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ML Powered Virtual Try-On: Transforming E-Commerce Fashion

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***Abstract*—The fashion sector confronts enormous difficulty with fit-related concerns, amounting to around $62 billion in yearly returns, with 70% of these returns ascribed to poor fit. There are intrinsic limits to getting a good fit when using traditional purchasing methods, both online and off. The goal of this research is to improve the accuracy, realism, and user experience of online garment fitting by developing a virtual try-on system based on machine learning. Through the use of cutting-edge computer vision methods like OpenCV and OpenPose for real-time body pose estimation, the system allows users to virtually try on clothes via an online interface. High-resolution camera video frames are captured as part of the process, which also includes body position detection, hand gesture recognition for clothing selection, and the overlaying of virtual clothes over the user's live video feed. Evaluation factors include technological performance, user experience, and impact on customer behaviour. According to preliminary findings, fit accuracy and user happiness have significantly improved, indicating that this technology may be able to close the gap between what customers expect from online purchasing and what they really experience. In the e-commerce fashion sector, the suggested system may lower return rates, improve consumer happiness, and increase engagement and sales.**

***Index Terms*— Virtual try-on, e-commerce, real-time interaction, computer vision, machine learning, pose detection, OpenCV and OpenPose.**

I. INTRODUCTION

With around $62 billion in returns a year, mostly from fit-related difficulties, the fashion sector faces a formidable challenge in addressing fit-related issues [12]. Furthermore, the inability to physically assess style and fit when purchasing online is a factor in the 70% of returns that are said to be caused by fit-related problems [12]. This demonstrates a significant disconnect between what customers expect from their online purchasing experiences and the reality, emphasizing the need for creative solutions to raise customer happiness and lower return rates.

Conventional wearables purchasing techniques come with their own set of difficulties, whether they be done online or off. Locating stores and trying on several outfits in trial rooms are only two examples of the time-consuming procedures that come with offline shopping [13]. On the other hand, the popularity of internet shopping which is fuelled by its affordability and convenience has increased demand for virtual try-on technology [15]. By digitizing the try-on process, virtual try-on systems provide promising alternatives by allowing customers to browse larger collections and virtually try on things, even in online channels [12].

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Virtual try-on systems' business potential has drawn a lot of interest, especially for online shopping and intelligent recommendation systems [14]. Nonetheless, current research mostly concentrates on creating realistic simulation systems with the goal of duplicating in-person try-on experiences [12]. Notwithstanding progress, difficulties continue to arise in faithfully capturing facial and body imagery, resulting in distorted impressions and less than ideal user experiences [12].

It takes a complex strategy that combines virtual try-on technology and machine intelligence to overcome these obstacles. The precision and realism of virtual try-on systems could be improved by machine learning techniques [12]. Virtual try-on systems can enhance apparel recognition, sizing recommendations, and the user experience overall by utilizing machine learning techniques [13]. OpenCV, a computer vision library, for example, can be integrated to enable effective body detection and garment superimposition, which expedites the virtual try-on process and offers platform-independent capabilities [13].

Furthermore, the fashion sector is adopting sophisticated customisation methods as consumer preferences shift toward customized fashion needs [16]. The necessity of matching product offerings to individual tastes is further highlighted by the rise of the "experience economy" [16]. This paradigm change is greatly aided by virtual customer fitting systems, which allow customers to easily try on several styles and options [16].

With these factors in mind, the goal of this project is to create a virtual try-on system that is machine learning based and improves the accuracy, realism, and user experience of virtual try-on technology.

II. Literature Survey

The way that garments are now searched for online doesn't always ensure that the consumer will get the correct size, and occasionally, after making a purchase, they discover that the item is not quite appropriate for them. As a result, a lot of things are returned, which takes a lot of time away from businesses and organizations.

