

AI-POWERED VIRTUAL TRY-ON SYSTEM FOR FASHION E-COMMERCE

¹Mrs. D. Kousari Kumari, ²Ms. A. Meghana, ³Ms. Ch.Akhila, ⁴Ms. D. Amulya, ⁵Ms. S. Shushma

¹Assistant Professor, Department of Information Technology, (^{2,3,4, 5}) B. Tech 4th year Students,
Information Technology, Vignan's Institute of Management and Technology for Women, Ghatkesar,
Telangana, India.

¹dkousarivm93@gmail.com, ²adulapurammeghana@gmail.com, ³chakhila2005@gmail.com,
⁴amulyasankalp8@gmail.com, ⁵sanangulashushma@gmail.com,

ABSTRACT

Fashion e-commerce is growing really fast these days. Customers can't actually try on clothes before buying them which makes things tricky. That uncertainty probably causes a lot of returns I suppose. This paper suggests using AI for virtual try-on setup. Users can see clothes on their own pictures that way. It pulls in computer vision and deep learning stuff along with pose estimation to make the simulations look real. The system mixes image processing and those diffusion models to keep the body shape right and the pose natural plus the fabric texture. It does not mess up the output much. Experiments show people feel more confident about buying and they engage better. Return go down too it seems.

For e-commerce sites this could be a good scalable fix. It makes shopping more personal and interactive kind of like trying things on without the hassle. Some details might get overlooked but overall it works.

Keywords— Virtual Try-On, Artificial Intelligence, Computer Vision, Deep Learning, E-commerce, Image Processing, Pose Estimation.

1. INTRODUCTION

Digital technology has changed the retail industry a lot, especially when it comes to selling clothes online. As the internet and smart gadgets have become easier to get, shopping websites have become more popular. Apart of our daily live that we need. On the internet shopping sites are great because they are easy to use, save you time, let you shop in other countries, and have a huge selection of products. People can shop in other countries, and have a huge selection of products. People can shop for clothes from anywhere and at any time. There are good things about shopping for clothes online, but there are also some big problems.

Shopping online has this big downside where you just can't try stuff on first. Like, in a normal store, you get to touch the clothes, feel the material and make sure it fits right and feels okay when you move around. That seems pretty important. But with websites, its all about reading descriptions and looking at those size charts plus some photos that don't really show everything. I think that why its tough to picture how something will actually look or fit on you, especially the size part, without having it right there. You end up guessing a lot.

People hesitate to click buy because of that uncertainty. It probably drops those conversion numbers they talk about, and yeah, more stuff gets

sent back later. Not sure if that the only reason, but it feels like a mess sometimes.

In this regard, consumer choice in the sphere of fashion purchasing is heavily dependent on visual appeal, personal preferences, and psychological factors. When shopping for clothes at traditional brick-and-mortar shops, consumers have the opportunity to instantly assess the way the item looks on them. In this case, consumers get a chance to evaluate the way an item looks from different perspectives and make a more confident purchase. Nevertheless, when shopping for clothes online, consumers should solely rely on pictures and descriptions and create an idea of that an item would look like in person. In this situation, customer expectations might differ from the one that a client expected to receive, this factor contributes to dissatisfaction and disappointment. Therefore, online fashion companies often face a problem of high return rates.

Artificial Intelligence (AI) has become an important tool for improving the online shopping experience. Technologists have developed complex algorithms that can create realistic representations of products and their interactions in a simulated virtual environment. They use AI along with computer vision and deep learning technologies. One major product innovation made possible by these technologies is virtual try-on technology. This technology allows customers to see how clothing will look on their

bodies, reducing the uncertainty that come with making online purchases.

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2. RELATED WORKS

Lately, there's been a lot of talk about how artificial intelligence is changing things in fashion online shopping. People want more personal touches and ways to interact, like trying stuff on without going to a store. I think researchers are using machine learning and deeper tech to make customers stick around longer, see products better, and maybe cut down on all those returns. It's sort of bridges what you get in a real shop with the digital side, using data to make it feel more real.

Early on, virtual try-on stuff was pretty basic. They just put 2D pictures of clothes over photos of people. Easy to set up, but it did not look right most of the time. Things like alignment were off, and it did not work well for different bodies or how you stand. So the results came out unnatural,

which made it hard to really use in actual shopping. That is why newer ways are focusing on 3D models and augmented reality. These let clothes fit better by thinking about depth and how the body is shaped, plus where things are in space. Users can make their own 3D avatars, like a digital version of themselves. It seems like that helps a ton with making it more accurate, though I am not totally sure how all the details work together yet. Some approaches still have kinks, but overall it pushes toward better experiences. Virtual try-on stuff has gotten way better with things like 3D models of people. These models let you see how clothes might fit and move around. It is kind of neat how that works.

Then there is AR, where you overlay clothes right on a live camera feed. That makes it feel real time, and users get more into it, I suppose. Engagement goes up because you can see it happening as you move.

