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An Enhanced Virtual Fitting Room Using Deep Neural Network

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Abstract- In today's world, fashion has become intricately linked to personal identity and cultural expression, with clothing choices varying significantly across individuals based on factors such as body structure, gender, social influences, and geographic background. While traditional shopping at brick-and-mortar stores allows customers to physically try on garments, this experience can often be time-consuming and limited by the availability of fitting rooms, leading to inconvenience and frustration. With the rapid expansion of online shopping plat- forms, consumers now seek more realistic and interactive ways to evaluate clothing virtually, yet existing systems frequently fall short of providing an immersive, tactile experience. This gap results in higher dissatisfaction, inaccurate visualizations, and increased product returns due to poor fit or misrepresentation of garments. To address these issues, this research introduces an advanced Virtual Fitting Room (VFR) system that leverages cutting-edge deep learning techniques, including Deep Neural Networks (DNNs) and Generative Adversarial Networks (GANs), within a two-dimensional framework to enable highly realistic virtual try-on experiences. The proposed system incorporates sophisticated computer vision methods, such as precise image segmentation, garment warping, and fabric behavior simulation, to create a natural, seamless inter- action wherein users can see how clothing appears on virtual avatars with remarkable accuracy. By focusing on realistic garment overlays that adapt to various body shapes and poses, this platform delivers an immersive environment that closely mimics physical fitting experiences, thereby enhancing user engagement and confidence. Implementing this technology not only improves customer satisfaction by providing a more authentic and visually appealing visualization but also reduces the likelihood of returns caused by mismatched expectations. Ultimately, this innovative approach contributes to a more sustainable and technologically advanced fashion retail ecosystem, transforming online clothing shopping into a more enjoyable and reliable process while addressing the needs of modern consumers and retailers alike.

Keywords-Virtual Dressing Room, Deep Neural Networks, 2D Virtual Try-On, Human Pose Estimation, Clothing Transformation, Generative AI Models, Image Processing, Online Fashion Commerce, Visual Computing Techniques, Fashion Technology Innovation

I. INTRODUCTION

The physical and virtual worlds represent two distinct yet increasingly interconnected realms. With the evolution of computer technology, humans have progressively transitioned toward the digital environment, striving to merge real and virtual experiences. One of the major challenges in online fashion retail lies in the inability of customers to physically try on garments before purchasing. Unlike traditional stores, where shoppers can assess the fit, comfort, and style of clothing through direct experience, online shopping relies heavily on static images and size charts. This often leads to discrepancies between customer expectations and actual product fit, causing higher return rates, financial losses for retailers, and dissatisfaction among consumers.

To address these limitations, Virtual Fitting Rooms (VFRs) have emerged as an innovative solution that enables users to visualize how clothes would look on them before making a purchase. Early VFR systems primarily depended on basic image overlays, where garments were superimposed on a user's uploaded image. However, such methods lacked realism as they failed to adapt to diverse body shapes, postures, and fabric dynamics.

Advancements in Artificial Intelligence (AI) and Deep Learning, particularly through Deep Neural Networks (DNNs), have opened new possibilities for improving the realism and interactivity of virtual try-on systems. In this study, we propose an Enhanced Virtual Fitting Room (EVFR) utilizing 2D Deep Neural Networks to provide a more lifelike and personalized try-on experience. Our system integrates advanced techniques such as pose detection, garment transformation, and Gener- ative Adversarial

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Networks (GANs) to achieve accurate and visually convincing clothing simulations.

II. RELATED WORK

Research in virtual dressing solutions has grown to include a range of innovative methods, such as augmented reality ap- plications and artificial intelligence techniques. Early systems primarily used simple image overlays, placing clothing images directly onto user photographs, which struggled to accurately adapt to different body shapes and postures. More recently, computer vision advancements have led to the creation of model-based fitting systems that generate three-dimensional representations of human bodies, thereby enhancing the real- ism of virtual try-ons. Nonetheless, these 3D approaches often demand significant computational resources and specialized hardware, limiting their practicality for widespread consumer use.