1. Bin Ren, Hao Tang, Fanyang Meng, Ding Runwei, Philip H. S. Torr, and Nicu Sebe present a novel two-stage Cloth Interactive Transformer (CIT) method for virtual try-on activities in their paper titled "Cloth Interactive Transformer for Virtual Try-On." The purpose of the proposed CIT is to capture long-range correlations between in-store apparel products and person representations that are cloth-agnostic. However, it demonstrates the limits of using 2D image-based approaches to effectively capture complex interactions between people and clothing items.
2. The system that is suggested in the paper "High-Resolution Virtual Try-On with Misalignment and Occlusion-Handled Conditions" by Sangyun, Lee, Gyojung Gu, Seunghyun Park, Seunghwan Choi, and Jaegul Choo takes a novel approach by carrying out the creation of segmentation and the warping of clothing at the same time, with these processes seamlessly exchanging information. Though innovative, the model has many drawbacks. Most importantly, it relies on the assumption that the training and test data come from the same distribution, which is a constraint shared by other image-based virtual try-on techniques.
3. The authors of the study "Virtual Try-On: Real-Time Interactive Hybrid Network with High-Fidelity," Umer Waqas, Yunwan Jeon, and Donghun Lee, present a hybrid interactive network that is made up of wrapping modules, appearance flow modification, and keypoint extraction to preserve the shape and fit of clothing on the body. However, it makes no mention of any precise quantitative assessments or comparisons with current techniques to confirm the viability of the suggested hybrid network.
4. VICO-DR, a collaborative synchronous Virtual Dressing Room (VDR) for image consulting, is introduced in the paper "VICO-DR: A Collaborative Virtual Dressing Room for Image Consulting" by Gilda Manfredi , Gabriele Gilio , Vincenzo Baldi , Hiba Youssef , Ugo Erra. Customers can virtually try on lifelike digital clothes selected by a human image consultant thanks to this technique. It creates a very realistic virtual world with real-time fabric modeling using Unreal Engine. However, this increases the computing burden of the program and may lead to less accurate circular anthropometric measurements when wearing thick apparel, which would affect the virtual representation's accuracy.
5. A novel method called Clothing-Oriented Transformation Try-On Network (COTTON) is introduced for virtual try-on tasks in the fashion industry in a paper titled "Size Does Matter: Size-aware Virtual Try-on via Clothing-oriented Transformation Try-on Network" by Chieh-Yun Chen, Yi-Chung Chen, Hong-Han Shuai, and Wen-Huang Cheng. With the use of segmentation and markers in clothing structure, COTTON accurately deforms garments to enable size adjustments during try-on. There hasn't been much discussion about COTTON's scalability and adaptation to various body forms and garment types, which may have an impact on how broadly applicable it is in real-world situations.

6. To enhance the synthetic outcomes of current virtual try-on techniques, Zhi Li, Pengfei Wei, Xiang Yin, Zejun Ma, Alex C. Kot’s paper, "Virtual Try-On with Pose-Garment Keypoints Guided Inpainting," suggests a pose-garment keypoints guided inpainting technique for image-based virtual try-on tasks. It extracts pose-oriented garment keypoints for target segmentation map estimation and garment warping using a graph-based approach. However, the suggested method's computational complexity and runtime efficiency are not specifically discussed in the paper.
7. OpenPose is used in the paper "Image-Based Virtual Try-On System with Clothing-Size Adjustment" by Minoru Kuribayashi, Koki Nakai, and Nobuo Funabiki to generate segmentation maps and discover important points. The method precisely modifies the clothing size in the virtual fitting photos by taking into account the dimensions of the wearer and the garment. A method's success in real-world circumstances may not be adequately represented by an evaluation based on a limited sample size.
8. The paper "A Virtual Trial Room using Pose Estimation and Homography" by Kshitij Tushar Shah, Mridul Pandey, Radha Shankarmani, and Sharvesh Patki addresses challenges affecting the retail industry, including long wait times in malls and the discomfort of traditional trial rooms. New approaches to mitigate these challenges include leveraging TensorFlow and OpenCV to build virtual trial rooms. The article offers a workaround that entails creating an Android app for online virtual clothes shopping. The application uses TensorFlow Lite to enhance the virtual try-on experience and OpenCV to accurately map clothing onto the user's body.
9. The growing economic potential of virtual try-on systems is highlighted in the paper "Multi-Pose Virtual Try-On Via Self-Adaptive Feature Filtering" by Chenghu Du, Feng Yu, Minghua Jiang, Xiong Wei, Tao Peng, Xinrong Hu, particularly for scenarios requiring several poses. It points out flaws in earlier techniques, like inefficient geometric distortion and lost information in the head and clothing during virtual try-ons. The authors suggest a novel multi-pose virtual try-on network to solve these problems. It uses the Filtering Synthesis Network (FSN) to produce detailed images of the human body and the garment, warps the in-store garment and human body in accordance with the human pose, and predicts the body-semantic distribution for the target pose. As shown on the MPV dataset, our approach performs noticeably better than the state-of-the-art methods currently in use in terms of metrics and visual outcomes.
10. Sen He, Yi-Zhe Song, and Tao Xiang's paper "Single Stage Multi-Pose Virtual Try-On" describes a single-stage model for Multi-Pose Virtual Try-On (MPVTON) that includes a parallel flow estimate module. This architecture increases computing efficiency by allowing end-to-end training in a single stage. The model is more sophisticated than previous VTON systems since it manages the dual objectives of pose and garment altering. The suggested model's performance measures and technical features are the main points of emphasis in this study. On the other hand, it might not adequately address potential scaling concerns, computational resources needed, or real-world application.
11. A 3D face pose estimation algorithm based on feature points is presented in the paper "Research on Face Pose Estimation Method for Virtual Try-on System" by Xiwen Shao. This approach is intended to estimate angles for any pose. This method is contextualized within existing techniques like deep learning, 3D reconstruction, and landmark identification, and it intends to improve virtual try-on systems. Across six degrees of freedom, the algorithm achieves great precision, with an accuracy within 30 degrees. This advancement has important uses in the fashion, gaming, and augmented reality sectors, where precise face position prediction can improve user engagement, tailored interactions, and virtual fitting experiences.