Deep learning is a big part of why these systems look so good now. Like GANs, they use two networks that compete to make fake images that seem real. Diffusion models take it further by building the image step by step, refining it along the way. Both help keep details like how fabric looks or lighting on the body. Without that, outputs just do not feel natural.

I am not totally sure, but reinforcement learning seems useful for predicting what people do next. RL systems learn from how users interact over time and adjust. In online shopping, it models buying habits to suggest stuff personally. The problem is, it needs tons of data and a lot of computing power. Real time use is tough unless you optimize a bunch.

That exploration versus exploitation thing in RL makes accuracy hard to keep steady. It is a real challenge there.

A quick look at different AI ways to analyze human behavior shows.

Research	Method	Limitation	Key Contribution
Jara et al. (2021)	SIoT, Complex Network Theory	Lacks real-time processing	Real-time behavioral insights via IoT and social data
Zhang et al. (2022)	CNN, RNN	Computationally intensive	High accuracy in behavior prediction
Wang et al. (2020)	Hadoop, Spark	Hadoop suffers from latency	Efficient analysis of mobility and congestion patterns
Lee et al. (2019)	Decision Trees + Deep Learning	Needs continuous updates	Enhanced fraud detection in online behaviors
Kim et al. (2023)	Reinforcement Learning	High data/computation requirements	Adaptive behavior modeling in recommendation systems
Sharma et al. (2021)	Encryption, Anonymization	Trade-off between utility and privacy	Secures sensitive behavioral data
Patel et al. (2022)	Apache Spark, Hive	Integration complexity	Faster real-time decision-making using Big Data
Gupta et al. (2020)	Natural Language Processing (NLP)	Challenges in context understanding	Emotion detection from social media content
Ahmed et al. (2021)	GPS Data, Machine Learning	Environmental variability	Accurate human mobility prediction in smart environments
Tan et al. (2022)	IoT Sensors, Data Fusion	Sensor reliability and fusion complexity	Improved activity tracking with sensor integration
Kumar et al. (2023)	AI, Deep Learning	Interpretability issues	Early disease prediction based on behavioral analysis

TABLE I. COMPARISON OF AI-BASED HUMAN BEHAVIOR ANALYSIS TECHNIQUES

3. PROPOSED METHODOLOGY

A. Existing System

Most e-commerce sites today use static product images, size charts, and customer reviews to help people decide what to buy. These methods give you basic information about the product, but they don't give you a personalised and realistic picture of how the item would look on you. This limit makes it hard for customers to make decisions and lowers their overall confidence when shopping online.

Old virtual try-on systems tried to solve this problem by using simple 2D image overlay methods. In these systems, pictures of clothes are placed directly on top of pictures of people without taking into account their body shape, pose, or depth. Because of this, the outputs that are made often look fake and out of place, with no proper fitting or natural look. These systems also have a hard time adjusting to different body shapes, lighting conditions, and complicated poses, which makes them less useful in real life.

Disadvantages of the Existing System:

- Lack of realistic and accurate visualization
- High product return rates due to poor fit estimation
- Limited personalization for individual users
- Inability to handle diverse body shapes and poses
- Low user engagement and satisfaction

B. Proposed System

To overcome the limitations of existing approaches, the proposed system introduces an advanced AI-based virtual try-on framework designed specifically for fashion e-commerce applications. This system enables users to visualize garments on their own images in a realistic and interactive manner.

The proposed framework integrates computer vision and deep learning techniques to analyze user images and accurately align garments with the body structure. It preserves important features such as pose, body shape, and identity while generating high-quality outputs. By leveraging modern image generation

models, the system produces visually consistent and natural results that closely resemble real-world appearances.

Additionally, the system is designed to be scalable and adaptable, making it suitable for integration into modern e-commerce platforms. It enhances user confidence during purchasing decisions and contributes to reducing return rates.

Advantages of the Proposed System:

- Realistic and high-quality garment visualization
- Enhanced user experience and engagement
- Reduction in product return rates
- High accuracy in garment alignment and fitting
- Scalable and efficient for real-time applications

C. Proposed Methodology

The proposed methodology consists of multiple stages that work together to generate accurate virtual try-on results. These stages include image preprocessing, pose estimation, garment alignment, and final image generation.

Initially, the user uploads an image, which is preprocessed to remove noise, normalize lighting conditions, and prepare it for further analysis. The system then applies pose estimation techniques to extract key body points such as shoulders, arms, and torso. These keypoints help in understanding the posture and orientation of the user.

Simultaneously, the garment image is processed and prepared for alignment. Using the extracted body keypoints, the garment is adjusted and mapped onto the user's body structure. A deep learning-based virtual try-on model then combines both inputs to generate a realistic output image. This process ensures that the garment fits naturally while maintaining visual consistency in terms of texture, shading, and proportions.

