

An Intelligent Design Recommender System for Handmade Accessories Using Augmented Reality and Vision-Language Models

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DOI: <https://doi.org/10.47772/IJRISS.2026.100800998>

Received: 09 September 2026; Accepted: 14 September 2026; Published: 22 September 2026

ABSTRACT

The handmade accessory industry continues to rely heavily on social media platforms and manual communication for product promotion, customization requests, and order management. This approach often leads to inefficient order tracking, communication errors, and difficulty for customers in visualizing customized accessories before purchase. This paper presents the Accessory Design Recommender System (ADRS), a mobile application developed to help customers browse handmade accessories, customize bracelet designs, receive intelligent design recommendations, and visualize accessories using Augmented Reality (AR) technology. The system integrates Kotlin, Supabase, Retrofit, CameraX, MediaPipe, the OpenAI API, Machine Learning, and Firebase Cloud Messaging to support recommendation generation, wrist detection, database management, and real-time notifications. The Agile methodology is adopted to facilitate iterative development and continuous improvement throughout the project lifecycle. The system also provides a web-based admin dashboard for product, order, and customer management. With core modules implemented and preliminary interface testing under way, the tool aims to improve purchasing confidence, simplify customization, and support the digital transformation of small handmade accessory businesses.

Keywords— Augmented Reality, Virtual Try-On, Design Recommender System, Vision-Language Models, Handmade Accessories, Mobile Commerce

INTRODUCTION

Many small handmade accessory businesses still rely on social media platforms such as Instagram, TikTok, and WhatsApp to manage customer orders and customization requests. This manual approach can lead to communication errors, inefficient order tracking, and difficulty handling requests, especially during busy periods such as event booth sales.

Traditional accessory-shopping approaches typically provide only static product images, leaving customers uncertain about how a customized accessory will actually look before making a purchase decision. Existing e-commerce and retail applications rarely combine product customization with interactive visualization, restricting customers' confidence in customized, made-to-order products.

Recent studies have shown that Augmented Reality (AR) and Virtual Try-On (VTO) technologies significantly improve customer engagement, product evaluation, and purchase intention across retail domains [1]–[5], and that vision-language models can generate personalized product recommendations directly from visual and textual input. However, few mobile applications integrate accessory customization, AI-driven design recommendation, and AR visualization within a single, user-centred platform.

This study develops the Accessory Design Recommender System (ADRS) using Kotlin and a Supabase backend that uses a vision-language model API to generate personalized bracelet design recommendations, paired with CameraX and MediaPipe for AR virtual try-on. The system enables users to browse products, customize bracelet designs, preview them virtually, and manage orders, while an admin dashboard supports product, order, and customer management. The integration between AI-driven recommendation and AR visualization is intended to

empower small handmade accessory businesses to move beyond manual, social-media-based selling toward a more efficient, engaging, and inclusive digital retail practice.

Background

Handmade accessory businesses are increasingly recognized as a segment underserved by mainstream e-commerce and retail technologies. Recent studies highlight that AR has emerged as a transformative technology in retail, enhancing product visualization and reducing uncertainty during online purchase decisions [1]–[3]. Despite this, most AR retail research and deployment remain concentrated in fashion, cosmetics, and general product categories, leaving customized, made-to-order accessories comparatively unexplored.

Virtual Try-On (VTO) technology has advanced considerably through computer vision and deep learning, enabling consumers to visualize products on themselves in real time using only a smartphone camera [6]–[10]. This reduces the uncertainty and high return rates associated with online shopping, though realism, computational cost, and privacy concerns around personal images remain open challenges.

Customer purchase intention and technology acceptance research, largely grounded in the Technology Acceptance Model (TAM) and Theory of Planned Behavior (TPB), consistently shows that perceived usefulness, ease of use, and trust drive adoption of online shopping platforms [11]–[15]. Usability research on AR mobile applications further shows that intuitive navigation and smooth performance are essential to sustained engagement [16]–[20].