III. Motivation

An urgent problem is the widening gap between the happiness of customers and their online purchasing experiences, especially in the fashion sector. Online shoppers frequently experience the problem of poorly fitting clothing, which raises the number of returns and decreases customer satisfaction even with the ease and cost of online buying. Customers are not just irritated by this disparity, but retailers suffer large financial losses as a result of fit-related returns, which total about $62 billion a year. Resolving this issue will have a significant impact on raising customer happiness, decreasing return rates, and eventually increasing the fashion industry's economic efficiency. We were motivated to tackle this problem by the latest developments in machine learning and computer vision technology. In particular, the real-time body posture estimation facilitated by the integration of OpenCV and OpenPose offers a strong basis for creating a virtual try-on system. Our drive is to close this gap by using cutting-edge technologies to deliver a more realistic and engaging online shopping experience, matching customer expectations with actual results.

IV. PROBLEM DOMAIN

The problem domain lies at the nexus of computer vision technologies and fashion e-commerce. Poor garment fit is a problem in the world of online purchasing, especially in the fashion business, where it can result in large financial losses and unhappy customers. Using advances in computer vision, like clothing overlay and position identification, provide a viable way to improve virtual try-on systems' accuracy and realism. This integration has the potential to completely transform the online buying experience by reducing the gap between what customers expect and what they actually receive and increasing the fashion industry's economic efficiency.

V. PROBLEM DEFINITION

The disparity between online clothing purchases and customer satisfaction which is mostly caused by poor fit is the root of the issue. For the fashion business, this problem leads to high return rates and considerable financial losses. To improve online shopping and lower return rates, the objective is to create a virtual try-on system that precisely superimposes digital clothing over consumers' live video feeds in real-time.

VI. STATEMENT

Creating a virtual try-on system in real time that precisely superimposes digital clothing on users' live video feeds in order to reduce fit-related problems and enhance the online buying experience for fashion consumers.

VII. GAP ANALYSIS

In the fashion sector, virtual try-on technology have made shopping better, yet there are still big gaps. User experience, realism and accuracy, accessibility and platform independence, interaction with e-commerce platforms, user input, and real-time video feedback are among the important areas that require improvement. Research on tailored recommendations, intuitive user interfaces, and smooth e-commerce system integration is lacking. Robust body and face depiction solutions are missing from realistic simulation systems. There is not enough research on accessibility for various user demographics. The present e-commerce platforms do not have defined APIs or implementation methodologies for integration. There are no systematic methods for obtaining and applying user feedback. Ultimately, the majority of systems lack real-time visual input and interaction because they rely on static images or pre-recorded movies.

VIII. SOLUTION METHODOLOGIES OR PROBLEM SOLVING

Considering every study gap about Virtual Try-On systems in the fashion industry, we designed a web-based e-commerce solution that helps consumers browse through a variety of clothing options and virtually try on without having to leave the site; its functional architecture is depicted in Figure 1.

Users begin perusing various outfits on the e-commerce website as soon as they arrive, trying to find what they prefer. They simply click to add an item to their cart when they find something they desire. The fascinating part is that there is a unique "Try On" button. Inquisitive users click on, and all of a sudden they are practically trying on the clothes they have selected. It resembles having a dressing room on their screen.

A. Step-By-Step Process

1. Webcam Capture:

The script starts by configuring a webcam capture using OpenCV's VideoCapture() function, which records live video frames by connecting to the computer's default webcam. Every frame that is captured is essentially an image of what the webcam is viewing at that precise moment.

2. Initialization of Pose Detection:

It then sets up a PoseDetector from the cvzone PoseModule to recognize and track human poses in the webcam feed. This module can recognize and monitor the human body's pose in each frame. It identifies major body parts such as the elbows, wrists, and shoulders as shown in Figure 2.

