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AI-Driven Virtual Try-on for Clothes

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ABSTRACT: The Virtual Fashion Fitting System offers an innovative virtual try-on platform powered by advanced AI technologies like GANs and LC-VTON. It enables users to interactively personalize garments and receive style suggestions through intelligent trend forecasting. With highly accurate body detection and garment alignment, the system significantly improves the user experience. Future developments aim to enhance garment rendering quality, particularly for intricate and detailed clothing designs.

KEYWORDS: AI-Powered Virtual Fashion Fitting, Virtual TryOn, Garment Customization, Fashion Trend Prediction, Skin Tone Detection, LC-VTON, Generative Adversarial Networks (GANs), Real-Time Garment Fitting, Personalized Fashion Advice, AI in Fashion Retail

I. INTRODUCTION

The online fashion industry has witnessed a major transformation with the evolution of virtual try-on technologies, redefining how consumers engage with apparel shopping [1]. These systems allow users to digitally visualize clothing on themselves, removing the need for physical trials. With advancements in artificial intelligence (AI) and deep learning, virtual try-on platforms have achieved remarkable improvements in precision, realism, and user personalization, creating more immersive shopping experiences [2].

The application of Generative Adversarial Networks (GANs) has been instrumental in enhancing the authenticity of virtual garments by producing lifelike fabric textures and patterns [3]. GANs excel in replicating how materials naturally fall and interact with different body types, offering users a dynamic and realistic try-on experience [4]. Additionally, frameworks like LC-VTON (Length-Controllable Virtual Try-On Network) have introduced greater flexibility by enabling users to adjust garment lengths and styles according to personal preferences [5].

Complementing these innovations, pose estimation and body mapping tools such as DensePose and OpenPose have greatly improved garment alignment by accurately identifying key body landmarks [6]. These models ensure that clothing fits seamlessly over varying body poses and shapes, enhancing the realism and comfort of the virtual try-on [7]. Furthermore, AI-powered fashion trend analysis leverages data mining from fashion blogs, social media, and e-commerce platforms to suggest trending outfits and accessories, making the user experience both stylish and up-to-date [8].

The AI-Enhanced Virtual Fashion Fitting System integrates these state-of-the-art technologies, enabling real-time garment customization and providing intelligent fashion recommendations. It aims to solve persistent challenges in online shopping, such as size uncertainty and lack of user interaction, delivering a more intuitive, accurate, and enjoyable virtual fashion experience.

II. RELATED WORKS

The utilization of artificial intelligence (AI) and machine learning (ML) within the fashion industry has led to groundbreaking progress, especially in areas like virtual try-on (VTO) systems, style prediction, and garment customization. This section reviews previous studies and technologies that have laid the foundation for modern virtual





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fashion systems, concentrating on virtual garment fitting, body landmark estimation, garment texture rendering, trendbased outfit recommendation, and real-time user-driven customization.

2.1 Virtual Try-On Technology

Virtual try-on technologies were initially introduced to bridge the gap between physical and online shopping experiences. Early solutions like FitMe and Looklet focused on overlaying garments on static body templates, which provided limited user interaction and often lacked realistic fit simulation. These early models struggled to adapt garments to individual body variations, leading to an on-personalized experience. Recent improvements in AI have revolutionized this space. The advent of advanced models like CP-VTON (Cloth Parsing Virtual Try-On Network) brought significant enhancements by parsing clothing items separately and refining garment fitting in a staged manner. CP-VTON first warps the garment roughly and then fine-tunes it to match the user's posture and body type more realistically. Similarly, VITON-HD elevated the quality of virtual try-ons by leveraging high-resolution image synthesis, allowing garments to maintain texture quality and details even after significant transformations. Despite these advancements, challenges remain when dealing with loose-fitting or layered garments that behave dynamically under motion.

2.2 Body Detection and Pose Estimation

Accurate body shape detection and pose tracking are fundamental to delivering believable virtual try-on experiences. Earlier methods depended on heuristic-based skeletal models, resulting in low precision when dealing with nonstandard poses or occlusions. The introduction of deep learning-based tools like OpenPose and DensePose revolutionized pose estimation. OpenPose, from Carnegie Mellon, became a milestone by accurately detecting full-body keypoints, improving garment alignment accuracy. It enabled multi-person pose tracking in real-time, increasing its application in dynamic virtual fashion platforms. DensePose, developed by Facebook AI Research (FAIR), offered even greater detail by mapping every pixel of a 2D image to the surface of a 3D body model. This allowed virtual garments to flow more naturally across varying poses and enhanced the adaptability of clothing simulations to different body proportions and positions.

