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Virtual Try-On and Customization

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Abstract

The rapid growth of online jewelry shopping has introduced several challenges, including a lack of user confidence, limited personalization, and increased return rates due to the absence of a "try-before-you-buy" experience. To address these challenges, this paper reviews recent advancements in virtual jewelry try-on and recommendation systems through the development of "VirtualGems," an AI-powered web-based platform that integrates computer vision, machine learning, and intelligent recommendation techniques to enhance the online jewelry shopping experience. The system utilizes real-time facial detection and landmark analysis using MediaPipe and OpenCV to accurately overlay jewelry images onto the user's live camera feed, enabling an interactive virtual try-on experience. Additionally, the platform analyzes the user's facial structure and automatically classifies face types to generate personalized jewelry recommendations using a database-driven recommendation model. Unlike traditional systems that rely on heavy augmented reality frameworks such as ARCore or Unity, VirtualGems employs a lightweight and scalable architecture built with a Django-based backend and a React-based frontend, ensuring flexibility, performance, and ease of deployment. The system also stores user interaction data, try-on history, and customization records to improve recommendation accuracy and user engagement over time. This paper evaluates the architecture, performance, advantages, and limitations of AI-assisted virtual try-on systems like VirtualGems and highlights their potential to improve user confidence, personalization, and satisfaction in online jewelry shopping environments.

1. Introduction

The rapid expansion of online jewelry platforms has transformed the retail landscape by offering accessibility, wider product availability, and competitive pricing to modern consumers. However, unlike other online retail categories, jewelry purchasing strongly depends on visual appearance, personal suitability, and aesthetic compatibility with the user. When customers cannot visualize how a necklace or ornament looks on their own face, uncertainty increases, confidence decreases, and product return rates rise significantly. Recent advances in artificial intelligence and computer vision technologies have enabled virtual try-on systems that simulate real-world fitting experiences directly through digital interfaces. These systems utilize facial detection, landmark extraction, image scaling, and overlay algorithms to accurately position jewelry images on live or captured facial images. Traditional augmented reality solutions such as Unity and ARCore provide powerful visualization capabilities but often require heavy computational resources and complex integration pipelines, limiting scalability for lightweight web-based applications. Meanwhile, most jewelry recommendation engines rely on generic approaches such as collaborative filtering or popularity-based rankings, which fail to consider individual physical attributes and real-time visual compatibility. Important personal characteristics, including face shape, proportions, and aesthetic harmony, remain underutilized in conventional recommendation systems. Furthermore, insufficient integration of behavioral analytics, such as try-on history and interaction tracking, reduces opportunities for intelligent personalization and effective product discovery.

This review paper examines the integration of real-

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time facial landmark detection, machine learning-based facial attribute analysis, and database-driven recommendation techniques within the VirtualGems framework. VirtualGems is a lightweight, AI-powered system developed using a Python Django backend and a React frontend, enabling real-time virtual try-on functionality and personalized jewelry recommendations without depending on heavy augmented reality engines. The system combines computer vision, scalable web architecture, and intelligent data management to enhance user interaction and recommendation accuracy. This paper reviews current research findings and analyzes the architectural design, methodologies, and implementation strategies employed in VirtualGems to demonstrate how integrated AI-driven web systems can overcome limitations of traditional online jewelry platforms.