As a more accessible alternative, two-dimensional deep learning-based virtual try-on methods have become increas- ingly popular due to their efficiency and ease of implemen- tation. These systems typically utilize pose estimation algo- rithms, such as OpenPose or DensePose, to detect key points on the body, allowing garments to move naturally with the user's movements. To ensure a realistic appearance, techniques like Thin-Plate Spline warping or optical flow models are employed to deform clothing images in a manner consistent with the user's pose and body contours. Moreover, semantic segmentation approaches are used to segment different body regions, ensuring clothing is properly aligned and visually convincing.

The use of generative adversarial networks (GANs) has also significantly improved the quality of synthesized images in virtual try-on applications. GANs can produce highly detailed and realistic images that retain intricate fabric features like texture and folds, thereby enhancing the authenticity of the virtual dressing experience. The synergy of these technologies creates immersive, personalized virtual fitting environments that closely resemble real-world try-ons, boosting consumer confidence and reducing return rates.

III. METHODOLOGY

A. Overview

The proposed Online Virtual Trial Room System begins by identifying and capturing key contours of the human body, such as the head, torso, and neck, based on the selected clothing type or accessory. These contours serve as reference points that guide the accurate alignment and placement of garments or accessories during the virtual fitting process.

B. Face Recognition

To identify the user, the system primarily relies on facial recognition. Detection is performed using Haar feature-based cascade classifiers, which effectively locate facial features in real-time through trained datasets. Once detected, the system establishes facial landmarks that serve as alignment references for virtual garment placement.

Fig. 1. Overview of the proposed Enhanced Virtual Fitting Room architecture showing Semantic Generation, Clothes Warping, and Content Fusion Modules.

C. Image Masking

In this stage, selected regions of the image are masked to differentiate between the subject and the background. Pixels within the masked area are assigned zero intensity values, effectively isolating the region of interest (ROI). This ensures that subsequent operations, such as clothing overlay or modifi- cation, only affect relevant portions of the image, maintaining image clarity and structure.

D. Edge Detection

Edge detection helps in defining the precise boundaries of the user's body. Gaussian filters are applied to remove image noise before identifying body edges, thereby preventing false detections. This refined outline assists in the accurate placement and scaling of virtual garments over the detected body frame.

E. Attire Scaling

As the user moves in front of the camera or display screen, the clothing image must dynamically adjust to maintain alignment with the user's posture and distance. The attire scaling mechanism ensures that the virtual apparel resizes in real time, preserving correct proportions and fit as per body motion.

F. Semantic Generation Module (SGM)

The Semantic Generation Module (SGM) plays a vital role in distinguishing between clothing and body regions. It identifies target garment areas while ensuring that essential body parts, such as arms and shoulders, retain their natural positioning and appearance.

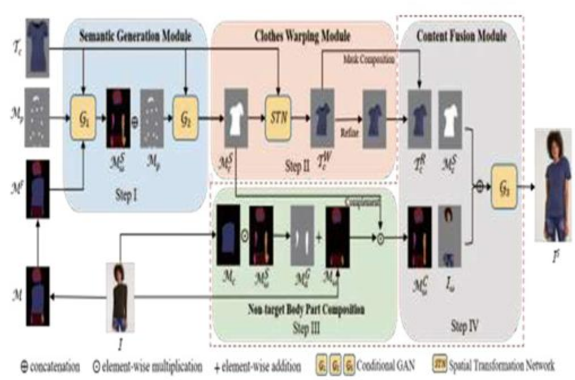

Fig. 2. Comparison of STN warping results with and without the second-order difference constraint.

This module uses a two-stage deep learning process: Stage 1 generates detailed masks for human body regions (head, arms, torso) by combining the pose map, fused body mask, and clothing image. Stage 2 combines the output masks and clothing data to generate a refined clothing mask through another GAN.