Together, these bodies of work motivate ADRS's approach: combining accessory customization with AI-driven recommendation and AR-based visualization, delivered through a usable mobile interface, to address a gap that general-purpose AR and VTO research has not yet targeted.

Related Work

Recent research has explored the use of Augmented Reality (AR) in retail to improve product visualization, customer engagement, and purchase decision-making. Laitinen et al. [1] reviewed consumer behaviour related to AR in retail and highlighted the potential of AR to improve customer interaction with products. Similarly, Chiu et al. [2] examined the use of AR applications in retail and demonstrated its relevance to improving the digital shopping experience. Guo and Zhang [3] further investigated AR online shopping experiences and their influence on customer purchase intention. These studies indicate that AR can reduce uncertainty when customers evaluate products online. However, the existing applications and studies mainly focus on general retail contexts rather than customized handmade accessories. The reviewed literature therefore provides a foundation for applying AR to accessory visualization, but does not directly address personalized bracelet design.

Virtual Try-On (VTO) technologies have also received considerable research attention, particularly in fashion and online retail. Batool and Mou [6] presented a systematic review of virtual fitting room technologies, highlighting the development of try-on systems that allow consumers to visualize products before purchase. Chen et al. [8] reviewed VTO systems in fashion consumption and discussed the development of computer vision and deep-learning approaches for virtual product visualization. Ghodhbani et al. [10] similarly surveyed virtual try-on systems and their application in enabling users to visualize products without physically visiting a store. Nguyen et al. [7] examined the impact of VTO on online shopping and consumer purchase intention, while Costa et al. [9] investigated consumer attitudes towards VTO using an extended Technology Acceptance Model. Although these studies demonstrate the usefulness of VTO in online shopping, most applications focus on predefined products, particularly clothing and fashion items, rather than user-designed and customizable handmade accessories.

Research on technology acceptance and online purchase intention provides another important perspective for the development of digital retail applications. Nguyen et al. [11] examined online purchase intention through the integration of the Theory of Planned Behavior (TPB) and Technology Acceptance Model (TAM). Nonis et al. [12] similarly investigated online purchase intention using an integrated TAM and TPB framework. Wistedt [13] examined consumer purchase intention in cross-border e-commerce, while Akbar and Manalu [14] investigated

online purchase intention using an extended TAM. Wang et al. [15] further examined factors influencing the adoption of online shopping platforms in Malaysia. Collectively, these studies demonstrate the importance of factors such as perceived usefulness, ease of use, trust, and other technology acceptance factors in influencing consumers' adoption of digital shopping platforms. However, these studies primarily investigate general e-commerce adoption and do not specifically examine how AI-based design recommendations and interactive customization influence customers' decisions when creating personalized accessories.

Usability and user experience are also important considerations for AR-based mobile applications. Davidavičienė et al. [16] evaluated user experience in AR mobile applications, while De Paolis et al. [17] investigated usability, user experience, and mental workload in a mobile AR application. Aslam and Davis [18] examined consumer expectations and experiences with AR applications in the fashion retail sector. Further studies have also evaluated AR content and interaction design [19], [20]. These studies indicate that intuitive navigation, acceptable cognitive workload, and responsive interaction are important for maintaining user engagement with AR applications. However, limited research has examined the combined usability challenges of AR visualization, user-directed product customization, and AI-based recommendation within a single mobile application.

Overall, the reviewed studies demonstrate that AR and VTO can enhance product visualization and online shopping experiences, while technology acceptance research highlights the importance of usefulness, ease of use, trust, and user experience. However, the existing literature largely addresses AR visualization, virtual try-on, e-commerce adoption, or recommendation as separate areas. There remains a research gap in integrating user-directed accessory customization, AI-driven design recommendation, and AR-based virtual try-on within a single mobile platform specifically for handmade and made-to-order accessories. ADRS addresses this gap by allowing customers to customize bracelet designs at bead level, obtain AI-generated design recommendations, and visualize the completed design on their wrist before placing an order. This integrated workflow differentiates ADRS from existing AR, VTO, and e-commerce applications.