2. Literature Review

Table No. I Literature Survey

	Sr. No.	Title and Author	Topic Reviewed / Methodology	Advantages and Disadvantages	
	1	*Virtual Jewelry Experiences in the Jewelry Industry* – Şevval İmre, IEEE, 2024	AR/VR try-on using Unity, 3D hand/face modeling	**Adv:** Realistic try-on**Disadv:** Hardware dependency	
	2	*Enhancing the Virtual Jewelry Try- On Experience with Computer Vision* – Hrutika Patel et al., IEEE APSCON, 2024	Mediapipe for face/hand tracking, OpenCV, real- time overlay	**Adv:** Cost-effective, immersive**Disadv:** Sensitive to lighting	
	3	*Jewelry Try-On using AR* – Prajapat et al., IEEE, 2022	AR with OpenCV + MediaPipe for hand detection	**Adv:** Simple architecture**Disadv:** Limited to rings/bracelets	
	4	*AR Technology in Jewellery Display* – Zhang-Wu, IEEE, 2023	Unity + Zappar-based earring visualization	**Adv:** Interactive face overlay**Disadv:** Reduced performance under constraints	
	5	*Mixed Reality for Virtual Jewellery Fitting* – Cheng et al., IEEE Journal, 2023	Mixed Reality with hand/face tracking and 3D models	**Adv:** User-friendly UI**Disadv:** Incomplete palm detection	
	6	*Real-Time Hand Tracking Using Mediapipe* – Zhang et al., IEEE, 2022	Hand landmark detection for AR overlays	**Adv:** High precision tracking**Disadv:** Poor detection in low light	
	7	*Skin Tone Classification using*	CNN classifier using	**Adv:** Accurate tone	

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		CNN – Patel et al., IEEE, 2023	YCrCb/HSV color space	matching**Disadv:** Lighting affects results	
	8	*ARCore Based Real-Time Face Shape Recognition* – Reddy et al., IEEE, 2023	ML Kit-based face shape classification	**Adv:** Lightweight ML model**Disadv:** Inaccurate with occlusion	
	9	*Improving AR Commerce Using Sceneform* – Rao et al., IEEE, 2024	ARCore + Sceneform for 3D AR projection	**Adv:** Enhanced 3D visualization**Disadv:** Requires newer hardware	

3. Related Work

Recent research on virtual try-on and recommendation systems has increasingly focused on integrating computer vision and artificial intelligence to enhance e-commerce user experience. This section presents an overview of techniques related to facial landmark detection, virtual jewelry try-on, appearance-based analysis, recommendation methods, and intelligent design approaches for VirtualGems. Facial landmark detection is essential for accurate virtual try-on implementation. Lugaresi et al. [1] introduced MediaPipe, a lightweight framework capable of real-time facial landmark extraction with high efficiency. Similarly, King [2] developed the Dlib toolkit for reliable facial feature detection and analysis. To improve performance and reduce computational overhead, several virtual try-on systems focus on lightweight real-time processing. Lee et al. [3] proposed an efficient on-device try-on approach minimizing external processing requirements. Kim et al. [4] optimized rendering techniques for improved responsiveness and efficiency in constrained environments. These studies demonstrate accurate real-time overlay capabilities but primarily emphasize visualization accuracy rather than integrating personalized recommendation features based on facial attributes and behavioral interaction data within scalable web platforms today.

Appearance-based analysis techniques have also contributed significantly to personalized visualization systems. Wang et al. [5] introduced machine learning methods for estimating face shape using facial landmark geometry. Zhou et al. [6] demonstrated efficient visual attribute classification using computationally simple transformation and clustering techniques. However, these approaches are often applied independently and lack integration with web-based jewelry platforms that require scalable recommendation mechanisms and user interaction tracking for personalized experience improvement and adaptive intelligent recommendation delivery systems. Recommendation systems remain crucial for delivering personalized user experiences in commerce environments. Many traditional approaches rely on behavioral patterns or popularity-based ranking without considering visual compatibility and facial characteristics[7].

Overall, existing virtual try-on and recommendation systems often operate as separate components and rely on complex architectures or resource-intensive augmented reality frameworks. VirtualGems addresses these limitations by integrating MediaPipe-based facial detection, OpenCV overlay, and database-driven recommendation within a scalable Django and React web architecture enabling real-time visualization and intelligent personalized recommendation capabilities.