G. Clothes Warping Module (CWM)

The Clothes Warping Module ensures that garments natu- rally adapt to the body's contour and pose. Spatial Transformer Networks (STN) with Thin-Plate Spline (TPS) transformations are utilized, enhanced by a second-order difference constraint that improves geometric alignment and minimizes distortions in garments with complex textures.

H. Content Fusion Module (CFM)

The Content Fusion Module (CFM) merges the refined clothing image with the original user image to create the final try-on output. This module focuses on preserving fine-grained body details while ensuring seamless garment integration.

The process includes non-target body composition and an inpainting process using a fusion GAN to fill missing areas and restore textures, improving visual continuity.

I. Try-On Module

The final Try-On Module employs an encoder-decoder network to refine and enhance the composite image. Unlike simple overlay methods, this deep learning-based approach generates natural-looking visuals by seamlessly blending gar- ments with body features, preserving both pose alignment and fabric authenticity.

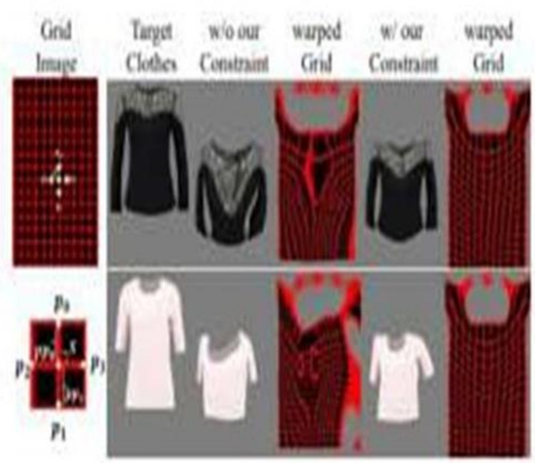

Fig. 3. An example of computing the complexity score C using reference pose maps and connected points.

Fig. 4. Steps involved in warping and refining clothing onto a model in the virtual try-on system.

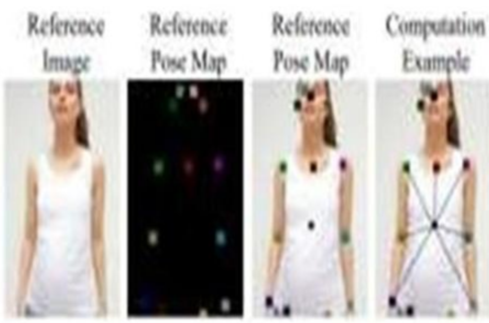

Fig. 5. Try-On Module Encoder-Decoder Network used for the final com- posite output.

IV. CONCLUSION

The rapid growth of online shopping, combined with consumers' desire for more personalized and immersive experiences, highlights the necessity for advanced algorithms capable of digitally fitting garments on users. One of the major drawbacks of conventional shopping is the time and effort required to physically try on multiple outfits, which can be both exhausting and inefficient.

To overcome this limitation, the proposed Virtual Styling Room acts as a digital fitting environment, enabling users to visualize how clothes would look on them in real time through live video streaming. By employing Kinect-based sensors and body-mapping techniques, the system accurately detects key body joints and contours, allowing virtual garments to be overlaid seamlessly onto the user's figure. This approach eliminates the need for physical trials while saving both time and energy.

The developed system offers a user-friendly interface, making it easily accessible even to individuals with minimal technical expertise. It provides flexibility for shoppers to explore different clothing options virtually while ensuring realistic visualization. From a commercial perspective, this technology serves as an effective tool for online retailers by enhancing customer engagement and reducing product return rates.

In conclusion, the proposed Virtual Fitting Room provides a practical, efficient, and visually realistic solution for digital garment fitting, bridging the gap between traditional shopping experiences and the evolving world of AI-driven fashion technology.

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