3. Loading Shirt Images:

The script specifies a folder with photos of various shirts. These photographs will be utilized during the virtual try-on. The application stores these photographs in a list that may be accessed and presented as needed. Constants, including aspect ratios and dimensions, are established to accurately scale shirt images based on pose detection.

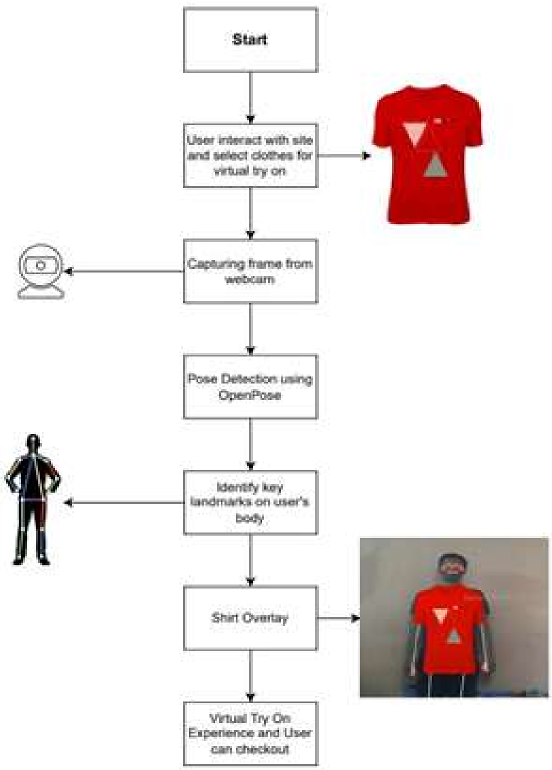

Figure 1. System Architecture

4. Frame Capture and Processing

The application enters an unlimited loop and continuously captures frames from the webcam. Each frame is enlarged to a consistent full-screen resolution to maintain consistency in processing and display.

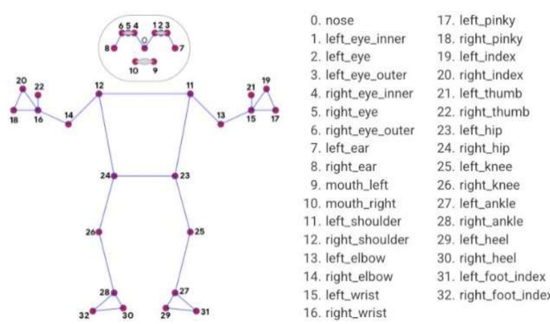

Figure 2. Full body landmark for pose detection

5. Pose detection in each frame:

The pose detection module locates essential body markers in each collected frame. The emphasis is mostly on the shoulder locations (landmarks 11 and 12) as shown in Figure 1, which are critical for properly arranging the shirt overlay.

6. Calculating Shirt Dimensions and Positions:

The distance between the shoulder points is utilized to determine the necessary width for the shirt image while keeping a predetermined aspect ratio. The shirt image is scaled based on this width to guarantee a natural fit on the detected body. An offset is determined to fine-tune the position of the shirt overlay, guaranteeing proper alignment with the body.

The distance d between two points P1(x1, y1) and P2(x2, y2) in two-dimensional can be calculated using Euclidean distance formula which is given in Equation (1):

$$d = \sqrt{(x_2 - x_1) + (y_2 - y_1)^2} \qquad (1)$$

7. Overlaying the Shirt Image:

The resized shirt image is then applied to the frame at the estimated position via the cvzone library's overlay function. This makes it look that the user is wearing a virtual shirt.

8. Shirt Selection via Hand Gestures:

The application also detects the location of the user's hands. If the right hand is lifted over a specific threshold, the algorithm interprets it as an order to proceed to the next shirt image. If the left hand is lowered below a particular threshold, it returns to the previous shirt image. Visual feedback, such as a filling ellipse, is used to signal the selection process. This allows the user to realize when a new shirt will be selected.

8. Display and interaction:

The processed frame, complete with the superimposed shirt and any selection markers, is shown in a window.
The loop continues, recording and processing fresh frames, enabling real-time interaction and a continuous virtual try-on experience.

9. Exit Conditions:

The software continues endlessly, constantly refreshing the visible frame, until the user pushes the 'q' key. This key hit interrupts the loop and terminates the program.

