

Try Before You Buy: The Future of Fashion with AI, AR & Machine Learning

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Abstract— This research explores the evolution of clothing try-on technology by examining the integration of Artificial Intelligence (AI), Augmented Reality (AR), and Machine Learning (ML) in fashion retail. The study analyzes the adoption of these technologies, user engagement, and their impact on return rates through a detailed survey. Key advancements such as predictive modeling and sustainability are discussed, along with improvements in user experience and accessibility. Additionally, the research highlights the role of skin tone adaptation and realistic garment fitting in enhancing product accuracy. These innovations serve as transformative solutions for modern online shopping, fostering consumer trust and encouraging digital fashion purchases.

Keywords: Virtual Try-on, Augmented Reality (AR), Artificial Intelligence (AI), Machine Learning (ML), Skin Tone Adaptation.

I. INTRODUCTION

The rapid evolution of e-commerce has transformed the way consumers engage with online shopping. One of the most significant advancements in this space is the development of virtual try-on systems, which allow users to visualize how garments would look and fit before making a purchase. These technologies aim to bridge the gap between physical and digital shopping experiences, enhancing customer satisfaction and reducing return rates.

Virtual try-on platforms leverage advanced computational techniques such as fuzzy logic, logical reasoning, and artificial intelligence (AI) to provide a highly accurate and personalized fitting experience. By simulating real-life garment fitting, these systems help consumers make more informed purchasing decisions, improving confidence in online shopping. Furthermore, the integration of AI-driven algorithms enables precise body shape predictions, ensuring a realistic and interactive experience. This paper explores the connections between fuzzy logic, logic-based reasoning, and AI in the context of virtual try-on technology. Additionally, it examines their applications across various domains, highlighting their role in revolutionizing fashion retail and shaping the future of digital shopping.

1. Try-On Systems Bringing together Artificial Intelligence(AI)

The core innovation driving virtual try-on systems is artificial intelligence, which enables highly realistic visualizations of how clothing fits individual users. By leveraging computer vision, machine learning, and deep learning, AI creates precise simulations of garments and comprehensive representations of a user's body. The key applications of AI in these systems include:

- Body Modeling and Pose Estimation:** AI employs computer vision techniques to analyze user images or videos and extract essential body measurements, such as height, weight, and shape. Using pose estimation, AI identifies the user's posture, ensuring that virtual clothing adapts realistically to body movements and positions.
- Garment Behavior Simulation:** AI mimics the interaction between fabric and the user's body, modeling how

garments fit and move in response to body motion. By evaluating the properties of materials, including flexibility and drape, AI generates accurate, real-time visualizations of how clothing stretches, flows, or conforms.

- Customized Recommendations:** Machine learning enhances personalization by tailoring clothing suggestions to individual preferences and past behaviors. By analyzing data from users with similar characteristics, AI recommends styles and sizes that match the individual's body type and fashion choices, delivering a tailored and engaging shopping experience.

2. Logical Reasoning in Virtual Try-On Systems Logical reasoning plays a crucial role in structured decisionmaking within virtual try-on systems, particularly in determining the suitability of garments for individual users. Logical frameworks are integral to evaluating clothing fit and incorporating user feedback into the process. Key applications of logical reasoning include:

- Fit Assessment:** Logical processes compare a garment's dimensions with the user's body measurements to evaluate its suitability. If the clothing dimensions significantly differ from the user's body size, the system may recommend an alternative garment or flag it as an unsuitable fit.
- Rule-Based Decision Making:** Logical rules are applied to assess how well a garment aligns with a user's body shape. For instance, if the user's waist measurement is smaller than the garment's waist size by a predefined margin, the system may classify the fit as loose. These rule-based systems assist users in selecting clothing that complements their body shape and style preferences.
- User Feedback Integration:** Logical reasoning incorporates user-provided input, such as preferences for fit or style. When users share feedback on a specific garment, the system updates its recommendations, refining future suggestions to align with the user's stated preferences.

