iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 14 Issue: IV Month of publication: April 2026

DOI: https://doi.org/10.22214/ijraset.2026.79947

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 14 Issue IV Apr 2026- Available at www.ijraset.com

AI-Powered Virtual Garment Trial Room

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Abstract: The AI-Powered Virtual Garment Trial Room is an innovative solution designed to enhance the online shopping experience by enabling users to virtually try on apparel and accessories. The project addresses a major limitation of e-commerce: the inability to physically try products before purchase. Using augmented reality (AR) technology and advanced image processing, the system captures the user's image via a webcam and superimposes selected garments and accessories onto their body in real-time.

The system leverages Haar cascade datasets for body and face detection and convolutional neural networks (CNNs) for accurate alignment of apparel. The Flask framework integrates the back-end Python scripts with an interactive HTML front-end, allowing seamless user interaction. Users can register, shop, and virtually try on items, while administrators can manage the product catalog through an intuitive interface.

This cost-effective solution eliminates the need for expensive hardware, relying instead on efficient software tools like OpenCV and Dlib. Future enhancements include the integration of advanced networks, such as Pose Alignment Network (PAN) and Texture Refinement Network (TRN), to improve accuracy and realism. By bridging the gap between physical trials and online shopping, this project promises to revolutionize the e-commerce industry and enhance customer satisfaction.

I. INTRODUCTION

A. Motivation

The AI-Powered Virtual Garment Trial Room is inspired by the challenges of online apparel shopping, where customers cannot physically try on garments before purchase, leading to dissatisfaction, returns, and cancellations. This project aims to address these issues by leveraging augmented reality and image processing techniques to provide a virtual trial experience. Initially conceptualized from a problem statement in the Smart Gujarat Hackathon, the project seeks to offer an affordable and accessible alternative to expensive hardware-based solutions, such as Kinect motion sensors.

B. Problem Statement

The inability to try on apparel before purchase is a significant limitation of e-commerce platforms, leading to customer dissatisfaction, high return rates, and order cancellations. Traditional solutions, like Kinect motion sensors, are expensive and inaccessible for most users. This project aims to develop a cost-effective, AI-powered virtual garment trial room using augmented reality and image processing techniques, enhancing the online shopping experience and bridging the gap between physical and digital retail.

C. Objectives

The main objective of this project is to provide an augmented reality-based solution for trying apparel and accessories online without the need for physical trials. This system reduces return rates and boosts customer satisfaction in e-commerce by offering accurate, real-time garment overlay on a user's live image or webcam feed.

D. Scope

The system's primary scope encompasses:

- E-commerce Integration: Seamlessly integrates with online platforms to provide users with a virtual dressing room, reducing return rates and cancellations.
- Customer Experience: Offers an interactive and personalized shopping journey, building confidence through real-time virtual try-ons.
- Cost-Effective Solution: Eliminates the need for expensive hardware using image processing algorithms that run efficiently on standard devices.

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- Technology Applications: Leverages Haar cascades, CNNs, and augmented reality for accurate body detection and realistic garment overlay.
- Future Expansion: Adaptable for cosmetics, eyewear, and furniture visualization; potential for VR integration for immersive shopping experiences.

E. Project Introduction

The AI-Powered Virtual Garment Trial Room is an innovative AR-based system providing users with a virtual dressing room. By using advanced body and face detection techniques, the system captures the user's image through a webcam and superimposes selected products, offering an interactive and personalized experience. The project uses Haar cascade datasets for body part detection and CNNs for accurate positioning and alignment of virtual apparel.

From a technical perspective, the project incorporates a Flask web framework to connect the Python-based back-end with an intuitive HTML front-end. Libraries like OpenCV, Dlib, and NumPy handle image processing tasks. The system includes modules for both administrators and users, enabling admins to manage product catalogs and users to register, shop, and virtually try on items.