2.3 Generative Adversarial Networks (GANs) for Garment Rendering

Early virtual fashion platforms often failed to replicate the texture, weight, and natural behavior of real garments. Garments would appear stiff or flat without proper interaction with the body model. The adoption of Generative Adversarial Networks (GANs) brought а transformation in garment visualization. GANs, comprising a generator and a discriminator, simulate realistic textures and fabrics by learning from large-scale fashion datasets. In fashion applications, projects like FashionGAN and Dressing in Order have demonstrated the ability to generate sequential images of dressing actions with garments rendered dynamically over time. CP-VTON+ further improved this by integrating cloth segmentation and pose guidance for higher fidelity results. Through adversarial training, GANs create smoother garment folds, more natural shadow effects, and intricate fabric simulations, making virtual try-on experiences much closer to reality.

2.4 AI-Driven Fashion Trend Prediction

Integrating fashion trend prediction with virtual try-on platforms has opened doors to highly personalized and dynamic shopping experiences. AI systems now scrape and analyze data from social networks, e-commerce reviews, and online magazines to detect rising fashion patterns. Projects like TrendNet apply machine learning models to large datasets of fashion imagery, analyzing visual elements like color, cut, and fabric to predict trend trajectories. Deep neural networks combined with Natural Language Processing (NLP) help interpret customer reviews and fashion blog posts to forecast popular styles. Recurrent Neural Networks (RNNs) and Convolutional Neural Networks (CNNs) are increasingly used to make real-time predictions based on incoming data streams. This functionality enhances virtual try-on systems by suggesting outfits that not only fit but also match ongoing style trends, making users feel more fashion-forward.

2.5 Garment Customization and Personalization

Modern consumers demand greater control over the products they purchase, including the ability to customize apparel in real-time. Virtual try-on systems are responding by offering options to modify garment features like fabric type, sleeve length, collar style, and color combinations dynamically. a. Challenges: Despite impressive progress, several obstacles persist.





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Pose and body shape variance: Even cutting-edge models like DensePose can struggle when images are captured under poor lighting or at awkward angles, leading to inaccuracies.

Garment complexity: Fabrics with unique textures such as mesh, lace, or heavy embroidery still pose rendering challenges, even for sophisticated GAN-based systems.

Trend prediction volatility: Fashion trends can shift rapidly due to viral influences or seasonal changes, requiring continuous retraining of prediction models to stay updated.

Real-time performance: Maintaining smooth, delay-free user interactions while allowing extensive customization remains technically challenging, particularly for mobile applications.

Addressing these challenges is crucial for advancing virtual try-on technology and delivering a flawless shopping experience.

III. DIAGRAMS FOR SYSTEM ARCHITECTURE AND PROCESSES

The flowchart illustrates the sequential steps involved in the Virtual Fashion with AI Personalization system, guiding the user from initial interaction to the final virtual try-on visualization. The key stages are outlined below:

1.Image Upload:

The process begins with users uploading or capturing a personal image through the system's interface. This image serves as the base for further processing.

2. Pose Estimation:

AI models such as OpenPose and DensePose are employed to detect and map the user's body keypoints, including shoulders, hips, and knees. This generates an accurate skeletal model necessary for realistic garment fitting.

3. Garment Selection:

Users are presented with a catalog of garments and can select their desired clothing items to try on virtually.

4. Garment Rendering with GANs:

Generative Adversarial Networks (GANs) are utilized to produce realistic garment textures and accurately overlay them onto the user's body. This step ensures that the fabric's draping, movement, and texture are convincingly simulated.

5. Real-Time Customization:

The system allows users to customize garments in real-time, enabling modifications to color, pattern, and design details. Changes are reflected instantly, offering a highly interactive experience.

6. AI-Driven Recommendations:

Leveraging AI-based fashion trend prediction, the system provides outfit suggestions tailored to the user's preferences and current fashion movements, enhancing personalization.

7. Final Output:

The system delivers a realistic visualization of the user wearing the selected and customized garment, offering options for further adjustments or finalizing the virtual try-on experience.

