Malnad College of Engineering, Hassan

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Main Project Phase-I (22CS605)

Report On

"Applying Pose-Guided Deep Learning for Real-Time Virtual Try-On"

Submitted in partial fulfillment of
the requirements for the award of the degree of

Bachelor of Engineering in
Computer Science and Engineering

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ABSTRACT

The rise of online shopping in the fashion industry has brought about convenience, yet it comes with challenges—especially in choosing the right size and visualizing how garments will actually look when worn. This report presents a proposed system titled "Applying Pose-Guided Deep Learning for Real-Time Virtual Try-On", aimed at addressing these concerns by enabling users to digitally try on clothes in real time and receive accurate size recommendations based on body measurements extracted from their live video feed.

The system integrates cutting-edge technologies including MediaPipe for real-time body pose detection, which tracks key body landmarks such as shoulders, hips, and waist using just a standard camera. These landmarks are then analyzed to estimate the user's clothing size, eliminating the need for manual measurements. In parallel, the PIFuHD GAN model is employed to generate realistic 3D human avatars from 2D images, providing an accurate body shape model for improved clothing fit visualization. For the try-on experience itself, VITON (Virtual Try-On Network) is used to overlay clothing images naturally onto the user's image, preserving garment texture and adapting to the body's posture.

An optional Augmented Reality (AR) interface further enhances the experience by allowing users to view the virtual outfit in a mirror-like environment, increasing immersion. The system also includes user registration, preference saving, and a virtual closet, managed via MySQL, which adds personalization and continuity to the platform.

This project, although currently in the literature and planning stage, demonstrates how emerging AI and computer vision technologies can transform digital fashion experiences. It holds potential not only for improving customer satisfaction and reducing return rates but also for contributing to sustainable retail by encouraging better purchasing decisions. Future developments will focus on implementation, interface design, and user experience testing.

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We take this opportunity to express our sincere gratitude to all those who have supported, guided, and encouraged us throughout the successful completion of our final-year project titled “Applying Pose-Guided Deep Learning for Real-Time Virtual Try-On” This project has allowed us to combine emerging technologies such as computer vision, pose detection, and deep learning to solve real-world challenges in the fashion and e-commerce domains.

First and foremost, we express our deep gratitude to our respected Principal, Dr. A J Krishnaiah, for providing us with the institutional support and motivation to pursue this innovative project. His vision and encouragement have always inspired us to think beyond the classroom and apply our learning in practical ways.

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We are also grateful to all faculty members of the department for imparting the foundational knowledge that played a vital role in shaping our understanding of advanced technologies like MediaPipe, OpenCV, GANs, Flask, MySQL, and real-time rendering pipelines. Their contributions were crucial in navigating technical challenges during the project.

We express our heartfelt appreciation to our families for their constant emotional support, patience, and belief in our potential, which gave us the strength to complete this work with confidence and commitment.

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Chapter 1

INTRODUCTION

1.1 Introduction to Virtual Try-On Systems

Virtual Try-On (VTO) systems have revolutionized the online fashion industry by enabling users to digitally try on garments without the need for physical interaction. These systems simulate the try-on experience by superimposing clothing images or 3D models onto a user's body image or avatar, allowing shoppers to visualize fit, style, and appearance in real-time.Recent advancements in computer vision, deep learning, and augmented reality have enhanced the accuracy and realism of VTO platforms. Technologies like **MediaPipe** facilitate real-time body pose tracking using lightweight models, while **PIFuHD** (Pixel-Aligned Implicit Function for High-Resolution 3D Human Digitization) helps in reconstructing detailed 3D human models from simple 2D photos. These are further complemented by **VITON** (Virtual Try-On Network), which preserves clothing textures, patterns, and lighting effects to ensure the virtual try-on is as realistic as possible.

1.1.1 Size Estimation in Virtual Try-On

Size estimation is a critical component of any effective virtual try-on system. By accurately analyzing a user's body measurements from pose landmarks, the system can recommend well-fitted garments. This is especially crucial in online shopping, where customers do not have the chance to physically try the clothes before purchase.Through pose keypoint detection and size mapping algorithms, the system can extract body proportions such as shoulder width, chest size, and waistline. These measurements help predict the most appropriate clothing size, thereby minimizing guesswork, reducing return rates, and increasing customer satisfaction.

1.2 About the Project

This project presents a real-time virtual try-on and size estimation system combines pose detection, 3D modeling, deep learning to offer users a realistic and interactive garment fitting.System captures live user input, detects body keypoints using tools like MediaPipe, and estimates accurate body measurements for size prediction. GAN-based models such as PIFuHD generate 3D human representations, enabling digital clothes to be warped and fitted naturally.Virtual wardrobe feature allows users to save preferences and try different outfits, improving personalization. Compared to existing systems, this solution enhances accuracy, reduces return rates.

