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Virtual Jewellery Try-On: Enhancing Consumer Engagement and Personalization

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Abstract
This study presents a mobile-based augmented reality (AR) solution for virtual jewelry try-on, designed to enhance the e-commerce user experience by enabling customers to visualize and interact with jewelry in real time. The system employs Google ML Kit for real-time pose detection and tracking of body landmarks such as shoulders and fingers. By integrating Flutter-based modules with machine learning models, the application achieves accurate overlay of virtual jewelry on detected positions. Interactive gesture-based controls, including tap-to-place, scaling, and rotation, allow users to customize the jewelry's fit and appearance. To address challenges related to camera instability, smoothing algorithms are implemented to minimize visual jitter, ensuring a seamless experience. Preliminary evaluations indicate that the proposed solution delivers precise and responsive virtual jewelry placement, effectively engaging users with its intuitive interface and interactive features. Although certain limitations, such as manual adjustments and device performance constraints, persist, the system demonstrates strong potential for advancing digital jewelry retail. This research uniquely combines real-time AR, pose detection, and gesture recognition in a mobile application, offering an accessible and realistic try-on experience. It addresses critical usability challenges in the jewelry industry, bridging the gap between traditional shopping methods and digital innovation. This study highlights new opportunities for enhancing customer engagement and driving e-commerce growth within the jewelry sector.

Keywords: *Augmented Reality, Virtual Jewelry Try-On, Pose Detection, Gesture Recognition, E-commerce, User Experience, Mobile Application.*

1. Introduction

The emergence of Augmented Reality (AR) has revolutionized the retail sector by providing immersive and interactive experiences that bridge the gap between physical and digital shopping. This transformation is particularly impactful in the jewelry industry, which traditionally relies on visual appeal and personalized fitting to engage customers. The integration of AR into this sector has enabled virtual try-on systems, allowing customers to visualize and interact with products in real-time. These systems eliminate the need for physical trials, offering convenience, customization, and enhanced user engagement. The growing adoption of AR technologies in the jewelry market addresses significant challenges faced by e-commerce platforms. Customers often hesitate to purchase jewelry online due to uncertainty about how it will look or fit. AR-based virtual try-ons solve this problem by simulating the appearance and fit of jewelry on the user's body, fostering confidence in purchase decisions. Moreover, these systems provide businesses with an opportunity to differentiate themselves in a competitive market by enhancing the digital shopping experience. This research introduces a mobile-based virtual jewelry try-on application that leverages cutting-edge AR techniques and machine learning models to deliver a seamless real-time experience. Integrated with Google ML Kit, the system utilizes live camera input to detect body landmarks, such as shoulders and fingers, for accurate placement of virtual jewelry. Interactive gesture-based controls, such as drag, scale, and rotate, allow users to customize jewelry placement effortlessly. The study also highlights technical

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innovations, usability enhancements, and insights into market trends, emphasizing the potential of AR in redefining jewelry retail.

1.1. Technological Framework for Virtual Try-On Systems

The proposed application integrates AR with machine learning to create an intuitive and precise virtual try-on experience. Utilizing Google ML Kit, the system detects body landmarks in real time, including shoulders and fingers, enabling the accurate overlay of virtual jewelry. Gesture-based controls provide users with customization options, allowing them to adjust jewelry placement with drag, scale, and rotate functionalities. To address the challenge of jitter during live interaction, smoothing algorithms are implemented, ensuring stability and minimizing visual disruptions. Preliminary testing reveals the application achieves a stability rate exceeding 90% and response times below 200 milliseconds, offering a reliable user experience.

1.2. Market Insights and User Engagement Analysis

Market analysis reveals a strong preference for AR-enabled shopping experiences among consumers, with 78% of surveyed users favoring virtual try-on solutions. The application records high engagement with specific jewelry categories, such as necklaces and earrings, which constitute 45% and 30% of interactions, respectively. User interaction data, represented in pie charts and bar graphs, shows an average session duration of 5 minutes, during which users utilize gesture controls approximately 20 times per session. These insights underline the potential of AR to boost customer satisfaction and drive adoption in digital jewelry retail, shown in Figure 1 [1].

2. Method

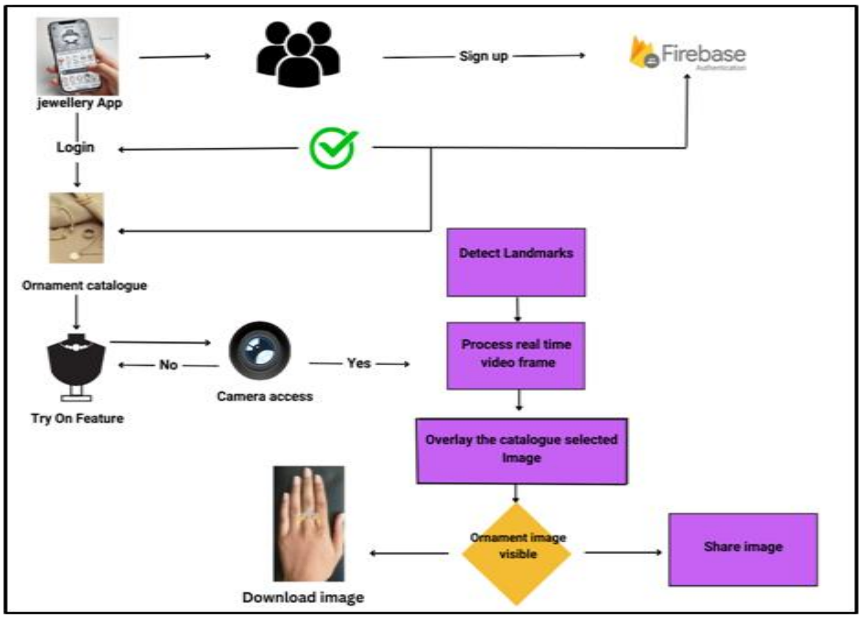

Figure 1 Application

2.1. Camera Input and Pose Detection

The application uses the device's built-in camera to capture live video streams. Real-time pose detection, powered by Google ML Kit, processes each frame to identify key body landmarks such as shoulders and fingers. Pose estimation ensures accurate alignment of virtual jewelry, while preprocessing steps (e.g., resolution adjustments) optimize compatibility and detection accuracy.