The flowchart illustrates the step-by-step process involved in the Virtual Fashion with AI Personalization system, starting from the user's interaction to the final virtual try- on result. The flow includes:

Image Upload: Users begin by uploading or capturing an image of themselves through the system's interface.

Pose Estimation: Using AI models like OpenPose and DensePose, the system identifies key body points (e.g., shoulders, hips, knees) to generate a skeletal model.





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Garment Selection: Users select a garment from the available options.

Garment Rendering with GANs: The system generates realistic garment textures and overlays them on the user's body using GANs.

- 1. Real-Time Customization: Users can modify garment attributes (color, pattern) in real-time, and the system reflects the changes instantly.
- 2. AI-Driven Recommendations: The system provides outfit suggestions based on current fashion trends and the user's preferences.
- 3. Final Output: The user receives a realistic visual of how the garment will look on their body, with options to make further adjustments or finalize the try-on.



Pose Estimation Diagram:





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Diagram demonstrates how pose estimation works in the virtual try-on system. Using models like **OpenPose** or **DensePose**, the system detects key body points such as the shoulders, hips, and knees. These body points form a skeletal structure used to accurately align garments on the user's body. The diagram shows both the input image and the resulting skeletal model, explaining how the system identifies body posture and orientation.



The garment customization flowchart outlines the user journey as they interact with the system to modify garments in real-time. Users can change colors, patterns, and garment details (e.g. buttons, zippers) using a user-friendly interface. The diagram shows how these changes are processed in real- time by the system and reflected instantly in the virtual try- on interface. This allows users to preview customized garments before making a purchase decision.

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IV. METHODOLOGY

The methodology employed in the development of the AI- Driven Virtual Fashion Fitting System follows a structured, modular approach, where each phase of the project is built, tested, and integrated sequentially. The methodology ensures that each component, from image acquisition to real- time feedback, is optimized for efficiency, user experience, and accuracy.

4.1 Image Acquisition and Preprocessing The process starts with users uploading an image of their body through the system's user interface or capturing it in real-time using a camera. Proper guidelines are provided to the user for optimal image capture, ensuring clear visibility of key body parts for accurate pose estimation and garment fitting. Once the image is acquired, it undergoes preprocessing steps to ensure the quality and compatibility of the image. Preprocessing includes: Resizing: Adjusting the image dimensions to match the system's input requirements.

Normalization: Ensuring consistent lighting and contrast levels.

Background Removal: Eliminating unnecessary background elements to focus solely on the user's body. The preprocessed image is stored in the Image Data Store for further processing in subsequent modules.

4.2 Body Detection and Pose Estimation After image preprocessing, the system uses Deep Learning models such as OpenPose or DensePose to detect key body landmarks, including shoulders, hips, and knees. These models map the user's body in 2D or 3D, forming a skeletal structure that is used to align the virtual garments accurately.

Pose Estimation: Detects body posture and key points to generate an initial skeletal structure.

Skeletal Mapping: Maps the detected points to a more detailed skeletal model.

Body Measurement: Measures the user's body proportions (e.g., height, width of shoulders) for accurate garment fitting. The results of body detection are stored in the Pose Data Store, ready for garment rendering.

4.3 Garment Rendering with Generative Adversarial Networks (GANs) Once the user's body pose is detected, the system proceeds to the garment rendering stage. Here, Generative Adversarial Networks (GANs) play a key role in generating realistic garments and fitting them onto the user's body. The GAN architecture consists of two parts: the Generator, which creates the garment textures and over- lays them on the user's image, and the Discriminator, which evaluates the quality and realism of the generated garment. Fit Garment: The garment is fitted onto the user's skeletal model.

Render Garment: The generator simulates the garment's texture and appearance, making it look natural on the user's body.

Customization Application: User-selected garment customizations, such as color and pattern, are ap- plied to the final garment using real-time processing. The rendered garment is stored in the Rendered Output Data Store, which holds the final try-on results

4.4 Real-Time Customization and Feedback To enhance user engagement, the system allows real-time customization of garments. Users can change the col- or, fabric, and patterns of garments through a user-friendly interface. The changes are processed instantly, and the system updates the virtual try-on results in real time. Process Customization in Real-Time: The system processes user modifications and applies them to the garment on the user's body. Generate Feedback: The system provides instant visual feedback based on the user's customization in- puts. This real- time interaction is powered by efficient data processing, ensuring that users experience minimal lag while interacting with the system.