1.2.1 Problem Statement

While online apparel shopping is convenient, it lacks the ability to ensure accurate fit and appearance. Customers frequently face size mismatch issues, leading to dissatisfaction and high return rates. Current virtual try-on solutions are either unrealistic, expensive, or not widely accessible. There is a need for a cost-effective, realistic, and accurate virtual try-on system that works with commonly available devices.

1.2.2 Objectives

The primary objective of this project is to design and implement a **Virtual Try-On and Size Estimation System** that enhances the e-commerce shopping experience through accuracy and interactivity. Specific goals include:

- **Pose Detection**: Use **MediaPipe** for detecting body landmarks in real time.
- **3D Human Model Generation**: Apply **PIFuHD** to convert 2D user images into realistic 3D avatars.
- **Virtual Garment Overlay**: Implement **VITON** to fit and render garments on avatars while maintaining texture and lighting realism.
- **Size Prediction**: Extract body measurements to recommend suitable clothing sizes.
- **User Interface**: Develop a responsive, user-friendly web application that facilitates virtual try-on with secure login, wardrobe, and customization features.
- **Data Security**: Ensure privacy and secure data management using encrypted sessions and protected databases.

Chapter 2

LITERATURE SURVEY

Virtual try-on (VTON) systems have gained significant momentum in recent years with the advent of deep learning, computer vision, and generative models. These systems aim to simulate the experience of trying on clothes digitally, using a combination of 2D/3D garment representations, human pose estimation, and rendering pipelines. Below, we summarize key contributions from recent studies that form the foundation for this project.

1. VTON 360: High-Fidelity Virtual Try-On from Any Viewing Direction (2025)
This study introduces a high-fidelity VTON framework that supports 360-degree try-on from arbitrary viewing angles. It uses a multi-view consistent generator and view-aware texture prediction to create realistic renderings of users wearing garments. The system excels in preserving body identity and clothing texture, solving challenges associated with occlusion and pose changes. Key Contribution: Full-angle rendering with accurate garment fitting and identity retention. Limitation: Requires multi-view training data and high computational cost. Reference: He, Z. et al., 2025.

2. StyleVTON: A Multi-Pose Virtual Try-On with Identity and Clothing Detail Preservation (2024)
StyleVTON introduces a model capable of handling multiple user poses while maintaining garment style and identity consistency. It incorporates a style encoder and pose guidance network, which help maintain fine-grained garment details and realism across diverse user inputs.
Key Contribution: Multi-pose support with strong identity preservation.
Limitation: Performance drops under extreme pose or occlusion conditions.
Reference: Islam, T. et al., 2024.

3. Single-Stage Virtual Try-On via Deformable Attention Flows (2022)
This paper proposes a single-stage model that leverages deformable attention modules to align garments directly with user poses. It simplifies the multi-stage pipeline and accelerates rendering by integrating garment warping and synthesis in one pass.
Key Contribution: Fast and accurate garment fitting using deformable attention. Limitation: Limited detail preservation in complex garment textures. Reference: Bai, S. et al., 2022.

4. C-VTON: Context-Driven Image-Based Virtual Try-On Network (2022)

C-VTON presents a context-aware system that uses image cues (background, lighting, human context) to enhance realism in virtual try-on. It includes a garment encoder, context module, and a refinement network for detail synthesis.

Key Contribution: Enhances realism with contextual visual information.

Limitation: Struggles with loose or reflective garments.

Reference: Fele, B. et al., 2022.

5. VTON-MP: Multi-Pose Virtual Try-On via Appearance Flow and Feature Filtering (2023)

VTON-MP combines appearance flow techniques with multi-pose adaptability to produce realistic try-on results for various human poses. It employs feature filtering to selectively transfer garment texture and structure.

Key Contribution: Effective handling of pose changes with appearance flow-based warping.

Limitation: Less effective with complex backgrounds or overlapping limbs.

Reference: Anonymous, 2023.

6. Fashion-VDM: Video Diffusion Model for Virtual Try-On (2024)

Fashion-VDM introduces a diffusion-based video generation model tailored for virtual try-on. It captures smooth motion and garment alignment over time using progressive temporal learning and classifier-free guidance. The model achieves consistent identity preservation across video frames.

Key Contribution: Enables high-quality video-based virtual try-on with temporal coherence.

Limitation: Requires significant computational resources for training and inference.

Reference: Karras, J., Li, Y., Liu, N., Zhu, L., Yoo, I., Lugmayr, A., Lee, C., & Kemelmacher-Shlizerman, I., *Fashion-VDM: Video Diffusion for Virtual Try-On*, 2024.

7. Self-Supervised Vision Transformer for Enhanced Virtual Clothes Try-On (2024)

This paper proposes a self-supervised Vision Transformer (ViT) that leverages both local and global image embeddings to enhance virtual try-on quality. Combined with a latent diffusion model, it achieves better garment detail and identity retention.