Table I. Summary Of Related Work and Research Gap

Ref	Method / Approach	Key Findings	Identified Research Gap
[1]–[3]	Review and empirical studies of AR retail applications	AR improves decision-making, personalization, and engagement while reducing purchase uncertainty	Focused on general retail (fashion, food, cosmetics); no application to customized handmade accessories
[6], [8], [10]	Systematic reviews of Virtual Try-On (VTO) systems	Deep-learning-based VTO enables realistic, real-time product visualization via smartphone cameras	Applied mainly to predefined clothing/cosmetic products, not to user-designed, customizable accessories
[11]–[13]	TAM/TPB-based studies of online purchase intention	Perceived usefulness, ease of use, and trust are key predictors of e-commerce adoption	Explains adoption of shopping platforms generally, not how AI recommendation affects customization decisions
[16]–[18]	Usability and UX evaluation of AR mobile applications	Intuitive navigation, low cognitive workload, and responsiveness drive AR adoption	Few studies evaluate UX where AR, customization, and recommendation are combined in one platform

Table I summarizes the positioning of the reviewed literature relative to ADRS. While AR and VTO research is well established for fashion, cosmetics, and general retail, and technology-acceptance research explains adoption of online shopping platforms broadly, none of the reviewed studies combine accessory customization, AI-driven design recommendation, and AR-based virtual try-on for handmade, made-to-order accessories within a single mobile platform. ADRS is proposed to address this gap.

METHODOLOGY

The Accessory Design Recommender System (ADRS) was developed using a systematic Agile software development process. The process consists of four major phases: analysis, design, implementation, and testing. Implementation and testing were executed iteratively to ensure the functional and non-functional requirements were effectively translated into a mobile solution designed to support accessory customization, AI-driven recommendation, and AR visualization.

A. Analysis Phase

The analysis phase aimed to understand the overall behaviour of the system. The ADRS requirements were modelled using a use case diagram (Fig. 1). The system's two main actors are Customer and Admin. Customers browse products, customize bracelet designs, manage shopping carts, track orders, and use AR visualization, while Admins manage products, orders, beads, and the bracelet production queue.

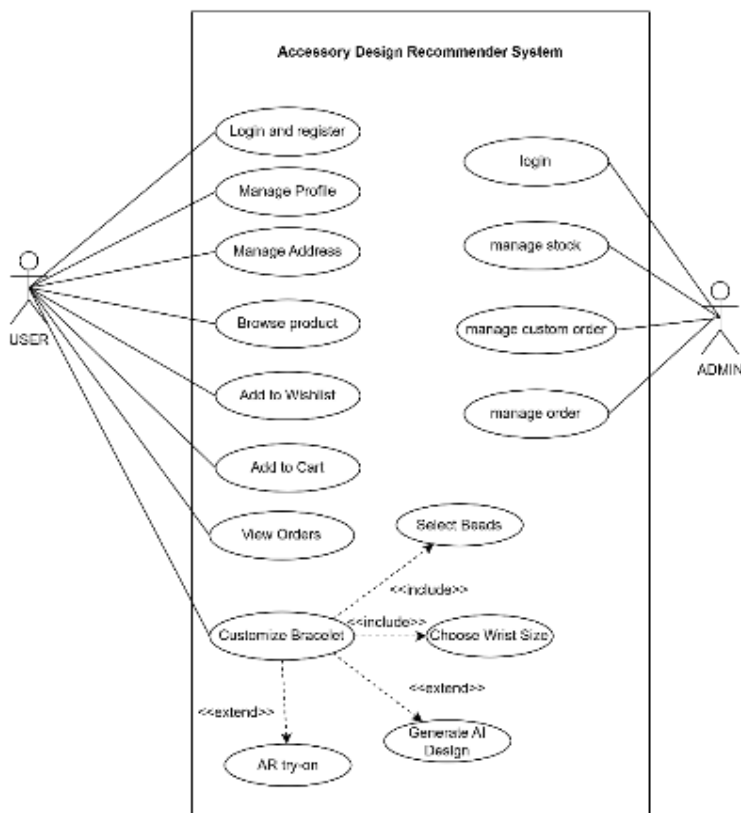


Fig. 1. Use case diagram of ADRS.