4.5 AI-Driven Trend Prediction and Virtual Stylist In addition to providing users with the ability to customize their garments, the system incorporates an AI-Driven Fashion Trend Prediction module. This module analyzes data from fashion blogs, social media platforms, and e- commerce websites to recommend trending outfits and accessories. The virtual stylist module further enhances the experience by providing personalized fashion advice based on the user's body shape, preferences, and trends. AI-Driven Suggestions: Recommends popular garments and accessories based on current fashion trends.





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Virtual Stylist: Analyzes the user's body type and preferences to suggest complete outfits and provide styling advice.

4.6Testing and Validation The system undergoes rigorous testing to ensure accuracy, performance, and user satisfaction. The testing includes: Unit Testing: Each module (e.g., body detection, garment rendering) is tested individually to ensure it functions as expected.

Integration Testing: All modules are tested together to verify that they work seamlessly.

Performance Testing: Measures system performance, focusing on the speed of real-time garment rendering and feedback.

User Testing: Feedback from users is gathered to refine the system's interface and accuracy.

The system's success is evaluated based on how well it aligns garments on various body types, the realism of the rendered garments, and the overall user experience.

V. RESULTS AND DISCUSSION

The AI-Driven Virtual Fashion Fitting System has undergone extensive testing and evaluation to ensure its functionality and effectiveness in delivering a seamless and accurate user experience. The testing phases included unit testing, integration testing, and user testing, all of which contributed to refining the system's components and addressing any challenges. Below is a detailed discussion of the results obtained from these testing phases.

5.1 Body Detection and Pose Estimation

One of the critical modules of the virtual try-on system is body detection and pose estimation, which form the foundation for accurate garment fitting. The system utilizes Deep Learning models like OpenPose and DensePos detect key body points such as the shoulders, hips, and knees. The results indicate a high level of accuracy in detecting body landmarks, which translates to better garment alignment and fitting.

Accuracy: Testing on different body types and poses showed an accuracy of over 90% in correctly detecting key body landmarks. This level of accuracy ensures that the garments are overlaid onto the user's image with minimal distortion or misalignment.

Pose Estimation: The system effectively handled various body postures, from standing straight to slightly bending, maintaining garment fitting integrity across diverse scenarios. The skeletal mapping and body measurement modules generated reliable data that supported accurate garment fitting.

5.2 Garment Rendering with GANs

The garment rendering component, powered by Generative Adversarial Networks (GANs), performed exceptionally well in generating realistic garment textures and simulating fabric behavior. The combination of AI- driven garment fitting and real-time rendering led to highly realistic try-on results.

Garment Realism: The use of GANs contributed significantly to the realism of the rendered garments. Textures like cotton, silk, and denim were simulated with a high degree of accuracy, ensuring that the virtual garments closely resembled their physical counterparts. User Feedback: Users noted that the garments appeared natural on their bodies, with the fabric adapting dynamically to their pose and body shape. This enhanced the sense of realism, making the virtual try-on experience more engaging and convincing.

Customization: Real-time garment customization (color, pattern, fabric type) also performed smoothly, with minimal lag during user interactions. The system was able to reflect changes almost instantaneously, contributing to an interactive and satisfying experience.

5.3 Real-Time Customization and User Feedback

The real-time customization module allowed users to modify garment details such as colors, patterns, and fab-rics. The system's ability to process these changes instantly and reflect them in the virtual try-on interface played a crucial role in enhancing user engagement.

User Engagement: Testing revealed that users spent significantly more time interacting with the system due to the ability to customize garments in real time. On average, users explored between 4-6 customization options before finalizing a garment, showing a high level of engagement.

Response Time: The system's response time for rendering customization changes was measured at less than 1 second, which ensured that users did not experience any frustrating delays while interacting with the interface.





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User Satisfaction: Feedback from the user testing phase indicated a 95% satisfaction rate in terms of the system's responsiveness and ease of use. Users appreciated the ability to see real-time updates on their customization choices.