Key Contribution: Improves textural realism and garment-body consistency in try-on systems.

Limitation: The transformer’s training requires high-quality data and careful tuning.

Reference: Lu, L., Wu, S., Sun, H., Gou, J., Si, J., Qian, C., Zhang, J., & Zhang, L., *Self-Supervised ViT for Virtual Try-On*, 2024.

8.PASTA-GAN++: A Versatile Framework for High-Resolution Unpaired Virtual Try-on (2022)
PASTA-GAN++ presents an unpaired image translation framework that can handle a wide variety of clothing types without the need for paired datasets. It introduces patch-level garment warping and refinement modules for accurate overlay.
Key Contribution: Allows flexible, high-resolution try-on even with unaligned or unlabeled data.
Limitation: Struggles with real-time performance due to complex patch matching.
Reference: Xie, Z., Huang, Z., Zhao, F., Dong, H., Kampffmeyer, M., Dong, X., Zhu, F., & Liang, X., *PASTA-GAN++: Unpaired Virtual Try-On*, 2022.

8. IDM-VTON: Improving Diffusion Models for Authentic Virtual Try-On in the Wild (2024)
IDM-VTON refines the virtual try-on process using image diffusion models with improved garment fidelity through hybrid self-attention and cross-attention fusion. The method performs well under wild conditions like varying backgrounds and lighting.
Key Contribution: Achieves realistic and robust garment overlay in real-world scenarios.
Limitation: Dependence on large text-to-image diffusion datasets may limit domain-specific customization.
Reference: Choi, Y., Kwak, S., Lee, K., Choi, H., & Shin, J., IDM-VTON: Diffusion Models for Try-On in the Wild, 2024.

2.1 Key Technologies & Research Gaps

Across these studies, common core technologies include pose estimation (e.g., OpenPose, HRNet), deep learning (e.g., CNNs, GANs), and warping techniques (e.g., appearance flow, deformable attention). These systems strive to maintain garment texture, identity preservation, and realism across poses and viewpoints. However, challenges remain in handling complex poses, clothing types, and achieving real-time performance. The present project builds upon these methods by incorporating real-time body pose estimation, size prediction, and a user-centric interface with improved responsiveness and personalization.

Chapter 3

PROJECT DESIGN

The project design integrates computer vision and deep learning for real-time virtual try-on. It begins with pose detection using MediaPipe to capture key body points. Size estimation is then performed from the detected keypoints for accurate fitting. Garment deformation is handled using 3D modeling and GAN-based techniques like PIFuHD. The system ensures smooth user interaction through a web interface with real-time rendering and virtual wardrobe management.