II. LITERATURE SURVEY

A. Virtual Try-On Systems

Several research studies have explored virtual try-on systems. M2E-Try-On Net introduced a model for realistic virtual try-ons, overlaying garments on user images. VITON (Virtual Try-On Network) focused on generating photo-realistic apparel overlays using deep learning techniques, which served as a foundation for more accurate and interactive solutions.

B. Body Detection and Pose Estimation

Haar cascades, a popular technique in image processing, have been widely used for object and face detection due to their computational efficiency. More advanced methods, such as Pose Alignment Networks (PAN), have demonstrated improved accuracy in detecting complex human poses, ensuring better garment alignment.

C. Image-Based Augmented Reality

AR has gained traction in virtual try-on applications. AR solutions rely on image processing algorithms and deep neural networks to overlay virtual objects on live or captured images. Studies show that AR-based try-ons significantly enhance user engagement and decision-making in e-commerce platforms.

D. Challenges and Future Directions

Existing solutions often require expensive hardware, such as Kinect sensors, or fail to provide real-time accuracy. Emerging trends involve integrating advanced neural networks like Texture Refinement Networks (TRN) and Fitting Networks (FTN) to enhance realism. Studies emphasize the potential of combining AR and VR for immersive shopping experiences.

III. SYSTEM ANALYSIS

A. Existing System

The existing virtual try-on systems primarily rely on hardware-intensive solutions like Kinect motion sensors or high-end augmented reality setups. These methods use motion-tracking sensors and cameras to align garments with body movements.

Disadvantages:

- High Cost: Expensive hardware makes these systems inaccessible for smaller businesses and regular users.
- Time-Consuming Setup: Calibration of motion sensors is time-intensive and requires skilled personnel.
- Limited Accuracy: Garment alignment often lacks precision, especially for varied body shapes and movements.

B. Proposed System

The proposed system utilizes cost-effective software-based solutions using image processing techniques (Haar cascades) and CNNs. It replaces hardware dependency with algorithms capable of running on standard devices.

Advantages:

- Cost-Effective: Reliance on webcams and open-source libraries significantly reduces implementation costs.
- Time-Efficient: The software-based approach is faster to deploy with minimal setup, making it user-friendly and scalable.

- Improved Accuracy: Advanced body detection using Pose Alignment Networks (PAN) ensures precise garment overlay and alignment.

IV. REQUIREMENT ANALYSIS

A. Functional Requirements

Functional requirements define what the system must do:

- Authentication of users whenever they log into the system.
- System shutdown in case of a cyber-attack or security breach.
- A verification email is sent to users upon first registration.
- Real-time garment overlay on live video feed via webcam.
- Admin CRUD operations on the product catalog.

B. Non-Functional Requirements

Non-functional requirements define quality constraints:

- Portability and cross-platform compatibility (Windows 7/8/10).
- Security: Secure authentication and data protection.
- Performance: Each request processed within 10 seconds.
- Scalability: Support for increased user loads.
- Reliability: Consistent real-time performance under normal conditions.

C. Hardware Requirements

- Processor: I3/Intel Processor
- Hard Disk: 160 GB
- RAM: 8 GB

D. Software Requirements

- Operating System: Windows 7/8/10
- IDE: PyCharm
- Libraries: CMake (3.12.0), Dlib (19.15.0), OpenCV (3.4.2.17), SciPy (1.0.0), NumPy (1.18.1), Flask (3.0.3)
- Technology: Python 3.10.8

V. METHODOLOGY

A. Haar Cascade Algorithm

The Haar Cascade algorithm detects body parts (face, eyes, upper body) in video frames through the following steps:

- Feature Extraction: Sliding windows of 24x24 pixels are passed over the image; features like edges and rectangles are computed using integral images.
- AdaBoost Classifier: Relevant features are selected and aggregated into a strong classifier for better accuracy.
- Cascade Structure: Multiple stages of classifiers are applied sequentially; each stage determines whether a region should proceed to further analysis.
- Output: Bounding boxes indicating detected regions (e.g., face, upper body).

