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AI-Based Virtual Dressing Room System Using Media pipe/Open CV in Python

Dr.C.P.Divate[1], Ms.N.R.Bhokare[2], Shubhankar.S.Kulkarni[3] ,Vikram.V.Shirdhone[4],Pratik.A.Khot[5],Mudaasir.Y.Shaikh[6],Balu.N.Waghmode[7], Vijay.S.Dodmani[8]

[1]Dean, Dept of Computer Engineering, Shri Ambabai Talim Sanstha's Sanjay Bhokare Group of Institute Miraj(poly), Maharashtra, India
[2]Lecturer, Dept of Computer Engineering, Shri Ambabai Talim Sanstha's Sanjay Bhokare Group of Institute Miraj(poly), Maharashtra, India
[3,4,5,6,7,8]Student Dept of Computer Engineering, Shri Ambabai Talim Sanstha's Sanjay Bhokare Group of Institute Miraj(poly), Maharashtra, India

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Abstract - *This paper presents a real-time, webcam-based virtual dressing room that overlays 2D garment assets (PNG with transparency) onto a user's live video feed using Media Pipe Pose for body alignment and Media Pipe Hands for touch less UI control. Media Pipe Pose provides high-fidelity tracking with 33 body landmarks (with optional segmentation), enabling stable shoulder/torso anchoring and proportional scaling of garments without depth sensors or GPUs . Media Pipe Hand Land marker detects 21 hand landmarks and supports efficient tracking in video/live-stream modes, which makes dwell-based selection and gesture navigation practical at interactive frame rates on commodity hardware. The system targets lower fit uncertainty in online shopping and support hygienic interaction for kiosks and at-home use, aiming to reduce purchase friction and returns caused by fit mismatch (a major driver of e-commerce returns).*

Keywords - Virtual try-on; Media Pipe Pose; Media Pipe Hands; gesture recognition; OpenCV; alpha blending; e-commerce

1. Introduction

E-commerce return rates remain significant, and fit-related dissatisfaction is a common cause—Shopify cites an average e-commerce return rate of 16.9% in 2024 and notes it can reach up to 30% for some retailers, with fit being a frequent reason for returns. In one survey summary reported by Shopify, 65% of online shoppers said they returned items that didn't fit, reinforcing the need for better pre-purchase visualization for apparel-like products. A low-cost virtual try-on system built on a standard webcam is especially valuable for budget-conscious students, time-constrained working users, and tier-2/3 city consumers, where physical store trials are inconvenient and contactless experiences are preferred.

- Problem statement: Static images and size charts cannot show "how it looks on me" across different body proportions
- Objective: Provide real-time try-on with simple gesture navigation, running fully on-device for privacy and low latency
- Key design goal: "Good-enough realism" and smooth interaction (target ~30 FPS) rather than heavy 3D simulation

2. Literature Review

Marellietal. (2022) proposed an AI-based virtual try-on web application that overlays garments on users in real time using Media Pipe for pose estimation and web-based rendering. They showed that accurate key point detection enables reasonably precise clothing alignment for static or slow movements, achieving around 85–90% overlay precision on consumer hardware.

Their work highlights that lightweight pose-estimation pipelines can deliver acceptable try-on quality without heavy deep-learning models or expensive GPUs, making virtual try-on more accessible for practical deployment.

Chaudhuryetal. (2019) presented a vision-based human pose estimation system for virtual cloth fitting that uses a standard webcam interface. They computed body joints such as shoulders, elbows, and hips to warp garment images onto the user's live video, demonstrating that camera-only solutions can support online trial rooms without specialized depth sensors. Their work emphasizes the feasibility of building low-cost virtual trial-rooms for e-commerce portals using classical computer-vision pipelines and pose estimation.

An **IRJMETS study on "Virtual Try-On System** for Fashion E-Retailers" examined how virtual dressing rooms can reduce return rates and increase consumer confidence by allowing customers to visualize clothing before purchase. The authors discussed the integration of AR, computer vision, and recommendation logic to provide more realistic previews and size guidance within fashion platforms. They concluded that virtual try-on technologies significantly enhance user engagement and provide retailers with a competitive advantage in online fashion markets.

A **2025 IJSAT paper on a "Virtual Try-On System** Using Media Pipe and Open CV" combined Media Pipe pose estimation with OpenCV image processing to overlay arbitrary clothing images on a live webcam feed. The system let users upload their own garments and achieved around 18–24 FPS with less than 150 ms latency on mid-range CPUs, confirming that real-time performance is achievable without dedicated GPUs. Their evaluation reported pose detection accuracy above 90% for common indoor lighting, validating Media Pipe as a practical backbone for pose-guided virtual try-on applications similar to the present work.