A central use case is Customize Design, which captures the system's ability to let a user select a wrist size and beads to build a personalized bracelet. Extending from this is Generate AI Design Recommendation, which uses the vision-language model to suggest suitable bead combinations based on user preferences, and AR Try-On, which lets the user preview the finished design on their own wrist before ordering.

B. Design Phase

The design phase transformed the requirements defined during analysis into an architectural framework supporting efficient data processing, scalability, and user accessibility. The framework follows a three-layer architecture, illustrated in Fig. 2.

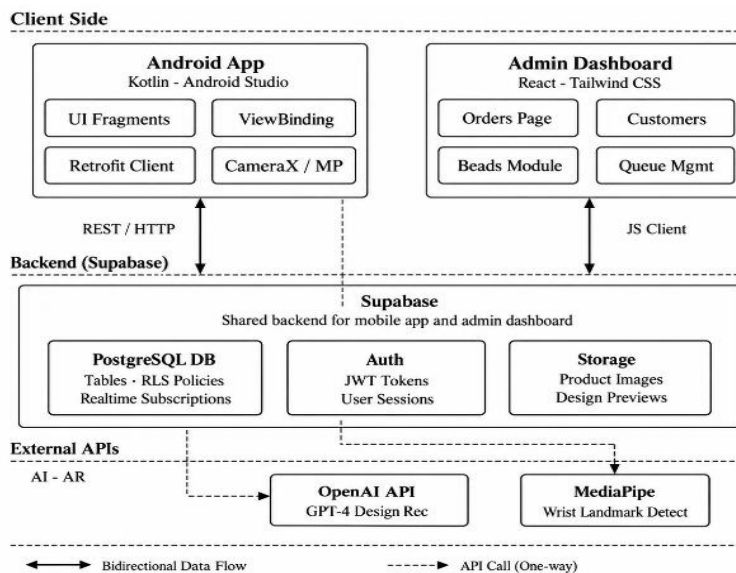


Fig. 2. System architecture of ADRS.

The Presentation Layer consists of the Android mobile application (Kotlin, ViewBinding) for customers and a React/Tailwind CSS web admin dashboard for administrators. The Application Layer handles business logic and external integrations: the Android app communicates with Supabase through Retrofit, CameraX and MediaPipe provide real-time wrist-landmark detection for AR try-on, and the OpenAI API generates bracelet design recommendations from user preferences and visual input. Firebase Cloud Messaging delivers push notifications for order and queue updates. The Data Layer is managed entirely by Supabase, providing a PostgreSQL database for structured data, a custom application-level authentication mechanism, and object storage for product images and design previews.

C. Development Phase

The implementation phase marked the transition from design to a functional system. Development began with setting up the software environment using Android Studio and Kotlin for the mobile application, and React JS with Visual Studio Code for the admin dashboard, with Supabase and PostgreSQL configured as the backend. Each module was implemented iteratively, following Agile principles. Account registration and authentication modules were developed first, followed by product browsing and shopping cart modules. The custom bracelet design module including bead selection, AI-based recommendation, and AR try-on was then developed and integrated, followed by order management, queue tracking, and the admin dashboard's product, order, and customer management modules. Version control was maintained throughout using GitHub, with a systematic commit and review process ensuring stable integration of new features.