D. System Architecture

The architecture of the proposed system is designed in a modular and layered manner to ensure efficiency and scalability. It consists of three primary components:

- **Input Layer:** This layer accepts the user image and garment image as inputs. It serves as the entry point of the system.
- **Processing Layer:** This layer performs core operations such as image preprocessing, pose estimation, feature extraction, and model inference. Advanced deep learning models are utilized in this stage to analyze and process the data.
- **Output Layer:** The final layer generates the virtual try-on image, where the selected garment is realistically visualized on the user's body.

Virtual Try-On System Architecture Diagram

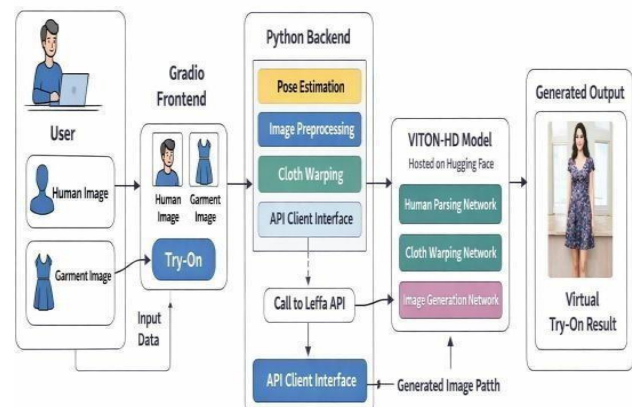


Fig1: System Architecture

E. Virtual Try-On Using Deep Learning

The proposed system leverages multiple deep learning and computer vision models to achieve realistic virtual try-on results.

- **Pose Estimation (MediaPipe):** This module detects key body points from the user image, enabling accurate understanding of body posture and alignment.
- **Diffusion Model (Leffa):** A diffusion-based image generation model is used to create high-quality and realistic try-on outputs. It ensures proper blending of garments with the user image while maintaining fine details.
- **Image Processing (OpenCV):** OpenCV is used for preprocessing, enhancement, and final blending of images. It improves visual quality and ensures smooth integration of garment and user image.

4. RESULTS

The proposed AI-powered virtual try-on system was evaluated based on its ability to generate realistic and visually consistent images by combining user inputs with selected garment images. The system successfully produces high-quality outputs that preserve key attributes such as the user's identity, body posture, and background while accurately aligning the clothing with the detected body structure.

The generated results demonstrate significant improvement over traditional virtual try-on methods, particularly those based on simple 2D overlay techniques. Unlike conventional approaches, the proposed system ensures proper garment fitting by

utilizing pose estimation and deep learning models, resulting in more natural and realistic visualizations. The alignment of garments with different body poses and orientations further highlights the robustness of the system.

Qualitative analysis of the output images indicates that the system effectively maintains texture details, lighting consistency, and proportional scaling of garments. The integration of diffusion-based models enhances image quality by reducing distortions and ensuring smooth blending between the garment and the user image. This leads to outputs that closely resemble real-world appearances.

In addition to visual improvements, the system contributes to enhanced user experience in e-commerce platforms. By providing realistic try-on previews, users gain better confidence in their purchasing decisions, reducing uncertainty related to size and fit. This improvement is expected to decrease product return rates and increase customer satisfaction.

Furthermore, the system demonstrates efficient performance in handling diverse inputs, including variations in user poses, clothing types, and image conditions. The use of optimized deep learning models and image processing techniques ensures that the system remains scalable and suitable for real-time applications.

Overall, the experimental results validate the effectiveness of the proposed methodology in improving visualization quality, enhancing user engagement, and addressing key challenges in online fashion retail.

5. CONCLUSION

The proposed AI-powered virtual try-on system presents an effective and innovative solution to the challenges faced in online fashion e-commerce, particularly the inability of users to physically try on garments before purchase. By enabling users to visualize clothing items on their own images, the system significantly reduces uncertainty related to size, fit, and appearance, thereby improving purchasing confidence and decision-making. The integration of advanced Artificial Intelligence techniques, including computer vision and deep learning models, allows the system to generate realistic and high-quality outputs while preserving user identity, body pose, and overall image consistency, resulting in a more natural and personalized shopping experience. This enhancement not only increases user satisfaction and engagement but also contributes to reducing product return rates, which is a major concern in e-commerce platforms. Furthermore, the system demonstrates

the transformative potential of intelligent technologies

in bridging the gap between online and offline retail experiences, making digital shopping more interactive and efficient. Although the proposed approach shows promising results, future improvements can focus on enhancing real-time performance, handling complex poses and diverse body types more effectively, integrating augmented reality for live try-on experiences, and ensuring better computational efficiency and data privacy. Overall, this research highlights the significant role of AI-driven virtual try-on systems in revolutionizing the fashion e-commerce industry and paving the way for more advanced, user-centric digital solutions.

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