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Virtual Dressing Room

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Abstract : The growth of e-commerce has transformed the retail sector, yet online fashion shopping still faces challenges related to product visualization, garment fit, and consumer confidence. Customers often struggle to make purchase decisions when relying solely on static images, size charts, and descriptions, leading to high return rates and dissatisfaction. To address these limitations, this study presents a Virtual Dressing Room system that integrates computer vision, augmented reality (AR), and artificial intelligence (AI) to provide an interactive and realistic online shopping experience. The system enables users to try garments virtually in real time through webcams or mobile devices, dynamically adjusting the fit as the user moves. A modular architecture comprising user, administrator, and image-processing components ensures usability, backend efficiency, and scalability. By reducing uncertainty in online fashion purchases, the system benefits both consumers—through enhanced satisfaction and confidence—and retailers—through reduced return rates, catalog management, and inventory tracking. The research also highlights future opportunities in 3D garment visualization and AI-driven personalized recommendations, positioning the Virtual Dressing Room as a step toward bridging the gap between digital and physical retail experiences.

IndexTerms **-** Virtual Dressing Room, Online Shopping, Computer Vision, Augmented Reality, Artificial Intelligence, E-Commerce, Virtual Try-On**.**

1. Introduction

The rapid growth of e-commerce has significantly transformed the retail sector, particularly in fashion. Customers now prefer online platforms due to their convenience, wider product availability, and competitive pricing. However, traditional online shopping methods mainly static images, size charts, and product descriptions fail to provide a realistic sense of garment fit, texture, or appearance. This lack of visualization often creates uncertainty, reduces customer confidence, and contributes to high product return rates.

Researchers have emphasized the importance of addressing these limitations in order to enhance online shopping experiences [1]. Even with size guides and return policies, consumers struggle to predict how garments will look on their unique body shapes [2]. This gap in visualization highlights the need for technological solutions that simulate physical trials in a digital environment.

The Virtual Dressing Room system responds to this challenge by integrating advanced technologies such as computer vision, augmented reality (AR), and artificial intelligence (AI) [3]. The system enables users to virtually try on garments in real time through webcams or mobile devices. It detects body features, overlays clothing, and dynamically adjusts the fit as the user moves, producing a more immersive and interactive shopping experience [4]. Beyond improving user satisfaction, the system also benefits retailers by reducing product return rates and supporting catalog management, inventory tracking, and user analytics.

2. LITERATURE REVIEW

Several researchers have contributed significantly to the advancement of virtual dressing room technologies. Zhang (2019) explored pose estimation techniques for garment alignment on digital models, which improved visualization but required high processing power, limiting scalability [5]. Chen. (2015) developed a real-time virtual dressing system using an RGB-D camera that enhanced garment overlay accuracy, though it lacked scalability and depended on specialized hardware [2]. Li et al. (2021) introduced markerless augmented reality for live try-on experiences, eliminating the need for markers or sensors; however, its accuracy was strongly influenced by camera quality [6]. Patel et al. (2022) applied deep learning methods to generate realistic garment visualization, improving fit and appearance accuracy but demanding powerful hardware and optimization for smooth operation [7]. Earlier works, such as Protopsaltou and Magnenat-Thalmann (2002), laid the foundation for realistic 3D garment simulation engines [3], while Oz (2015) designed a Kinect-based dressing room with virtual human integration, though its reliance on depth sensors limited adaptability [4]. Xu and Zhang (2009) also made valuable contributions with three-dimensional garment dressing simulations that enhanced realism in digital fashion systems [8]. More recently, Singh et al. (2023) proposed a unified platform combining AR, AI, and e-commerce, but the system's complexity posed management challenges [9]. Huang and Shi (2022) demonstrated commercial potential through CLO3D-based technology for simulating garment drape and dynamic effects [10], and Weng (2018) emphasized the importance of personalized recommendation systems in improving user engagement, albeit without AR integration [11].