D. Testing Phase

The testing phase validated the functionality, performance, and usability of ADRS through unit testing, integration testing, and User Acceptance Testing (UAT), following the evaluation approach used in comparable AR and TAM-based mobile usability studies (Xi et al., 2024; Hocaoglu et al., 2025). UAT was conducted with 33 respondents who interacted with the ADRS prototype and completed a structured questionnaire using a five-point Likert scale (Strongly Disagree to Strongly Agree). The questionnaire was organised into four evaluation areas: System Usability (four statements), Accessory Customisation and AI Recommendation (five statements), AR Visualisation and Virtual Try-On (four statements), and Overall Satisfaction and Intention to Use (four statements). Demographic information, including gender, ethnicity, age group, education level, and frequency of purchasing handmade or customised accessories, was also collected, together with open-ended feedback on the customisation, AI recommendation, and AR try-on features. Data collection is continuing beyond the 33 respondents reported here to reach a broader sample ahead of final submission.

RESULT

This section presents the outcomes of the tool implementation and usability evaluation to date, highlighting the actual user interfaces and functionalities of ADRS as well as the results of the User Acceptance Testing described in Section IV.

A. User Acceptance Testing Results

Out of the 33 UAT respondents, 22 (66.7%) were male and 11 (33.3%) were female; 29 respondents (87.9%) were aged between 18 and 24 years, the largest age group; and 17 respondents (51.5%) held a Degree-level qualification, the largest education group. Regarding purchasing behaviour, 17 respondents (51.5%) reported purchasing handmade or customised accessories sometimes, indicating that most participants had prior experience with the product category being evaluated.

Table II summarises the mean scores obtained for each of the four evaluation areas. All four areas achieved mean scores above 4.00 out of 5, indicating consistently positive perceptions across usability, customisation and recommendation, AR visualisation, and overall satisfaction. The AR Visualisation and Virtual Try-On area recorded the highest scores overall, with the ability to preview an accessory before purchasing rated most highly (mean 4.64), consistent with prior findings that AR visualisation particularly strengthens purchasing confidence for customised products (Guo & Zhang, 2024; Cvetković et al., 2026).

Table II. Summary of UAT Results (n = 33)

Evaluation Area	Mean Score (Out of 5)	Highest-Scoring Statement
System Usability	4.48	Overall ease of use of the application
Accessory Customisation & AI Recommendation	4.55	AI recommendations help users choose an accessory design
AR Visualisation & Virtual Try-On	4.64	Ability to preview an accessory before purchasing
Overall Satisfaction & Intention to Use	4.61	Satisfaction with the overall performance of the application

Within System Usability, the overall ease of use of the application achieved the highest mean score (4.48), suggesting that participants generally found ADRS easy to navigate and operate. Within Accessory Customisation and AI Recommendation, the statement that AI recommendations help users choose an accessory design achieved the highest mean score (4.55), supporting the value of the vision-language-model-based recommendation approach adopted in this study. Open-ended responses indicated that participants responded positively to the main interactive features of ADRS, while also identifying areas for improvement, particularly AR responsiveness, customisation flexibility, AI recommendation accuracy, accessory variety, and payment options.

B. Core Application Dashboard

Upon successful authentication, administrators are directed to the Admin Dashboard (Fig. 5), which displays total customers, orders, pending orders, and revenue, alongside charts summarizing business performance. Customers are directed to the mobile Home screen, featuring a search bar, personalized welcome message, and quick access to Favourites and saved designs.