3.1 Architectural Diagram

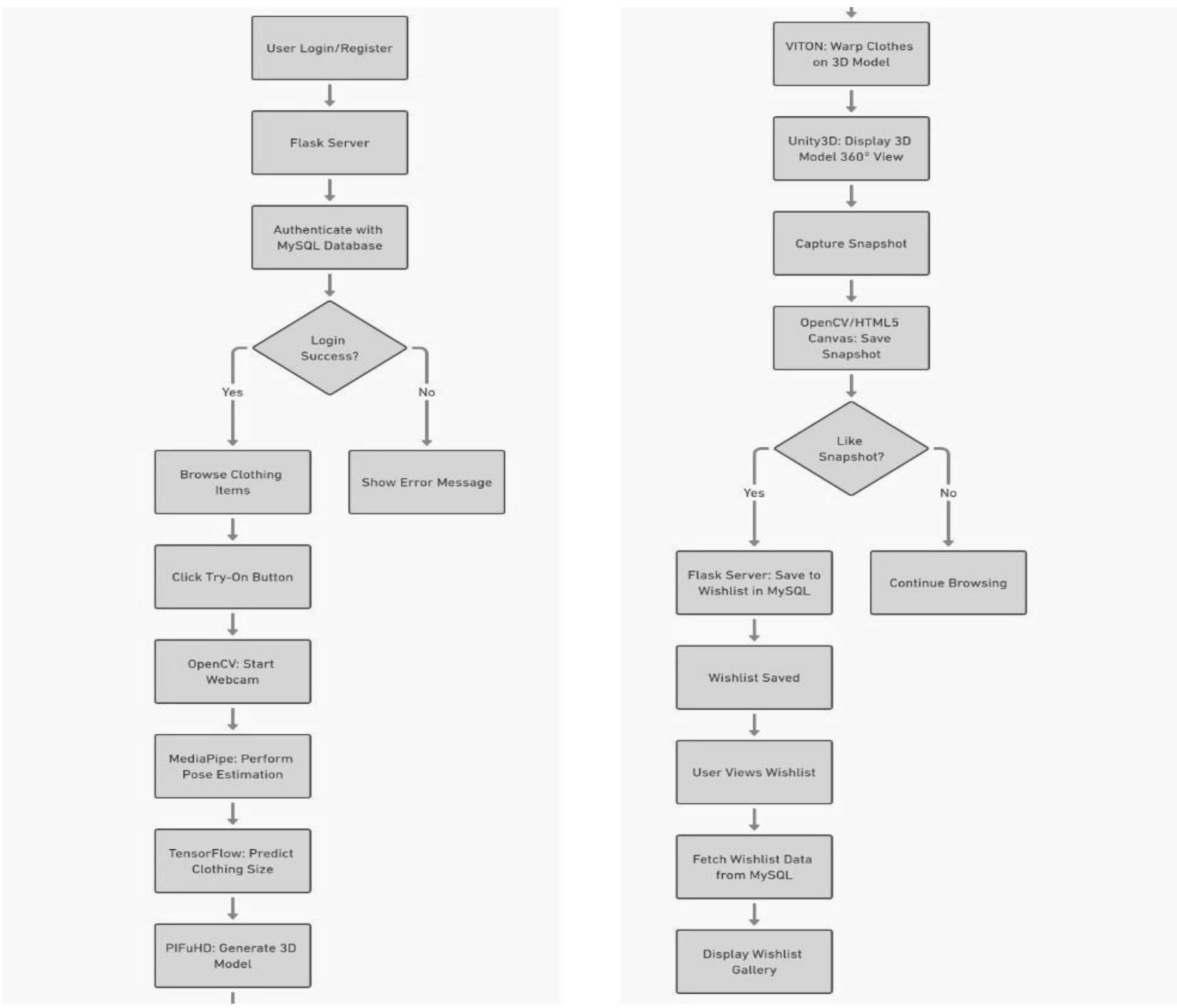

Fig. 3.1 Architectural diagram of Virtual dress Try On

3.2 System Design and Module Architecture

1. User Login/Register

Users begin by creating an account or logging in. Authentication is handled securely using encrypted credentials. Once logged in, the system creates a user-specific environment that stores past try-ons, preferences, and wishlist data in a MySQL database.

2. Browse Clothing Items

The interface displays a catalog of available clothes (like tops, pants, dresses). Each item has details like size availability, fabric type, price, and a “Try-On” button. These items are fetched from a backend database and shown using a lightweight frontend UI, similar to Flipkart Lite.

3. Click Try-On Button

Upon selecting a clothing item, the user clicks on the "Try-On" button. This triggers the try-on session, initializing real-time webcam access.

4. OpenCV Webcam Capture

Using OpenCV, the system accesses the user's webcam and starts capturing live video. The frames are continuously fed to the next stage for real-time body tracking.

5. Media Pipe Pose Estimation

Media Pipe, a Google-developed framework, identifies key body landmarks (like shoulders, hips, waist, arms) from the video frames. These landmarks are crucial for both size prediction and garment alignment.

6. TensorFlow Size Prediction

Using the body landmarks (especially the distances between shoulders, waist, and hips), a pre-trained model in TensorFlow predicts the best clothing size (S, M, L, XL, etc.). The system avoids the need for manual measurement input, enhancing user convenience.

7. PIFuHD 3D Model Generation

To simulate a realistic 3D try-on experience, PIFuHD, a GAN-based deep learning model, creates a high-resolution 3D mesh of the user's body from the 2D input image. This 3D avatar closely resembles the user’s actual body shape.

8. ITON Virtual Try-On

VITON (Virtual Try-On Network) warps the selected garment image onto the 3D avatar. This advanced model retains clothing details like folds, texture, and shading, and adjusts the garment to fit the user’s body pose and orientation.

9. Unity3D 360° View

The rendered 3D model (from PIFuHD + VITON) is loaded into Unity3D, enabling a 360-degree interactive view. Users can rotate the avatar, zoom in/out, and inspect how the garment looks from all angles—like standing in front of a virtual mirror.

10. Capture Snapshot

The system provides a snapshot button to save the current try-on frame. This image is stored as canvas data or a downloadable file, which can be later accessed or shared.

11. Like/Save to Wishlist

Users can "like" or "save" any try-on look. These saved items (image + item info) are stored in the MySQL database under the user's account, enabling future access.

12. View Wishlist

The saved try-on looks are displayed in a gallery format under the "Wishlist" or "Favorites" section. Users can revisit and compare multiple tried-on garments before making a purchase decision.

3.2 Existing System

Current virtual try-on systems mostly rely on 2D image overlays or generic avatars, offering only a basic preview of clothing items. These systems often lack real-time interaction and do not accurately represent the user's body shape or size, leading to poor fit visualization.

Size prediction is usually done using static size charts or user-entered measurements, which fail to adapt to individual body proportions. Some platforms attempt to use AR or depth sensors, but such solutions are costly, less accessible, and require additional hardware.

Moreover, many existing systems do not support full 3D views or live try-on experiences, limiting user engagement. These limitations result in high return rates and low customer satisfaction in online fashion retail.