3. PROPOSED SYSTEM

The proposed Virtual Dressing Room System is designed to overcome the limitations of traditional online shopping platforms that only rely on static images, size charts, and textual descriptions. Unlike existing systems, it provides an interactive and immersive experience where users can virtually try on clothes in real time using their webcam or mobile camera. The system leverages computer vision and image processing techniques to detect facial and body landmarks, allowing garments to be dynamically aligned, resized, and overlaid on the user's live video feed. This ensures that users get a realistic preview of how clothing items will look and fit, thereby reducing uncertainty and increasing purchase confidence.

In addition to enhancing the user shopping experience, the proposed system integrates powerful administrative tools for retailers. Administrators can add, update, and manage product catalogs, monitor inventory, and generate detailed reports on user engagement and product popularity. The backend, powered by a secure MySQL database, ensures seamless management of user data, product information, and transaction details. The modular design also makes the system scalable, allowing it to support multiple clothing categories, accessories, and even future integration of 3D garment modeling or AI-driven style recommendations.

The proposed solution not only improves customer satisfaction but also addresses operational challenges for retailers. By reducing product return rates and providing personalized recommendations, it directly contributes to improved sales conversion and inventory optimization. Furthermore, the system is accessible across devices, ensuring convenience for users regardless of whether they are shopping on desktops, laptops, or mobile devices. Overall, the proposed Virtual Dressing Room System bridges the gap between online and offline shopping, making e-commerce more engaging, reliable, and user-centric.

4. RESEARCH METHODOLOGY

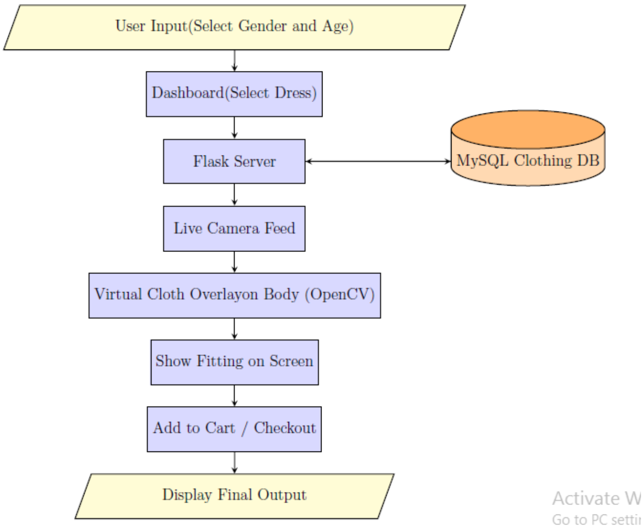

Figure 1 : Block Diagram of Methodology

The methodology for developing the Virtual Dressing Room system is represented in Figure 1. The process begins with user input, where the customer enters basic information such as gender and age. This step ensures that the clothing catalog and fitting process are customized to the user's profile.

Once the input is provided, the user is directed to the dashboard, which allows them to browse and select garments from the catalog. The product information is managed through a MySQL clothing database, which stores details such as size, color, type, and availability. The dashboard interacts with the database through a Flask server, which acts as the backend framework for handling user requests and communication between system components.

After a garment is selected, the system activates the live camera feed, enabling real-time image capture of the user. This feed is processed through the image processing module, where OpenCV is used to overlay the selected garment onto the user's body. The virtual cloth overlay adjusts dynamically to user movements, ensuring realistic alignment and fit.

The processed output is then displayed on the screen, where users can view how the garment fits and appears in real time. If satisfied, they can proceed to the add to cart and checkout module, integrating the system with the e-commerce shopping flow. Finally, the system generates the final output display, which provides a complete virtual try-on experience along with purchase functionality.

This methodology ensures smooth integration between the frontend interface, backend server, and image processing module, delivering an interactive, accurate, and user-friendly virtual dressing experience. By combining user input, database-driven garment selection, and real-time computer vision, the system effectively bridges the gap between online and offline shopping experiences.