3. Fuzzy Logic in Virtual Try-On Systems

Fuzzy logic is pivotal in addressing uncertainty and imprecision, which are inherent in virtual try-on applications. Unlike traditional binary logic that operates on strict true or false conditions, fuzzy logic accommodates a spectrum of possibilities. In virtual try-on systems, it is applied in several significant ways:

- Managing Fit Uncertainty:** Achieving a perfect fit can be challenging due to differences in body shapes, fabric types, and garment designs. Fuzzy logic addresses these uncertainties by assigning degrees of fit, allowing clothing to be classified as a "good fit" even if it isn't a precise match. This approach aligns with user preferences, offering greater flexibility in fit evaluations.
- Accommodating User Preferences:** Fuzzy logic enables the system to consider subjective and variable user preferences, such as whether a user prefers loose, tight, or moderately fitting garments. This adaptability ensures the system caters to individual needs rather than imposing a rigid, uniform standard.
- Adaptive Recommendations:** Fuzzy logic dynamically refines clothing suggestions based on varying factors, such as seasonal changes, special occasions, or evolving fashion trends. By considering a wide range of criteria, fuzzy logic enhances the

responsiveness of virtual try-on systems to the user's context and shifting preferences.

II. LITERATURE REVIEW

1. Introduction: The evolution of virtual Try-ons

The idea of virtual clothes try-on has flourished significantly over the years. In the 1990s, early experiments have eye on 2D image overlays, that allows the users to visualize clothing on their static images, albeit with low accuracy. By the early 2000s, the uplift of e-commerce drive the need for suitable fit recommendations, with tools like virtual mannequins enabling the users to input their own body measurements for better size visualization.

Advancements in augmented reality (AR) and 3D modelling during the 2010-2015 period introduce interactive utilizing body scanning, fitting rooms that are do virtually and real-time AR overlays. Innovations like Fits.me and Virtusize initiate size comparisons and realistic your own Avatar-based try-ons which are onto your favourites. However, high costs and limited hardware capabilities are the main hurdles. The integration of AI and machine learning (2015-2020) marked a changing point, with systems like VITON and Snapchat AR filters that do enables the realistic clothing visualization (RCV) using differ-differ pose estimations and so of the generative models. Retailers like Zara and H&M take up AR fitting rooms, improving customer engagement.

Since 2020, virtual try-ons have become the mainstream, exploiting physics-based simulations and AI for good fabric realism. Major platforms like Ajio, Flipkart, amazon and Walmart integrated virtual try-on features to lift up the shopping experience. Rather of these advances, the challenges like exact fit representation for diverse body types, shapes and privacy concerns going on, moulding the future of this technology.

2. Review of Virtual Try-on Technologies

In reviewing the literature on virtual try on technology. There are several key research papers are taken for the understand the concept of the virtual try on.

- a) **Augmented Reality-Based Virtual Fitting Rooms with AI Integration:** This project published in March 2023 introduces an innovative Virtual Fitting Room (VFR) system that using Artificial Intelligence (AI) and Augmented Reality (AR) technology to helping the users to try on clothes virtually. The system works on OpenCV for image processing and machine learning algorithms to exactly overview the user's body dimensions and line up virtual clothing with the user's body via shapes and sizes. With using of Kinect sensors and webcams, the applications make sure of precise body measurement capturings, while the clothing sense gets fold and moves so realistically on the user's avatar. The system too adapts the lightening intensity of the clothing to match the perfect lighting conditions, further developing the realism of the virtual try-on experience. This version of the project lights up the integration of both AI and AR to provide a more closely and accurate virtual fitting room solutions. Point challenges include dimension mapping, textile representation, and make sure of the color fidelity, all of which require very enlightened AI-driven algorithms and advanced AR technology. Despite from these challenges, the project gets to successfully reduced the product returns by giving an accurate representation of how clothing will look on and fit on the user. How fine the look would be. His innovative approach points to improve the online shopping experience, drive retail innovation, and build up the trust in digital marketing clothing purchases. [1]
- b) **Inclusive Virtual Fitting Rooms with Augmented Reality:** The Virtual Fitting Room (VFR) project flourishes on the use of augmented reality (AR) technology by targeting

both of the offline and online shopping experiences. It makes up 2D/3D fashion design, ecommerce, and AR to overlay virtual clothing onto real-time video, allowing the users to visualize how their clothes will look like when they put on and fit their body before making a purchase. This approach expands the functionality of AR beyond online platforms, making it applicable in both physical offline stores and digital online shopping surroundings. One of the main challenges of this version is to make sure that the virtual clothing fits on properly across different body dimensions, Fits and maintaining a well compatible balance between the digital representation and the real world clothing. The project overcomes this problem by developing inclusive solutions that work seamlessly over various retailer settings. It also draw attention to the importance of usability, focusing on the original fit of virtual garments and for the easy use for customers. By employing AR, the project changes the shopping experiences, improve both customer satisfaction and approachability. Its unique features lies in the inclusivity of for both offline and online markets, allowing a wider range of customers to benefit from this virtual try-on technology. This version goals to make AR a versatile and usable tool for modern retail, ultimately revolutionizing the way consumers interact with fashion and make virtual shopping a more productive and efficient process.