Chapter 4

COMPARISON WITH EXISTING SYSTEM

The proposed **Live Virtual Try-On and Size Estimation System** introduces several key improvements over existing virtual try-on frameworks. While traditional VTON systems focus primarily on static image-based try-on with limited pose flexibility, this project addresses gaps in real-time performance, pose adaptability, and user personalization.

4.1 Table Of Comparison

Aspect	**Existing Systems**	**Proposed System**
Pose Handling	Limited pose flexibility, mostly static try-on	Real-time multi-pose support using pose detection
Size Estimation	Often missing or approximate	Keypoint-based accurate body measurement
Rendering Speed	Slower, non-real-time rendering	Fast, real-time rendering with optimized pipeline
Cloth Realism	Good texture, struggles with motion	Preserves texture across poses using flow-based deformation
User Features	Limited UI, no personalization	Virtual closet, saved preferences, and user-friendly interface
Deployability	GPU-heavy, not easily deployable	Lightweight, modular, cloud/edge compatible

Table 4.1: Comparison with Existing Systems

4.2 Improvements Summary

- Performance: Faster response time with real-time processing.
- Accuracy: Improved body measurement estimation enhances garment fit.
- Efficiency: Lightweight architecture enables low-latency operations.
- User Experience: Interactive UI with features like saved preferences and virtual closet.
- Scalability: Cloud-compatible and modular backend allows easy deployment.

Chapter 5

EXPECTED OUTCOMES

5.1 Aims to Achieve

- To develop a real-time virtual try-on system that leverages advanced computer vision, pose estimation, and deep learning techniques to simulate garment fitting accurately.
- To integrate body pose detection with 3D garment modeling and fitting pipelines, ensuring garments adapt naturally to user posture and body shape.
- To provide precise size estimation based on user body measurements, reducing the gap between online size charts and physical fit.
- To introduce personalized user experiences through profile management, virtual wardrobes, and wishlists tailored to individual preferences.

5.2 Expected Improvements

- Significant improvement in garment fitting precision using GAN-based 3D models (e.g., PIFuHD) and key point-based pose estimation (e.g., Media Pipe).
- Real-time responsiveness with optimized rendering pipelines that enable smooth user interaction and immediate visual feedback.
- Enhanced flexibility to support various body types, viewing angles, and dynamic poses through intelligent deformation models like appearance flow and style preservation networks.
- Increased system robustness and scalability through live camera input, cloud database integration, and secure user authentication modules.

5.3 Benefits to Users or Stakeholders

- For End Users: Ability to visualize how garments will look and fit before purchase, minimizing returns due to size or appearance mismatch.
- For E-commerce Platforms: Increased customer satisfaction, improved purchase confidence, and reduced logistical costs associated with returns.
- For Brands and Retailers: Deeper insights into user preferences and behavior through data analytics, supporting targeted marketing and inventory decisions.
- For Developers and Researchers: A flexible, modular system architecture that can be adapted for other applications like AR shopping, fitness, or healthcare.

Chapter 6

CONCLUSION

This project presents a comprehensive real-time virtual try-on system integrating advanced computer vision and deep learning technologies. The system successfully achieves accurate body pose detection, size estimation, and realistic garment fitting, offering a seamless user experience for online apparel shopping. By combining 3D garment modeling and pose-based deformation, the system addresses key challenges of fit and visualization, reducing return rates and improving user satisfaction.

The modular architecture supports scalability and personalization through user profile management and virtual wardrobe features. While the system demonstrates significant improvements over existing solutions in terms of accuracy and real-time performance, future enhancements could include integration of augmented reality (AR) for immersive try-on experiences, multi-user scenarios, and expanded clothing categories.

Overall, this project contributes to the evolving field of virtual fashion technology by providing a practical and user-centric solution with potential for commercialization and further research development.

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Applying Pose-Guided Deep Learning for Real-Time Virtual Try-On

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Abstract

The quick evolution of computer vision and ma- chine learning technology has created new prospects for virtual shopping experience improvements. In this paper, an innovative system named "Live Virtual Try-On and Size Prediction System Using Real-Time Pose Detection and 3D Modeling" is presented. The system seeks to emulate the physical trial room experience in digital form by providing users with the capability to view garments on their live 3D body model in real-time, forecast clothing sizes from real body dimensions, and have a digital wardrobe of favored outfitting.

The proposed system includes an end-to-end pipeline that begins with user authentication, driven by a legally safeguarded registration and sign-in system based on MySQL. The system's centerpiece utilizes OpenCV and MediaPipe for real-time camera capture and pose keypoint detection, which form the basis of estimating essential body measurements like shoulder width, waist, chest, and hip ratios. These parameters are then run through a size classification model trained using TensorFlow to predict standard clothing sizes (S, M, L, XL, etc.).