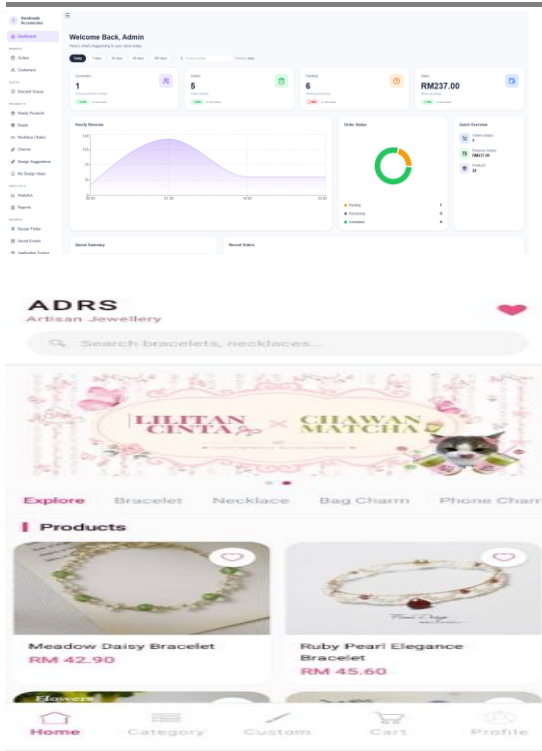


Fig. 5. Admin Dashboard and mobile Home screen.

C. Product Browsing and Shopping

Customers can browse products by category (Fig. 6), view product details, and manage their shopping cart before checkout. The admin dashboard's Products and Beads interfaces (Fig. 7) administrators manage inventory, including stock levels, pricing, and product status.

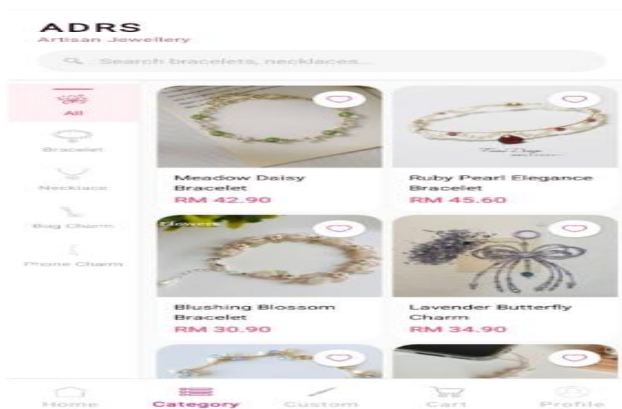


Fig. 6. Category page and shopping cart interface.

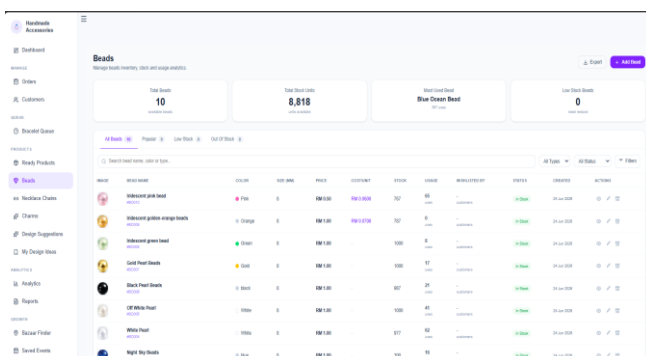


Fig. 7. Products and Beads interfaces of the admin dashboard.

D. Custom Design and AR Try-On

The central functionality of the system is custom bracelet design. Users select a wrist size (Fig. 8) and choose beads through the Custom Dashboard, after which the system can generate an AI-based design recommendation. Once a design is finalized, users preview it through the AR Try-On feature (Fig. 9), which uses CameraX and MediaPipe to overlay the bracelet design onto a live camera feed of the user's wrist.

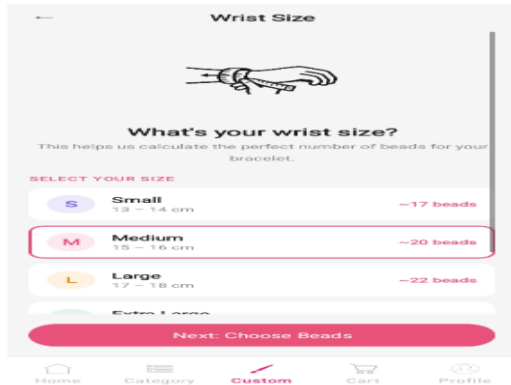


Fig. 8. Wrist size selection and Custom Design dashboard.