Proposed Work This section analyzes the conceptual design of VirtualGems, an AI-powered virtual jewelry try-on and recommendation system developed to address limitations associated with conventional online jewelry platforms. The system integrates computer vision, real-time image

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processing, and database-driven recommendation techniques within a unified and scalable web-based architecture.

The VirtualGems platform follows a client-server architecture with modular components that separate user interaction, facial analysis, recommendation processing, and data management to ensure scalability, maintainability, and low latency. The system enables users to visualize jewelry realistically through live camera-based virtual try-on and receive personalized recommendations based on facial attributes and interaction history. This modular approach allows efficient handling of real-time processing and intelligent decision-making while maintaining performance across web environments. Shown in Figure 1 illustrates the overall workflow of VirtualGems. Initially, the user accesses the platform and selects a jewelry product. The system then activates the camera, detects facial landmarks using MediaPipe, and overlays the selected jewelry using OpenCV. Simultaneously, the recommendation engine analyzes stored facial profile and interaction data to suggest suitable jewelry items, enabling personalized visualization and enhanced user experience.

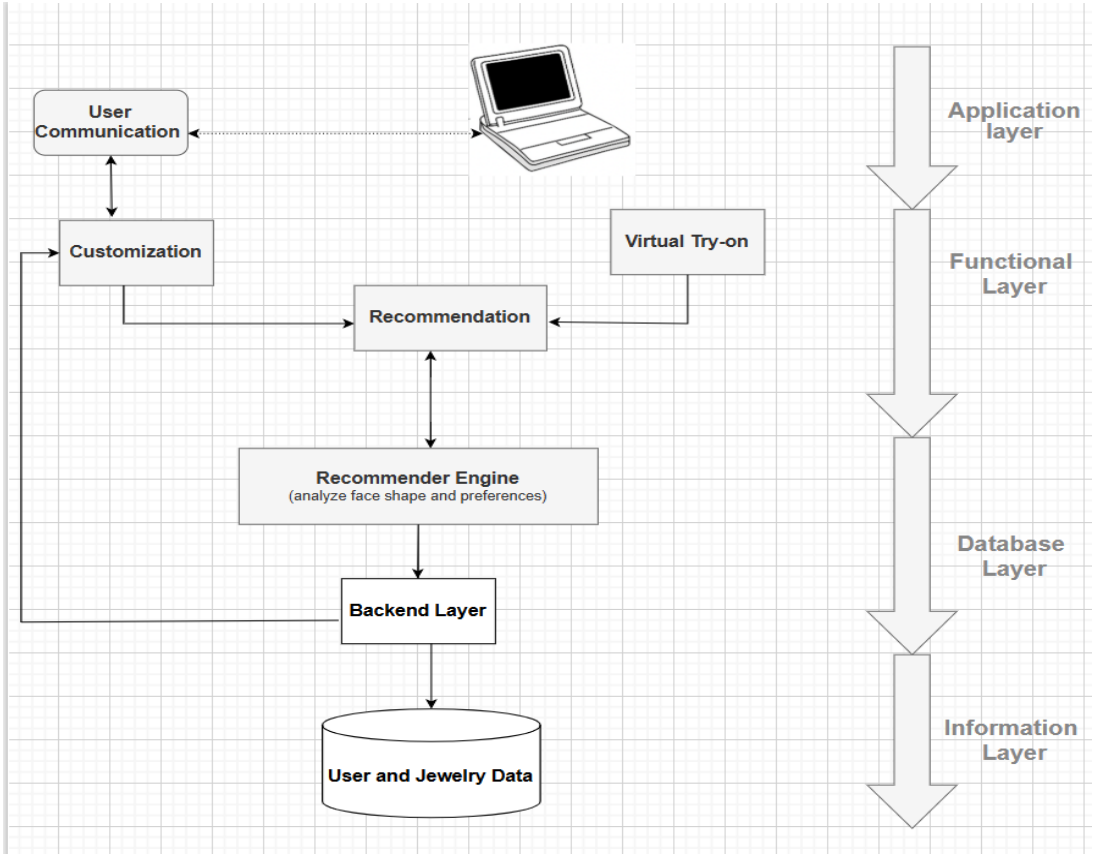

Figure 1 shows the VirtualGems system's overall workflow.