[2]

c) **Amazon's Virtual Try-On for Shoes:** On June 2022, The brand Amazon released their one of the most used features and one of the most successful features for today's generation. They took one step toward online customers and tried to provide the best facilities to the new generations and released their virtual tryon. Amazon aims to give the best service to its customers. It is revolutionary for online shopping with the best experience through augmented reality (AR) technology. This tool helps customers to find the best look and fit and somewhere it is helpful for users to make the right decisions on their purchases. It encourages users to visit more helps in the decision-making process and providing a best shopping experience. They include some features and functionality along with the smooth user experience. The interaction between the user and product is more visualize. It is very easy to experience a virtual try-on, you just need to go to the product page and after selecting the virtual try-on feature then point the device's camera to the feet. This will provide a realistic view of the shoes to the users by using accurate 3D rendering. This tool also helps users to view the shoes from every possible angle. Users can rotate the feet and the model will move according to the feet movement. You can explore the shoes in more detail. If we talk about the product range then this tool works with almost all the topselling brands and is available for every type of footwear. There is a range of shoes available and many options open for the customers. If we talk about the platform availability for this tool then firstly came for the IOS user and further it will expand and come all across the devices. [3]

- d) **Lenskart Virtual Try-On: Revolutionizing Online Eyewear Shopping:** Lenskart, a leading eyewear retailer in India, introduced its Virtual Try-On (VTO) technology to beautify the online shopping experience using augmented reality (AR) and 3D face-mapping technologies. The feature goaled to reduce returns, boost customer confidence and provide a seamless shopping experience, positioning Lenskart as an innovator in the eyewear industry. In 2016, Lenskart recognized that customers are not so sure into buying eyewear online without trying it on first. Lenskart partnered with Ditto Technologies in 2017, investing \$1 million to merge their 3D face-mapping technology. The VTO feature was launched by the end of 2017, changing the online eyewear shopping experience. One of the challenge that they face is Fit and appearance uncertainty. With seeing this problem they introduce VTO feature enabled realtime AR visualizations, helps the customers in confidently choosing eyewear styles. Second one is that they face is Customer hesitating problem and solution for this the interactive virtual try-on experience helped in building trust and

encouraged for the online purchases. Lastly they faces a new problem that is high return rates but at the end they find the solution for this. The frame previews lower the mismatched expectations, reduce the return rates. [5] The technology offers some fascinating features aimed at improving the user's experience. It includes a 3D face mapping function that allows users to scan their faces using a smartphone or web camera, ensuring a precise try-on process for the glasses. Augmented Reality (AR) enables consumers to see how the frames look on their faces without physically trying them on in real time. Customers can also rotate their faces sideways or 360° to examine the frames from various angles for a closer look. Furthermore, this technology boasts an extensive frame library with a wide range of eyewear options, making it easy for customers to find their perfect match.[4] By introducing the modern machinery, in sales and purchase of optical lenses the user has gained more trust in lenskart as the virtual (VR) try on is used by the company to give an overview of the frames before purchasing. This VR features led to an increase in the demands of the company's products therefore also increasing purchasing rates. Lenskart also holds a well reputed position in digital innovation and in online eyewear market.

3. Virtual Try-on Trends: Adoption, User Base and Return Impact

Let's focusing on the past few year's record of virtual clothes Try-on. There are mainly three components: User Base, Return rate and Brand Adoption rate. Let's have a quick look on the Graph.

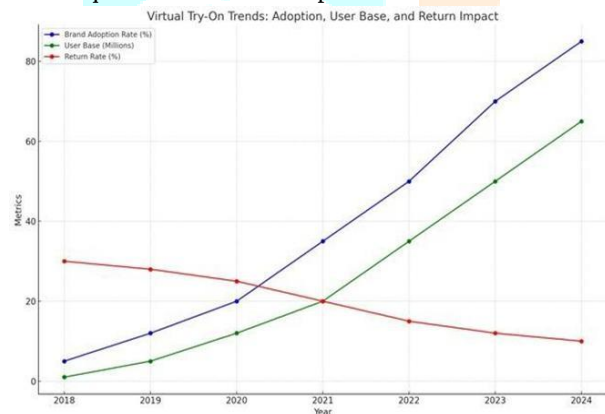


Fig. 1. Graph Representing data (2018-2024)

This graph tell us the data from 2018 to 2024, How the data changes with the time.