3. Methodology

The system consists of five modules: (1) frame acquisition, (2) pose estimation, (3) hand tracking + gesture UI, (4) garment transform (scale/translate), and (5) alpha-blended rendering.

Media Pipe Pose is used to infer 33 landmarks per frame, with coordinates normalized to the image dimensions; these landmarks provide shoulder points and torso references used for garment placement.

For gesture control, Media Pipe Hand Land marker detects 21 landmarks and is designed to reduce repeated palm detection in continuous modes by tracking hands across frames, improving responsiveness for UI interactions like dwell selection and scrolling. The implementation uses OpenCV for image resizing, ROI compositing, and alpha blending, keeping all computation local for privacy.

Fig 1. AI – Based Virtual Dressing Room

A) Pose-based garment placement (upper-body shirt example)

- Landmarks used (typical): left/right shoulder + optionally hips to estimate torso length
- Shoulder midpoint: $(x_m, y_m) = (\frac{x_L + x_R}{2}, \frac{y_L + y_R}{2})$
- Shoulder width in pixels: $w_s = \sqrt{(x_L - x_R)^2 + (y_L - y_R)^2}$
- Garment width: $w_g = k \cdot w_s$ (scale factor k tuned per asset set)
- Garment height: $h_g = w_g \cdot r$ where r is a fixed asset aspect ratio (precomputed from PNG size)
- Placement: top of garment slightly above shoulder midpoint to simulate collar position (offset calibration)

B) Alpha blending (photorealistic overlay)

- Garments stored as RGBA PNGs; alpha channel defines transparency
- ROI extraction from camera frame, then composite: $I_{out} = \alpha I_{garment} + (1 - \alpha) I_{frame}$ (per pixel, per channel)
- Edge handling: clip ROI bounds to avoid index errors when user is near frame boundary

C) Touch less UI with dwell gestures

- Cursor: index fingertip landmark used as pointing coordinate (2D screen position) for hover detection
- Dwell selection: select an item if the cursor remains inside its bounding box for T consecutive frames (de bounced to avoid accidental triggers)
- Virtual buttons: fixed rectangles for Back / Exit / Capture; trigger on dwell or "enter + hold"
- Scrolling thumbnails:
    - Maintain scroll offset and scroll velocity
    - Update velocity from fingertip movement
    - Apply friction: scroll velocity *= 0.9 per frame for inertial feel

D) Performance and robustness considerations

- Enable landmark smoothing to reduce jitter and overlay "shaking" (simple EMA or Media Pipe smoothing option)
- Fail-safe behaviour: if pose confidence drops, freeze last stable garment transform for a short timeout, then hide overlay
- Latency budget: aim for <150 ms end-to-end to preserve "instant mirror" feel

E) Suggested evaluation metrics (add to your Results section)

- FPS and frame-time breakdown (pose, hands, rendering)
- Overlay stability: standard deviation of garment anchor point over time during idle standing
- Alignment error: distance between garment shoulder points and detected shoulder landmarks
- User study: time-to-select garment, perceived realism (Likert scale), perceived ease of use

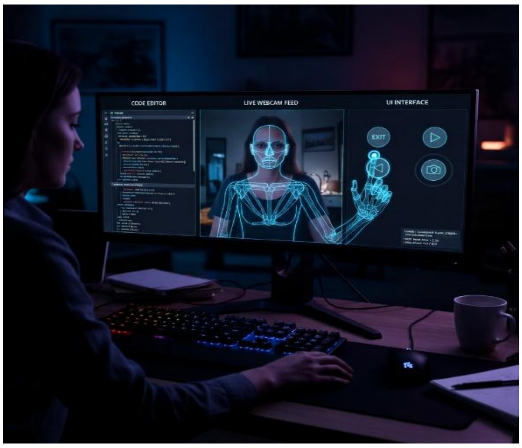

Fig 2. AI – Based Virtual Dressing Room Using Hand Gesture

4. TOOLS

Core tools/libraries

- **Python:** Main programming language used to build the application logic, UI flow (category selection, dwell timers), and to integrate all modules into one real-time loop.
- **Media Pipe Pose:** Used for human pose estimation and garment anchoring; the Media Pipe Pose landmark model predicts 33 pose landmarks and can optionally output a full-body segmentation mask.
- **Media Pipe Hands / Hand Land marker:** Used for touch less interaction; it detects 21 hand landmarks (fingertips, joints, palm points), which you use for cursor control (index fingertip) and dwell-based selection.
  Computer vision and rendering tools
- **OpenCV (cv2):** Used for webcam capture, frame processing, UI drawing (buttons, thumbnails), resizing garment PNGs, and overlay rendering.
- **Alpha blending (RGBA overlay):** Implemented using Open CV/Numpy-style pixel blending so transparent PNG garments merge naturally with the live camera frame.