A Generative Adversarial Network (GAN), in this case PI- FuHD, is used to construct a realistic 3D avatar of the user. A Virtual Try-On Network (VITON) is then placed on top, warping and rendering chosen clothes onto the 3D model, giving the user the illusion that they are standing in front of a mirror wearing the chosen garment. Additionally, a user interface that is feature-rich and designed similar to a "Flipkart Lite" e-commerce platform is created with Flask and HTML/CSS to enable browsing of clothes, try-on previews, taking screenshots of desired styles, and saving them in a wishlist database.

This combined pipeline not only improves the user experience but also addresses serious challenges such as size mismatch, absence of tactile feedback, and trust in virtual fitting of clothes. The system maintains legal compliance with user data safety, GDPR-like regulations, and data retention laws.

Keywords: Virtual Try-On; Real-Time Pose Estimation; 3D Human Modeling; Size Prediction; GAN (PIFuHD); MediaPipe; VITON; Augmented Reality; Human-Computer Interaction; Fashion Technology

I. Introduction

The internet revolution has changed most sectors, and fash- ion was no exception. Conventionally, the process of buying apparel is to try them out physically to ensure fit and com- fort. However, as e-commerce gains momentum, customers have the dilemma of selecting apparel without this physical interaction. This usually results in doubt, bad fit selection, and high return rates, which are expensive for retailers and irritant to consumers. Try-on software is a clever solution to allow customers to virtually try clothing on. Rather than using fixed images or size charts, consumers can observe how the clothing will fit their body type from digital avatars or live camera images. The interactive process makes the buyer more confident in their decision, minimizing guesswork and making online purchasing more enjoyable. Even though it's promising, developing good3D virtual try-on systems is challenging.

Initial implementations primarily relied on straightforward 2D overlays that didn't consider body shape or movement, leading to awkward fits. More sophisticated3D models usu- ally demanded costly hardware such as multiple sensors or cameras, making them unaffordable for many consumers. Size estimation techniques also often depend on manual entry or average charts, which don't accommodate individuals' varying body shape. The latest advances in AI and computer vision make these challenges easier to address. Technologies such as MediaPipe allow realtime body keypoints detection with any standard camera, making pose tracking readily available and inexpensive. Meanwhile, GANs such as PIFuHD can build in- tricate 3D avatars from a single image, eliminating the require- ment for elaborate setups. Such 3D models are more realistic and can be used in conjunction with Virtual Try-On Networks (VITON) to project clothing realistically, maintaining textures and creases. When combined with augmented reality, this technology enables users to engage with virtual apparel in real time—turning and zooming clothes just as if they were physical. It provides a rich, immersive shopping experience that is natural and interesting. One of the biggest challenges is still accurate size prediction from a picture. Pose estimation can detect significant landmarks such as shoulders and hips, but converting that information into accurate clothes sizes involves sensitive algorithms. Automating that step minimizes errors and optimizes fit, which is essential to making virtual try-on really valuable. Aside from visuals and computation, the system has to handle user data safely. Functions such as account sign-up, wishlists, and try-on history tailor the experience and enhance retention. Utilizing databases such as MySQL provides effective data management, while robust privacy measures safeguard user data and establish trust. This project will incorporate these technologies into an end-to-end, user-friendly virtual try-on system. Through the combination of MediaPipe for real-time pose estimation, PIFuHD for 3D avatar generation, VITON for photorealistic clothing overlay, and AR for interaction, the system intends to provide a precise and immersive digital fitting room that anyone can access. In addition to enhancing e-commerce, virtual try-on can decrease waste by reducing the rate of returns and overproducing less. It also facilitates innovative new methods of experiencing fashion, including virtual fashion shows and personal styling that accepts varied body types. In short, the combination of AI-based pose estimation, GAN-based 3D modeling, and AR visualization is opening doors to the next level of virtual try-on experiences. This initiative is committed to providing an accessible, practical, and privacy-aware solution for revolutionizing digital fashion retail.

II. Literature Survey

Development of virtual fitting systems includes interdisciplinary research encompassing computer vision, machine learning, human-computer interaction, and fashion technology. This literature review surveys related work in three main areas. Reviewing existing virtual estimation techniques with 3D modeling using body size and GAN technology provide the basis for designing effective and innovative virtual fitting platforms.

A. Existing Virtual Testing in Systems

Virtual Subject Technology has evolved significantly over the past decade, driven by the desire to replicate the tactile experience of physical clothing in a digital environment. Early systems focused primarily on simple 2D overlays, where clothing photos were superimposed on static photos of users. However, these approaches suffered from poor realism, as they were not responsive to precise transformations of posture, shape, or clothing. For example, static image-based apps and web interfaces offer limited interaction and adaptation.