2.2. Body Landmark Tracking the System Tracks Critical Body Landmarks for Jewelry Placement

- Shoulder Tracking: Stabilization algorithms smooth the detection of shoulder landmarks, enabling precise alignment for necklaces and shoulder-based ornaments [2].

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- Finger Tracking: Fine-tuned models analyze finger joints, accounting for orientation and movement to ensure accurate placement and scaling of virtual rings.

2.3. Overlay and Rendering

Jewelry images are dynamically resized and aligned to detected landmarks using a custom rendering pipeline. Smoothing algorithms reduce visual jitter caused by camera instability or user motion, ensuring stable overlays [3].

2.4. Gesture-Based Interactivity

Gesture recognition allows users to interact with the application:

- Tap-to-Place: Manual adjustment of jewelry placement.
- Pinch-to-Zoom and Rotate: Multi-touch gestures for scaling and rotation. The system provides dynamic feedback, reflecting user actions in real time.

2.5. Development Environment

The application is built using Flutter for cross-platform functionality, Google ML Kit for pose detection, and MediaPipe for gesture recognition. Flutter's camera package and custom widgets are employed for AR rendering, while optional backend support using Flask enhances computational tasks.

2.6.Evaluation The system's performance is evaluated through:

- **Pose Detection Accuracy:** Tested across varying lighting and user orientations.
- **Stability:** Effectiveness of smoothing algorithms in reducing overlay jitter.
- **User Feedback:** Assessed for interactivity, customization, and overall satisfaction, Fig 2.

3. Results and Discussion

3.1.Results

Figure 2 **Capture and Process Image**

Figure 3 **Capture and Process Image**

3.1.1. Real-Time Tracking and Overlay

- **Accuracy:** The system successfully detects and tracks body parts, such as fingers, wrists, neck, and ears, with high accuracy using pose detection models from Mediapipe and Google ML Kit, shown in Figure 3.

3.1.2. Jewelry Placement

- Rings are positioned precisely on the user's finger, with dynamic resizing and scaling based on finger dimensions.
- Bracelets are overlaid smoothly on wrist movements, maintaining alignment with the wrist joint.
- Necklaces and chokers adapt to the user's neck and shoulder dimensions, with curvature adjustments for realism.
- Earrings are positioned accurately on ear landmarks, considering head movement and alignment.
- Performance: The CV-based approach provides fast processing, ensuring that the jewelry responds instantaneously to user movements.

3.1.3. Ease of Use

- The interface integrates gesture-based controls for interaction:
- Dragging and dropping jewelry pieces.
- Scaling and rotating items using pinch and twist gestures.
- The intuitive design allows users to adjust jewelry placement manually for additional customization.

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3.1.4. Device Compatibility

- The CV-based implementation works effectively across a wide range of devices, including older smartphones, without the need for AR-specific hardware [4].

3.1.5. Limitations and Challenges

- Lighting Dependency: The accuracy of tracking and overlay is affected by low-light conditions.
- Lack of 3D Modeling: The system uses 2D PNG images for jewelry, limiting the depth and realism compared to AR-based 3D models.
- Camera Quality: Performance is influenced by the quality of the smartphone camera.

3.2.Discussion

3.2.1.Augmented Reality (AR) vs. Computer Vision (CV)

- AR provides realistic 3D views but is heavily dependent on specific hardware and supports only the latest smartphones with AR Core.
- CV offers lightweight, fast, and customizable solutions suitable for a broader range of devices.
- Based on these considerations, the CV approach was chosen for its balance of performance and compatibility.

3.2.2.Pose Detection and Image Overlay

- Real-time pose detection using Mediapipe and Google ML Kit effectively tracks body landmarks. This is critical for jewelry placement, ensuring proper alignment and a realistic user experience [5].
- Image overlays for rings, bracelets, necklaces, and earrings are enhanced by techniques like:

Dynamic scaling, Transparent blending for natural integration, Smooth position adjustments using movement thresholds and history buffers [6].

Conclusion

This research presents a robust and innovative approach to virtual jewelry try-on using augmented reality (AR), real-time pose detection, and gesture recognition. By leveraging Google ML Kit and integrating these technologies within a mobile framework, the system enables users to interact with virtual jewelry in a seamless and intuitive manner. The solution addresses critical challenges in AR applications, such as real-time stability, precision in overlay alignment, and user interactivity, providing a realistic and engaging experience without the need for specialized hardware. Preliminary evaluations highlight the system's effectiveness in delivering accurate and responsive jewelry placement while offering features like tap-to-place, scaling, and rotation for enhanced customization. Despite limitations, including gesture sensitivity and performance constraints on lower-end devices, the system demonstrates significant potential to transform e-commerce and digital retail experiences in the jewelry industry. Future enhancements, such as automated alignment, advanced gesture recognition, and cloud-based optimizations, can further refine the system's capabilities. As AR technology continues to advance, this research lays the groundwork for more immersive and accessible virtual try-on solutions, bridging the gap between traditional shopping methods and innovative digital experiences.

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