Fig. 9. AR Try-On interface.

E. Order and Queue Management

Administrators manage customer orders and the bracelet production queue through dedicated interfaces (Fig. 10), tracking each order's status from Waiting through In Progress, Ready, and Collected. Customers receive push notifications via Firebase Cloud Messaging as their order's status changes, and can view current queue position from the mobile app.

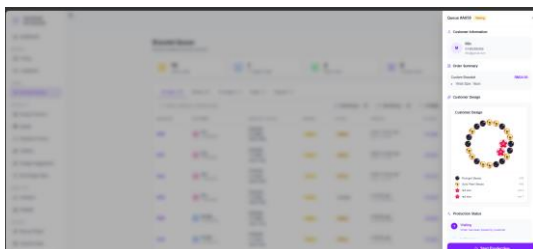


Fig. 10. Orders and Bracelet Queue interfaces of the admin dashboard

CONCLUSION

The development of the Accessory Design Recommender System (ADRS) has achieved its primary goal of creating an intelligent mobile solution that assists customers in customizing handmade accessories, receiving AI-driven design recommendations, and visualizing designs through Augmented Reality before purchase. The system integrates mobile app technology, a vision-language-model-based recommendation mechanism, and AR try-on to analyse user preferences and generate personalized bracelet designs.

Throughout the project, each development phase from analysis to implementation was systematically executed. The analysis phase defined clear user requirements focused on customization, recommendation, and visualization. The design and implementation phases translated these requirements into a modular, three-layer architecture integrating Kotlin, Supabase, CameraX, MediaPipe, and the OpenAI API. Core modules, including authentication, product browsing, custom design, AR try-on, and order/queue management, have been implemented on both the Android application and the admin dashboard, as demonstrated by the interface screenshots presented in Section V.

The system contributes to the broader field of AI-assisted mobile commerce by combining accessory customization, intelligent recommendation, and AR visualization within a single platform, targeting a segment handmade, made-to-order accessories that existing AR and recommendation research has largely overlooked. Its design is intended to be accessible to users with varying technical literacy and extensible to additional accessory types and larger product catalogues.

In conclusion, ADRS is positioned as a reliable, efficient, and user-friendly platform that supports personalized accessory customization for small handmade accessory businesses. Completion of the ongoing functional and user-acceptance testing will provide the quantitative validation needed to confirm the system's readiness for real-world deployment.

Future Works

For future development, the system will be extended in four main directions. First, customization support will be extended beyond bracelets to additional product types such as multi-layer necklaces, broadening the recommendation and AR try-on pipeline accordingly.

Second, the recommendation mechanism will be refined toward a more explainable, deterministic scoring approach rather than relying solely on generative model output, improving the transparency and consistency of design suggestions presented to customers. A feedback loop capturing customer responses to recommended designs will also be explored to improve recommendation relevance over time.

Third, additional AR-based features will be explored beyond single-accessory try-on, such as combined try-on of multiple accessory types (for example, a bracelet paired with a matching necklace or charm) within a single AR view, and AR-assisted size or fit comparison against a customer's saved wrist measurement, further strengthening the role of AR in supporting purchase decisions.

Fourth, the underlying wrist and hand landmark detection model will be trained on a larger and more varied dataset to improve AR try-on accuracy and stability across different skin tones, lighting conditions, and hand poses. Expanding the admin dashboard's analytics capabilities and broadening AR device compatibility will also support the system's scalability as the business grows.

ACKNOWLEDGEMENT

The authors would like to express gratitude to Fakulti Teknologi Maklumat dan Komunikasi (FTMK), Universiti Teknikal Malaysia Melaka (UTeM) for their invaluable support and resources provided throughout this research

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