B. Dlib Facial Landmark Detection

Dlib's facial landmark detection is used to accurately position accessories:

- Face Detection: Dlib's pre-trained frontal face detector identifies the face region.
- Landmark Localization: The shape predictor extracts 68 facial landmarks corresponding to eyes, nose, mouth, and jawline.
- Mapping: Specific landmarks are mapped to accessories (e.g., goggles: landmarks 36–47; earrings: landmarks 1–5 and 12–16).

C. OpenCV Sprite Overlay

Garments and accessories are overlaid using alpha blending:

- Read Sprite: The garment/accessory image is loaded with an alpha channel (cv2.imread() with -1).

- Resize Sprite: Dimensions are adjusted to match the detected body part while maintaining aspect ratio.
- Overlay Logic: Alpha blending combines the sprite with the video frame using the formula: Output Pixel = (α × Sprite Pixel) + ($1 - \alpha$) × Frame Pixel.

D. *Future: Pose Alignment Network (PAN)*

PAN will enhance garment alignment by identifying keypoints such as shoulders, hips, and elbows, dynamically adjusting the garment's angle and scale to fit the detected pose.

E. *Future: Texture Refinement Network (TRN)*

TRN will improve visual quality by segmenting the garment area and mapping the garment's texture onto the segmented region with smooth edges and realistic texture scaling.

VI. SYSTEM DESIGN

A. *Input Design*

During input design, the system focuses on capturing accurate user data through webcam feeds and product catalog inputs. Well-designed input screens ensure proper data capture with accuracy, simplicity, and validation controls to minimize errors.

B. *Output Design*

Output design focuses on delivering real-time video frames with garment overlays. The system renders updated frames to the user continuously, ensuring smooth, lag-free visualization aligned with the user's body movements.

C. *UML Diagrams*

The system design is documented through the following UML diagrams: Use Case Diagram (system functionality and actor roles), Class Diagram (system classes, attributes, and relationships), Sequence Diagram (interaction order between processes), Collaboration Diagram (object organization and method call sequences), Deployment Diagram (physical hardware deployment), Activity Diagram (step-by-step workflow of system activities), and Component Diagram (modular system components and their interactions).

D. *Data Flow Diagram*

The DFD illustrates data movement across the system: from user registration and login, through product selection and AR overlay processing, to cart management and checkout. Admin operations flow through a separate secure channel for catalog management.

VII. IMPLEMENTATION AND MODULES

A. *Admin Module*

Purpose: Manages the product catalog for the virtual trial room.
The admin module provides secure login, and CRUD operations — adding products with category, name, cost, and image; updating existing entries; and deleting outdated products. All changes are reflected instantly in the user interface.

B. *User Module*

Purpose: Enables users to interact with the system for virtual trials and purchases.
Users can register and securely log in, browse categorized products, add items to cart, and initiate virtual try-ons. The AR overlay is activated upon product selection, superimposing the garment onto the live webcam feed.

C. *AR Module*

Purpose: Handles live video feed and overlays garments/accessories on detected body regions.
The AR module captures webcam frames, applies Haar cascade and Dlib detection, then dynamically resizes and positions selected garments or accessories over the detected regions using alpha blending for a seamless overlay.

D. *Video Processing Module*

Purpose: Processes video frames for detecting and superimposing garments/accessories.

This module captures live video using OpenCV, reads and processes each frame, applies detection algorithms, and continuously updates the overlay for each new frame, rendering the result back to the user in real-time.

VIII. CONCLUSION

The AI-Powered Virtual Garment Trial Room presents a cost-effective and practical solution to the limitations of online apparel shopping. By integrating augmented reality, Haar cascade detection, Dlib facial landmark mapping, and OpenCV sprite overlay within a Flask-based web application, the system enables real-time virtual try-ons using only a standard webcam.

This project demonstrates that advanced virtual try-on functionality can be achieved without expensive hardware. The system's modular design allows for straightforward future enhancements, including Pose Alignment Network (PAN), Texture Refinement Network (TRN), and Gated Recurrent Units (GRU) for temporal frame stability. The proposed system is poised to significantly reduce return rates, increase customer confidence, and bridge the gap between physical and digital retail experiences.