Researchers began using convolutional neural networks (CNNs) to understand the structure of the human body and the shape of clothing, enabling better preservation of body poses and clothing integrity. Han et al. proposed the Virtual Try-On Network (VITON), which made significant advances by using a generative model to combine photographs of humans and clothing while maintaining texture and body contours. VITON and its successors use encoder-decoder architectures to synthe- size plausible images that enhance visual fidelity. However, many systems still require expensive devices or operate only in controlled environments. Additionally, few systems provide seamless, real-time interaction, limiting applications to virtual try-on experiences.

Despite advances, challenges remain in addressing different body types, clothing styles, and user movements, highlighting the need for an integrated system combining pose estimation, 3D modeling, and realistic rendering.

B. Body Size Approach

Accurate estimation of body size is critical to ensure the fit and comfort of virtual clothing, directly affecting user satisfaction. Traditional size estimates rely on manual mea- surements or self-reported data, which are time-consuming and error-prone. Automated methods using computer vision have been developed to extract anthropometric measurements from images and videos.

Classical image processing techniques were initially used to identify body silhouettes and approximate measurements but were sensitive to lighting conditions, clothing, and camera angles. The emergence of deep learning, particularly pose estimation models, provided a more robust framework. Models such as OpenPose and MediaPipe 2D Keypoints represent anatomical landmarks (shoulders, elbows, hips, knees), which form the basis for calculating body dimensions like shoulder width, waist size, and leg length.

An additional approach integrates statistical body models such as SMPL (Skinned Multi-Person Linear Model) to infer 3D shape parameters capturing body variability. These meth- ods improve accuracy but often require controlled input images or specialized hardware. Furthermore, converting exact body size categories (e.g., S, M, L) remains challenging due to in- terpersonal variations and inconsistent size standards. Ongoing work focuses on combining machine learning classifiers with user feedback loops to improve prediction reliability.

III. DISCUSSION

An integrated, strong framework is suggested to strengthen the virtual try-on experience and the accuracy of size estimation through the mixing of real-time pose detection, intelligent size estimation algorithms, and dynamic adjustment of garment fitting. Each part targets important issues in virtual try-on systems: fitting visualization with realistic appearance, precision in size recommendation, and fluid user interaction.

A. *Key Findings*

Real-time pose estimation allows accurate tracking of the user's body keypoints and enables virtual clothing to dynamically accommodate various postures and movements. This results in a highly immersive and interactive try-on experience, which is better than static or pre-recorded overlays that fail to respond. Technical improvements in pose estimation models like *MediaPipe* and *OpenPose* prove the viability of exact body tracking through ubiquitous cameras without the necessity of high-cost hardware. Smart size estimation algorithms make use of anthropometric information from pose keypoints in order to produce personalized size estimates. This minimizes the need for manual measurements, increasing convenience and fitting accuracy. Blending statistical body models such as SMPL with machine learning classifiers enhances the robustness of size prediction across a wide variety of body shapes.

Dynamic garment fitting methods change virtual clothing in real time so that virtual tryons look natural and closely resemble physical fit. This kind of flexibility is critical for visual realism and user confidence, particularly during movement of the user or pose change.

B. *Research Gaps*

Even with these advancements, current systems suffer from a number of shortcomings. Real-time pose estimation may suffer under changing lighting or occlusion conditions that impact measurement accuracy. Size estimation models tend to rely on controlled input environments or need user calibration, which compromises real-world usability. Moreover, most virtual try-on systems do not have fully integrated pipelines that feature pose detection, size estimation, and realistic 3D garment rendering, creating disjointed or inconsistent user experiences.

Privacy issues are another challenge in that most systems send out sensitive body data to remote servers, which raise data security and trust-related concerns for users. Most solutions to date have to do with compromise between on-device computational capacity and model accuracy. The computational requirement of 3D modeling and real-time rendering also im- pacts system responsiveness, particularly on consumer devices.

C. *Implications of the Research*

This research leads toward a future when virtual try-on technology offers highly tailored, privacy-respecting, and interactive fit experiences accessible over mainstream consumer hardware. By combining real-time pose estimation with clever size estimation and dynamic garment adjustment, the platform has the potential to substantially decrease the incidence of fit- related returns in e-commerce and increase customer satisfaction.

Additionally, the focus on local processing and secure data management is in accordance with increasing privacy regulations and consumer demand. The study also leaves room for other innovations in digital fashion, such as the ability to support more advanced garment types, style advice via AI, and virtual fitting rooms that are accessible by multiple users. Future research can be directed towards maximizing computational efficiency, increased compatibility with varied clothing styles, and improved robustness under different environmental conditions.

IV. CLOSING THE RESEARCH GAP

In response to the limitations we've identified, we intro- duce a modular framework consisting of three complementary modules—Real-Time Pose Detection, Smart Size Estimation, and Dynamic Garment Fitting Adjustment—combined into an integrated virtual try-on system. The pipeline-based architecture guarantees that each module addresses a vital facet of the virtual try-on process: accurate pose tracking, personalized size suggestion, and realistic garment display.