B. Evaluation

The impact on customer behaviour, user experience, and technical performance are all considered in the machine learning evaluation of the virtual try-on system. Every component aids in comprehending the system's usefulness and efficacy, which in turn directs additional improvement and optimization.
Pose Detection Accuracy: Evaluate the pose detection module's efficiency in determining the user's exact body posture in real time. To measure performance, use common metrics like pose estimation accuracy and joint localization error.
Precision of Shirt Overlay: Assess how accurately the user's live video feed is covered by the shirt overlay. Examine how virtual clothing fits and aligns in relation to the user's body landmarks, taking scaling and placement accuracy into account.
Accuracy of Hand Gesture Recognition: Assess the accuracy of hand gesture recognition when choosing a shirt. Evaluate how well the system can recognize user movements and initiate the switching between various shirt options.
The evaluation of multiple pose detection systems demonstrates significant difference in accuracy. OpenPose and AlphaPose follow closely behind with accuracies ranging from 85-90%, indicating their superior performance in detecting human positions. Figure 3 includes more methodology and accuracy information.

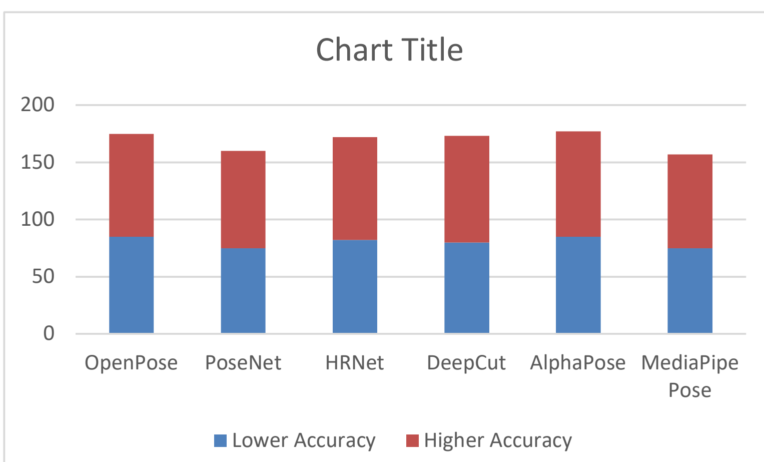

Figure 3. Comparison of various pose detection techniques along with their accuracy

IX. RESULTS

We have successfully created a virtual try-on system that employs computer vision techniques to allow users to try on garments in real time. The technology accurately fitted garments to the user's physique, and users were pleased with the results. Figures 4 and 5 depict users experimenting with different outfits on themselves.

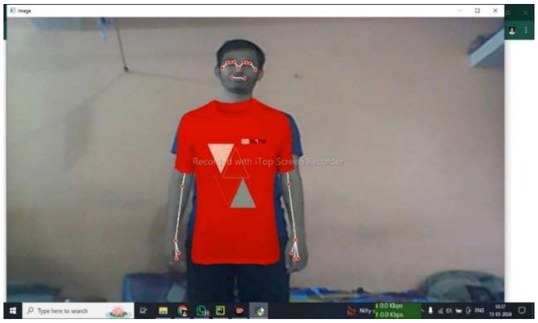

Figure 4. User trying out different garments on themselves

Figure 5. User trying out different garments on themselves

X. CONCLUSION

In conclusion, our research presents a novel approach to virtual try-on utilizing the CVZone library with integrated pose detection mechanisms. Through thorough implementation and evaluation, we have demonstrated the effectiveness of our system in providing users with a seamless and immersive virtual fitting experience. Our system not only accurately fits garments to the user's body in real-time but also enhances user satisfaction and confidence in online shopping. By bridging the gap between online and offline shopping experiences, our virtual try-on system has the potential to revolutionize the way consumers interact with fashion products online, ultimately leading to increased sales and customer engagement for fashion retailers. Moving forward, further research can explore enhancements to the system, such as incorporating advanced garment simulation techniques and expanding the range of supported garments and body types, to continue improving the virtual try-on experience for users.

FUTURE SCOPE

While this research establishes a foundation for an virtual try on application, there are exciting avenues for further exploration:

Integrating a recommendation system: While the user tries on the garment, the system generates feedback based on the fit. Positive feedback prompts recommendations for similar garments, while negative feedback triggers suggestions for garments that may better suit the user's body. This will improve customer satisfaction and potentially increase sales conversion.

Advanced Body Measurement Techniques: We can include various alternative factors like body mass index (BMI) or 3D body scanning, beyond skeletal joint detection which can enhance the accuracy of virtual try-on experience.

Cross-Platform Integration: We can expand the web-based try-on to mobile apps or in-store AR mirrors allowing customers to virtually try on clothes in various settings.

Social Sharing Features: We can incorporate a social sharing functionalities that will allow use to share their experience with friends on social-media that will result in increase of brand awareness and customer engagement.

Virtual Tailoring: Users can input their body measurements and utilize real-time visualization to virtually tailor garments and digitally try them on, providing a convenient and efficient alternative to conventional tailoring methods.

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