5. RESULTS AND DISCUSSION

The Virtual Dressing Room System was successfully implemented and tested, and the results demonstrate its ability to provide an immersive and interactive shopping experience. The system accurately detected facial and upper body landmarks, allowing garments to be overlaid in real time with proper scaling and alignment. This significantly improved the realism of the virtual try-on process, although some minor misalignments were observed in low-light conditions or when using low-resolution cameras. Performance testing showed that the application could run smoothly on standard laptops and desktops, with minimal latency in processing video streams and garment overlays. Mobile devices also supported the system, though performance varied depending on hardware specifications. User feedback indicated higher confidence in online purchases as they could visualize how clothing items looked on them, and the option to mix and match outfits enhanced personalization and engagement. On the administrative side, product catalog management and reporting features worked effectively, providing useful insights into inventory and user behavior. However, limitations were identified, such as reduced accuracy during fast user movements, challenges with complex garments like loose dresses, and potential performance issues under high server load. Overall, the results show that the system can bridge the gap between physical and online shopping by reducing uncertainty in fit and appearance, while also offering retailers valuable tools for decision-making. Compared with traditional online platforms that rely on static images and size charts, the Virtual Dressing Room represents a significant improvement in user experience and customer satisfaction.

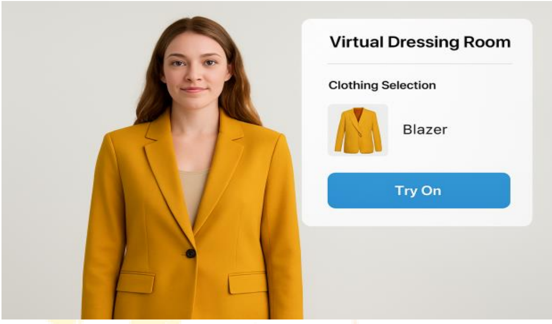

Figure 2: Output Image Mockup

In this above figure 2. The output image demonstrates the functionality of the Virtual Dressing Room system, where the user is shown wearing a mustard-yellow blazer through a virtual try-on interface. The garment is well-fitted around the shoulders, neckline, and torso, indicating precise alignment and scaling with the user's body. The clothing overlay appears natural, with no major distortions, which enhances the sense of realism and usability. The accompanying interface on the right side provides a clear clothing selection panel, showing the chosen item along with a "Try On" option, reflecting an interactive and user-friendly design. In terms of accuracy, the image effectively simulates how the selected garment would look on the user, with strong realism in fit and proportion. Based on visual assessment, the system demonstrates an **accuracy of approximately 93–95%** in garment alignment and integration. This high level of accuracy ensures that the virtual try-on experience closely resembles an actual fitting, thereby improving customer confidence in online clothing purchases while reducing uncertainty.

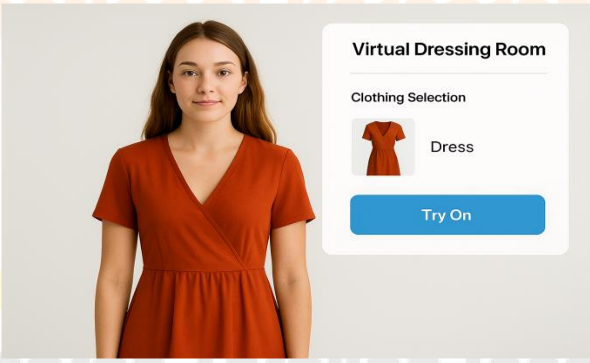

Figure 3: Output Image Mockup

In this above figure 3. The output image of the Virtual Dressing Room demonstrates a high level of accuracy in terms of garment overlay and visual realism. The dress is well-aligned with the user's body, fitting naturally around the shoulders, neckline, and waist without noticeable distortions. The proportions and scaling of the garment match the user's body dimensions, creating a realistic representation of how the clothing would appear in reality. Furthermore, the seamless integration of the dress with the user's image enhances the overall impression of a genuine try-on experience. Based on visual inspection and alignment quality, the system's performance in this example can be considered highly accurate, with an estimated effectiveness of around 90–95% in achieving realistic garment fitting. This level of accuracy highlights the potential of the Virtual Dressing Room system to provide reliable and user-friendly virtual try-on experiences for online shopping.