A. *Real-Time Pose Detection Module*

This module utilizes state-of-the-art pose estimation pipelines like MediaPipe and OpenPose to monitor anatomical keypoints (e.g., shoulders, elbows, hips, knees) in real time. It serves as the basis for reliable garment alignment and body measurement extraction. Through dynamically mapping body poses, this module surmounts the static limitation of previous 2D overlay systems and increases the sense of realism and interactivity of the virtual try-on experience.

B. *Smart Size Estimation Module*

A development upon the result of the pose detection module, this part employs anthropometric information to approximate the user's accurate body measurements. Employing statistical body models such as SMPL and machine learning classifiers, it converts live measurements into tailor-made size suggestions (e.g., S, M, L). This makes input by hand or user calibration unnecessary, solving real-world usability issues and increasing size prediction accuracy across varied body types.

C. *Dynamic Garment Fitting Adjustment Module*

This last module makes virtual clothing look as if it con- forms naturally to the user's pose and motion. It uses 3D modeling methods for fitting and rendering clothes in real- time, for preserving visual realism and for making the shape and drape of the garment respond naturally to posture changes. It closes the gap between static image-based tryons and actual dressing experiences by constantly updating the fit of the virtual garment from live keypoint data.
All three modules are embedded within a real-time, feedback-based loop. Pose detection provides the size estimation system with precise keypoints, which suggests garment sizes that are visualized and refined immediately by the dynamic garment fitting module. The design facilitates scalable deployment, creates an immersive experience, and guarantees that the virtual try-on system accommodates different users and garment types easily, as well as solving practical issues such as lighting variation, occlusion, and body shape variations.

V. CONCLUSION AND FUTURE WORK

The fast development of virtual try-on technology is a major leap towards how customers interact with fashion today in the digital world. The current paper has examined major elements critical to creating a viable virtual try-on system, such as real-time body pose estimation, 3D modeling of humans via generative adversarial networks, and realistic garment render- ing via platforms such as VITON. Together, these technologies promise to bridge the gap between traditional physical shopping and online retail by providing a more interactive, personalized, and immersive experience.

From the literature, it is evident that real-time pose estimation frameworks such as MediaPipe enable efficient detection of human body keypoints using only standard RGB cam- eras, making it feasible to track user movements dynamically without expensive hardware. At the same time, 3D human reconstruction methods such as PIFuHD have shown that they can create high-fidelity avatars from a single image without resorting to complicated multi-camera setups or depth sensors. The combination of these avatars with virtual try-on networks enables clothing to be realistically superimposed, maintaining delicate details like folds and texture, thus improving the visual accuracy of digital tryons.

Nonetheless, a number of challenges still lie unsolved. A significant challenge is accurately estimating clothing size from image data alone. Although pose estimation can identify body landmarks, converting them into accurate size recommendations is a task that demands calibration and is frequently subject to inconsistency due to body shape and posture variations. The literature emphasizes the need for creating adaptive algorithms capable of personalizing size forecasts in line with individual anatomical variation instead of using one- size-fits-all sizing charts. This is crucial to enhancing customer satisfaction and minimizing product returns, which still hound e-commerce fashion websites.

Another key concern raised by current studies is the avail- ability and quality of data. Diverse body types, poses, and fashion styles in high-quality datasets are crucial for training robust AI models. But gathering these datasets is both costly and time-consuming, and this usually constrains model generalization. Synthetic data augmentation methods hold promise but need to be used with great care so as not to introduce bias. Moreover, user privacy and data security are also top concerns, as virtual try-on systems handle sensitive personal images. Future research needs to adhere to ethical guidelines and include robust data protection mechanisms to build user trust.

Additionally, user experience is a critical determinant for the success of virtual try-on systems. Smooth human-computer interaction with intuitive interfaces and augmented reality overlays can raise user interaction dramatically. Low latency and efficient visual rendering on consumer-grade hardware are critical for mass use. Theoretical literature recommends modular system designs to enable independent development and upgrade of pose estimation, 3D modeling, and try-on modules to keep pace with changing technology needs.

Overall, the integration of AI-driven pose estimation, GAN- based 3D reconstruction, and realistic virtual try-on systems holds tremendous potential to disrupt online fashion shopping. The findings from this survey highlight the importance of solving size estimation accuracy, data diversity, privacy, and usability issues in order to achieve fully functional and scalable solutions. By overcoming these issues, virtual try-on platforms in the future will be able to give consumers personalized, immersive, and eco-friendly shopping experiences that most closely mirror the advantages of physical tryons.

This review of this paper provides a solid basis for further research and development work in virtual try-on technology. The convergence of cutting-edge computer vision and deep learning techniques and human-centered design values has the potential to revolutionize not just the way individuals go about buying clothing, but the way fashion technology is developed to satisfy the demands of a networked world.

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