5.4 AI-Driven Fashion Trend Prediction and Skin Tone Detection

The inclusion of the AI-Driven Fashion Trend Prediction and Skin Tone Detection modules was well-received by users and significantly improved the system's personalization features. These modules provide users with personalized recommendations, considering their skin tone and the latest fashion trends

Fashion Trend Prediction: This module successfully analyzed current fashion trends from online data sources such as social media and fashion websites. The system offered users up-to- date fashion sugges- tions, which increased the relevance and appeal of the recommended garments.

Skin Tone Detection: The skin tone detection module enabled the system to recommend garments and colors that complement the user's complexion. This personalized approach enhanced user satisfaction, with 80% of users that the color suggestions were helpful in their decision-making process.

Outfit Suggestions: The system not only suggested garments but also offered complete outfit recommendations, including accessories and shoes, which made the virtual try-on experience more holistic.

5.5 Performance Testing

In terms of system performance, the virtual try-on system was tested across various devices and network conditions to ensure smooth operation. The goal was to minimize lag during garment rendering and customization while providing real-time feedback.

Processing Speed: On average, the system took 0.8 seconds to generate and render garments after the image upload and pose estimation stages. This performance was consistent across devices such as desk- tops, tablets, and smartphones. Scalability: The system demonstrated high scalability, handling up to 1,000 concurrent users with no significant drop in performance. This indicates that the system can support large-scale deployments for commercial use.

Cross-Platform Compatibility: The system was tested on different platforms (web browsers, mobile apps), and the results showed that the system adapted seamlessly across devices, maintaining the same level of performance and user experience.

5.6 Overall User Experience and Future Enhancements

The overall user experience of the system was highly positive, with users particularly appreciating the realism and personalization offered by the virtual try-on system. The addition of features like skin tone detection and fashion trend prediction made the experience more personalized and relevant to individual users.

User Feedback: Most users reported that they felt more confident in making purchase decisions after using the system, as the virtual try-on provided a clear and realistic preview of how the garments would look on their bodies. Areas for Improvement: While the system performed well overall, some users suggested improvements in the system's ability to handle more complex garment designs, such as those with intricate patterns or textures like lace. Future enhancements will focus on refining the rendering of these more complex de- signs to further enhance the realism of the garments.

VI. DISCUSSION

The Virtual Fashion Fitting System demonstrates several strengths, particularly in its ability to offer a highly personalized shopping experience. The integration of AI- driven features like GANs (Generative Adversarial Networks) and LC-VTON (Context-Driven Virtual Try-On Network) has enabled the system to provide real- time feedback and interactive garment customization, creating an engaging and intuitive user experience. Users can modify garment attributes such as color, pattern, and fabric, with instant visual updates, which signif- icantly enhances user satisfaction and increases the likelihood of confident purchase decisions.

However, the system also faces some challenges, primarily related to image quality and specific garment types. Lowquality user images can affect the accuracy of body detection and pose estimation, potentially leading to inaccurate garment fitting. Additionally, certain garment types—especially those with complex designs, intricate patterns, or fabrics such as lacepose rendering challenges. The system's current capabilities, while robust, struggle with achieving a high level of detail in such cases, which may affect the overall user experience. Looking forward, future





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work will focus on: Enhancing the AI-Driven Trend Prediction Engine: This feature will be further refined to offer even more personalized fashion recommendations based on a wider variety of sources, including real-time data from fashion platforms and social media.

Exploring Advanced Garment Rendering Techniques: Incorporating more advanced techniques, such as 3D garment rendering and fabric simulation, will improve the system's ability to handle complex garment de- signs and materials, further enhancing realism.

VII. CONCLUSION

The Virtual Fashion Fitting System successfully addresses the challenges faced by online fashion shoppers by offering an engaging, interactive, and personalized experience. By integrating cutting-edge AI technologies. such as GANs, LC- VTON, and AI-driven trend prediction, the system provides seamless solutions for virtual try-on, real-time customization, and wardrobe management. The system's real-time feedback on garment customization, combined with body detection technologies like OpenPose and DensePose, ensures accurate garment fitting for various body types and poses. Additionally, the inclusion of skin tone detection and AI-generated fashion trends has elevated the system's ability to offer highly personalized fashion recommendations.

While there are areas for improvement—especially in rendering intricate garment designs and ensuring consistent image quality—the system's potential is vast. Future work will focus on addressing these challenges, making the system even more robust and scalable for large-scale commercial applications.

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