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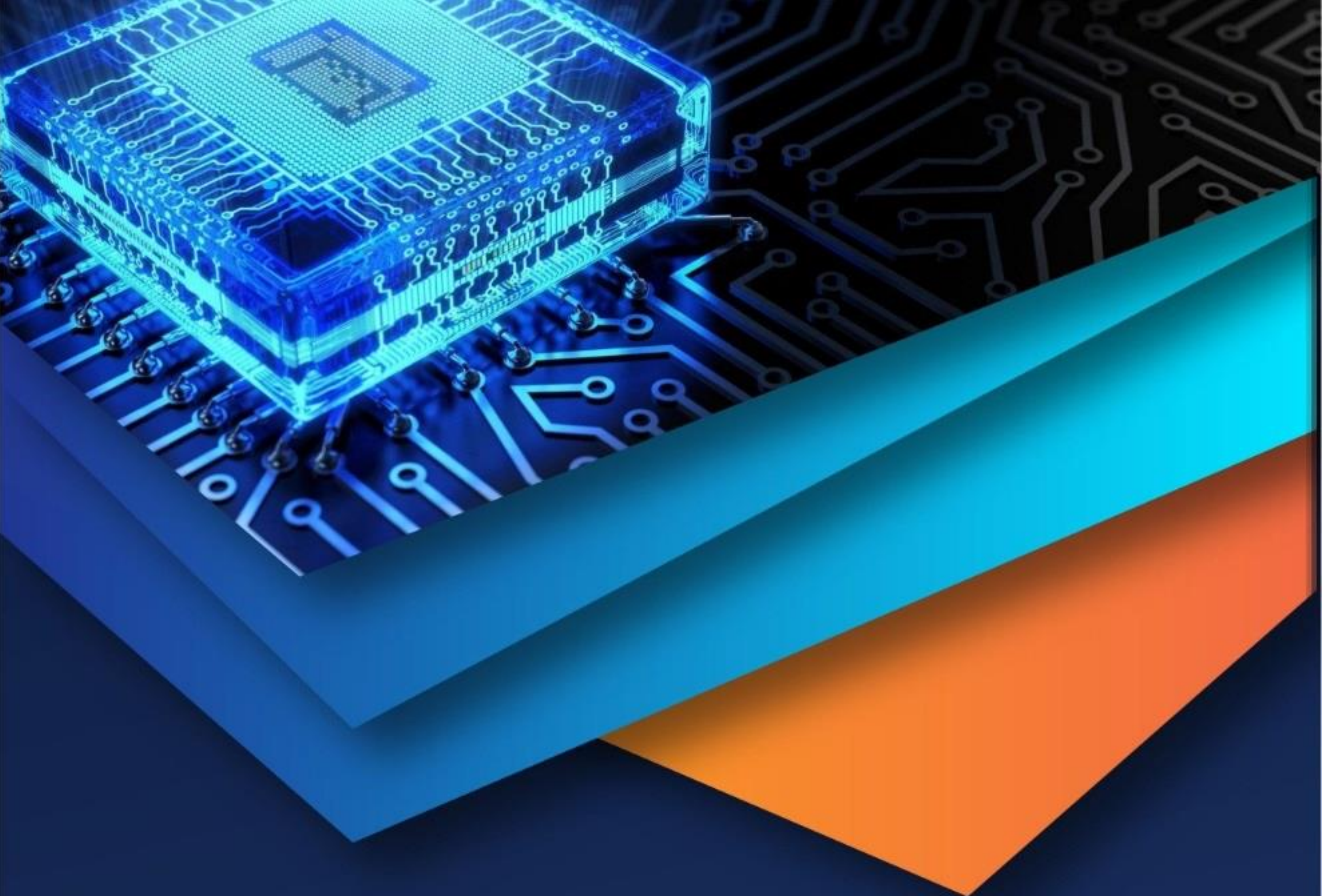

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