As illustrated in Fig. 1, the personalization module is centered around facial analysis as the primary component. The real-time detection of facial landmarks, including the jawline, chin, cheeks, and neck region, enables accurate geometric feature extraction required for determining the user's face shape. The virtual try-on stage allows users to visualize how different jewelry items appear on their

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live camera feed. The selected necklace images are accurately aligned and overlaid onto the detected neck and facial landmark positions to achieve a realistic visualization effect. The overlay dynamically adjusts according to the user's movements, ensuring proper positioning and scaling. Unlike systems that depend on complex 3D rendering engines, VirtualGems uses lightweight 2D image overlay and real-time facial landmark tracking to ensure faster performance and lower system requirements. The backend system manages facial analysis, recommendation logic, and database interactions using an API-driven architecture. Facial landmark data is processed to determine face shape, and based on this classification, suitable jewelry products are retrieved from the database using predefined recommendation mappings. The backend also manages user data, try-on sessions, customization history, and recommendation records. The frontend serves as the user interaction interface, enabling users to browse products, activate try-on functionality, view personalized recommendations, and explore customization options. The modular system design ensures scalability and allows independent updates to the frontend, backend, and AI modules without affecting overall system performance. Overall, the VirtualGems system integrates multiple functional stages, including user authentication, facial landmark detection, face shape analysis, personalized recommendation generation, real-time virtual try-on visualization, and customization tracking. By combining these components into a unified architecture, the system provides an efficient, responsive, and personalized virtual jewelry experience while minimizing latency and computational overhead.

4. Results and Discussion

The evaluated system, VirtualGems, proves to be an effective solution with promising outcomes in improving personalization and visual interaction for online jewelry platforms. The reliability of real-time facial landmark detection using MediaPipe has been observed to provide accurate necklace positioning on live camera images. The performance of face shape classification models for identifying user facial structure has been satisfactory and consistent.

The integration of facial feature analysis with database-driven recommendation mapping helps to improve the relevance of suggestions by linking detected face types with suitable jewellery products stored in the system database. The lightweight system architecture also enables low-latency processing and efficient try-on execution on standard consumer devices without requiring heavy AR engines in practical real-world usage.

5. Discussion

The results demonstrate the effectiveness of integrating Computer Vision and database-driven recommendation concepts within a single virtual try-on and recommendation system. One major advantage of the VirtualGems system is its lightweight architecture, which enables real-time facial detection and overlay processing without requiring expensive 3D rendering engines or heavy AR frameworks. However, certain limitations still exist in this implementation. The facial landmark detection and face shape classification accuracy can be affected by lighting conditions, camera quality, and user positioning. Additionally, the current two-dimensional jewelry overlay may produce less realistic visualization compared to full three-dimensional rendering approaches. The recommendation system, which relies on predefined face type mappings, may initially provide limited personalization without sufficient user interaction history. Despite these limitations, VirtualGems represents a significant step toward efficient, scalable, and personalized virtual jewelry try-on systems for modern e-commerce platforms.

Conclusion

The VirtualGems system demonstrates how integrating real-time computer vision, facial attribute analysis, and database-driven recommendation mechanisms can address key limitations in online jewelry retail. This approach is highly significant for advancing e-commerce by enabling interactive, personalized, and reliable virtual try-on experiences. Through the structured integration of facial detection,

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try-on visualization, and recommendation mapping, VirtualGems enhances user confidence and decision-making. This unified system contributes to improved user engagement, better personalization accuracy, and overall customer satisfaction while maintaining a scalable and efficient architecture suitable for modern web-based jewelry platforms. .

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