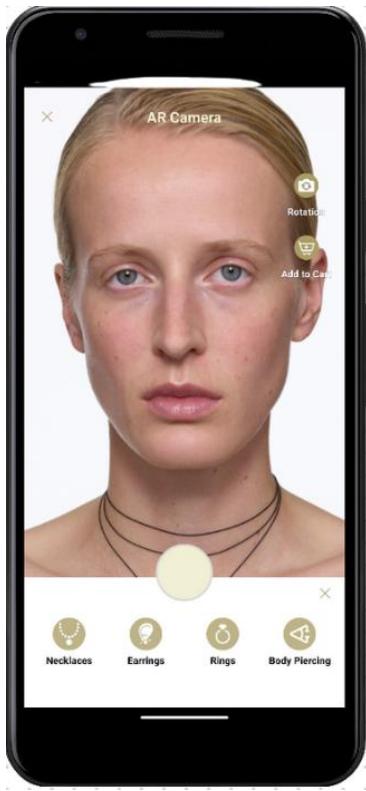
User to check brand contact information → Click to Contact us



Contact Us Page

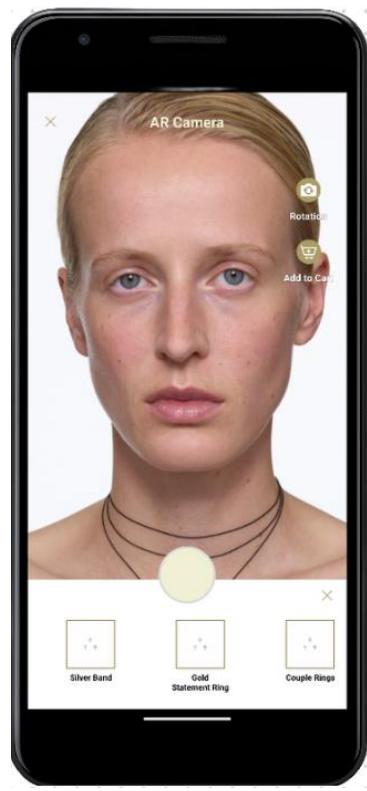
<p>Alternative Flow 1: News → Click to News</p>	 <p><b>News Page</b></p>	<p>User to read article → Click to article</p>	 <p>Cụ thể, Cục Quản lý Dược đã thu hồi số tiếp nhận phiếu công bố mỹ phẩm của các doanh nghiệp gồm: Công ty TNHH Đầu tư và phát triển HSD (địa chỉ ở Hưng Yên); Công ty TNHH Dịch vụ phần mềm Human Offshore Partners (địa chỉ ở quận Hà Đông, Hà Nội); Công ty TNHH liên minh HS (ở Hà Đông, Hà Nội); Công ty cổ phần đầu tư và thương mại Japan Connection (Hà Đông, Hà Nội); Công ty TNHH thương mại dịch vụ BB Việt Nam (Thanh Xuân, Hà Nội); Công ty TNHH đầu tư và phát triển 3M-INTEL (Gia Lâm, Hà Nội); Công ty TNHH HEBE VN.</p> <p>Ngày 30/5, đại diện Cục Quản lý Dược cho biết việc doanh nghiệp xin từ nguyên rút số tiếp nhận là bình thường và tuân thủ đúng quy định hiện hành.</p> <p><b>News Page</b></p>
<p>Alternative Flow 2: Privacy Policy → Click to Privacy Policy</p>	 <p><b>Profile Page</b></p>	<p>Users scroll to read privacy policy</p>	 <p><b>Privacy Policy Page</b></p>

Primary  
Flow: AR  
Camera  
system →  
Click Scan



Scan AR Page

User click  
category to  
scan  
product



Scan AR Page