Supporting utilities

- **NumPy:** Commonly used with OpenCV for fast array operations (pixel-wise alpha blending, masks, ROI slicing) and efficient **math.**
- **OS / pathlib (Python standard library):** Used to load garments from folders (gender/category structure), manage directories, and save captured snapshots.

5. Benefits of an AI - based Virtual Dressing Room System:

User-centric benefits

- **Contactless try-on**: Users can try multiple outfits virtually without physically changing clothes, which saves time and improves hygiene in trial-room or kiosk setups.

- **Better fit and style confidence**: Seeing garments aligned on their own body helps users judge look and fit more accurately than static product photos, reducing confusion about size and style.

- **Convenience and speed**: Hand-gesture navigation and instant overlay let users switch outfits quickly, making it easy to compare several options in a single session.

Retailer and business benefits

- **Reduced return rates**: More accurate visualization before purchase lowers returns due to wrong size or style, which directly saves logistics and restocking costs.
- **Higher engagement and conversion**: Interactive virtual try-on keeps customers on the platform longer and increases purchase confidence, which is linked to higher conversion rates and average order value.
- **Actionable data and personalization**: The system can log which categories and designs users try most, enabling better inventory planning and future AI-based style recommendations.

Technical and deployment benefits

- **Low hardware and setup cost**: The system runs with a normal webcam, CPU, OpenCV, and Media Pipe, avoiding specialized sensors or GPUs and making deployment in labs, kiosks, or small shops feasible.

- **Real-time performance**: Pose and hand tracking pipelines similar to this design have demonstrated 18–30 FPS on mid-range laptops, which is adequate for smooth AR interaction.
- **Modular and extensible design**: Garments are simple PNG assets organized by gender and category; developers can add new clothing, gestures, or features (e.g., pants, accessories, size suggestions) without changing the core pipeline.

6. APPLICATION/IMPLEMENTATION

- **E-commerce Integration:** E-commerce platforms can integrate virtual try-on technology to let customers visualize clothing before buying. This reduces return rates and improves customer confidence, making online shopping more effective.
- **Offline Fashion Stores:** Virtual mirrors in physical stores allow customers to try on clothes without needing fitting rooms, enhancing convenience and reducing wait times during busy periods. This also helps stores optimize floor inventory and boost customer engagement.
- **New Season Sales:** Virtual mirrors can showcase new season collections, letting customers instantly try on the latest trends, driving sales and offering personalized recommendations for seasonal promotions

7. LIMITATIONS AND CHALLENGES:

A) Limitations:

- No Unity/Unreal Engine Integration: Due to limited expertise in high-end AR tools, we opted for a more accessible approach.
- Hardware Constraints: Advanced tools require powerful hardware, making it impractical for all users.
- Prototype Stage: The system is a working prototype using Snap AR, limiting advanced customization.
- Rendering Realism: While functional, the current rendering approach lacks ultrarealistic fabric physics and dynamic lighting

8. Conclusion

The AI-based Dressing Room built with Media Pipe Pose, Media Pipe Hands, and Open CV demonstrates a practical real-time virtual try-on system that works on commodity hardware and enables gesture-based interaction.

By detecting human pose landmarks and fingertip positions from a live camera feed, the application can automatically scale and position shirts on the user's upper body and allow hands-free selection of garment categories and designs. This approach provides an affordable and accessible alternative to physical trial rooms and can enhance user engagement in both online and offline fashion environments.

Future work can focus on integrating segmentation and depth estimation for better foreground-background separation and more realistic occlusion (e.g., partial hiding of garment behind arms).

3D garment models and physics-based simulation could be incorporated to improve realism, especially during complex movements or side views. Additional features such as automatic size recommendation, face-based style personalization, multi-user support, and mobile deployment would make the system more robust and closer to commercial-grade virtual dressing room solutions.

9. Future Scope

Future enhancements may include:

- **Semantic segmentation and depth estimation** for realistic occlusion (e.g., arms over clothing)
- **3D garment models with physics-based simulation** for improved draping realism
- **Automatic size recommendation** using body proportion analysis
- **Face-based personalization** for style suggestions
- **Mobile and web deployment** for broader accessibility
- **Multi-user support** for shared kiosks

These improvements would bring the system closer to **commercial-grade virtual dressing room solutions.**

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