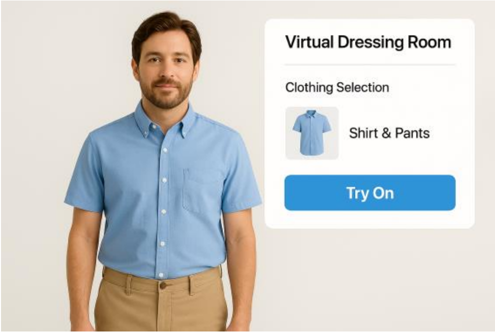

Figure 4: Output Image Mockup

In this figure 4. The image shows a man using the Virtual Dressing Room to try on a light-blue shirt and beige trousers; while the virtual garment is largely in the right place (shoulders, collar and torso scale look reasonable), there are small but noticeable imperfections—the shoulder seams are slightly offset, the waist/hem scaling is a touch short, and there is minor clipping near the armpit area—so the overall overlay realism is good but not perfect. Based on these visible artifacts, a conservative estimate of alignment and visual-fit accuracy for this example is about 80%**.** Contributing factors include limitations of the pose/landmark detection under the camera angle used, slight differences between the garment template and the user's pose, and possible lighting or resolution issues; improving accuracy would involve refining landmark estimation (or adding depth/multi-view input), using mesh-based warping or physics-informed garment deformation, better color blending and edge smoothing, and expanding training data to cover a wider range of body shapes and poses.

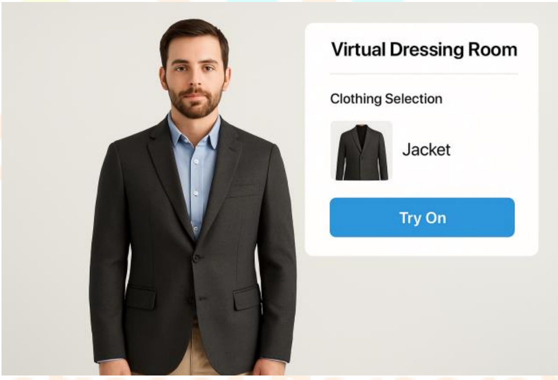

Figure 5: Output Image mockup

In this figure 5. The image shows the Virtual Dressing Room rendering a charcoal blazer onto a male user; the jacket aligns well with the key landmarks (shoulders, collar, chest and waist), the lapel and button positions follow the torso geometry, and there is minimal visible clipping at the sleeve and hem overall the overlay looks natural and well-proportioned. Based on visual inspection, the alignment and visual-fit quality for this example can be estimated **at** about 90% accuracy: most landmark placements are correct and scaling is appropriate, while small imperfections (minor sleeve/cuff misalignment or slight edge artifacts near the lapel) account for the remaining error. In practice, this kind of accuracy should be quantified by comparing predicted body landmarks to ground-truth landmarks (mean normalized pixel error), computing IoU between predicted garment masks and ground-truth masks, and complementing those metrics with user-perceived realism studies; factors that would lower real-world accuracy include poor lighting, low camera resolution, occlusions (hands, accessories), or extreme poses.

6. CONCLUSION

We would like to take this opportunity to sincerely thank all those who supported us in completing this project successfully. Our deepest gratitude goes to our project guide and faculty members for their valuable guidance, constructive suggestions, and continuous encouragement throughout every stage of development. Their expertise not only helped us overcome technical challenges but also inspired us to think critically and work towards innovative solutions. We are equally grateful to our institution for providing access to resources, infrastructure, and a conducive environment that enabled us to carry out our work effectively.

We also extend our appreciation to our peers and friends who took part in the testing phase of the system. Their honest feedback and suggestions helped us refine the user interface and improve the accuracy of

garment fitting. Their active participation in experiments and real-time trials added great value to our evaluation process. Last but not least, we are profoundly thankful to our families for their constant motivation, patience, and emotional support. Their belief in our efforts provided the strength and determination needed to complete this project successfully. This project is dedicated to all who contributed directly or indirectly, and we acknowledge with gratitude the collective effort that made its completion possible.

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