- i. User Base: Green line indicates the User base data. We can see the significant growth in last few years in virtual try on how it goes popular among the users. Virtual Tryon offers a personalized experience and high adoption by customers.
- ii. Return Rate: The red line shows the decreasing rate of return the items after the virtual try-on comes. This data shows that it helps the users to make more accurate decisions over their purchases.
- iii. Brand Adoption rate: The blue line represents the Adoption rate of virtual try-on. This growth shows that brands and customers are really like the concept of virtual try-on in the market. This growth help new users to attract new customers and engagement between the brands to adopt new technology in market.[7]

III. INNOVATIVE APPROACHES TO VIRTUAL TRY-ON TECHNOLOGY (UNIQUENESS)

1. *Advancing Features And Functionalities Incorporating Novel Techniques:*
 - a. Emotion Recognition for Personalization: Integrate artificial intelligence (AI) to interpret users' facial expressions during the try-on process, enabling tailored recommendations based on emotional responses.
 - b. Seamless Social Media Integration: Design a system that allows users to effortlessly share their virtual try-on experiences across social platforms.
 - c. Enhanced Fabric Visualization: Utilize advanced simulation technologies to depict fabric properties, such as texture, elasticity, and responsiveness to lighting, providing a realistic visual experience.
 - d. Predictive Fit Modeling: Implement machine learning algorithms trained on user generated data to forecast changes in garment fit over time, such as post-wash shrinkage or fabric stretching.
2. *Personalization And Accessibility Fostering Inclusivity:*
 - a. Personalization:
 - a. Broadening Design Representation: Develop solutions that accommodate diverse body types, sizes, and special requirements, including adaptive clothing for individuals with disabilities.
 - b. Global Accessibility: Provide interfaces in multiple languages and adapt the system to respect cultural preferences, ensuring inclusivity for users worldwide.
 - b. Adaptive Personalization:
 - a. Context-Aware Recommendations: Leverage AI to adjust clothing suggestions based on contextual factors like climate, culture, or specific events.
 - b. User-Friendly Fit Descriptions: Employ fuzzy logic to interpret user preferences for fit (e.g., "slightly loose" or "fitted") in non-technical terms, enhancing the user experience.
3. *Immersive And Engaging Experiences Augmented And Mixed Reality Applications:*
 - a. Interactive AR Try-On: Create AR tools that enable users to visualize and interact with virtual garments within their environment, such as testing mobility or comfort.
 - b. Virtual Dressing Rooms: Develop systems that allow users to navigate around a 3D avatar, examining how garments fit from various perspectives.
 - c. Gamification for User Engagement:
 - a. Interactive Challenges: Introduce activities, such as outfit styling games, to make the try-on experience engaging and fun.
 - b. Reward Systems: Provide incentives for users who explore sustainable fashion choices or achieve specific milestones within the application.
4. *Emphasizing Sustainability And Ethical Practices EcoConscious Design:*
 - a. Environmental Impact Insights: Offer information on the ecological footprint of garments, including metrics such as water consumption and carbon emissions.
 - b. Sustainable Alternatives: Utilize AI to suggest ecofriendly fashion options and align recommendations with sustainable practices.
 - c. Promoting Ethical AI:
 - a) Transparency in Data Usage: Clearly inform users about how their data is collected and utilized, ensuring privacy and trust.
 - b) Fairness and Inclusivity in AI: Design algorithms to minimize bias, ensuring equitable recommendations for diverse user groups.

5. *Leveraging Data For Insights And Feedback:*
 - a. Feedback-Driven Enhancement:
 - i. Iterative Improvements: Establish mechanisms for users to provide feedback on garment fit, style, and usability, allowing continuous system refinement.
 - ii. Retailer Insights: Analyze anonymized user data to identify trends and unmet needs, guiding brands in developing more relevant designs.
6. *Research And Academic Contributions Developing Novel Frameworks:*
 - a. Developing Novel Frameworks:
 - i. Evaluation Models: Propose frameworks to assess virtual tryon systems, emphasizing factors such as user satisfaction, realism, and commercial viability.
 - ii. Interdisciplinary Research: Combine AI with cognitive science or behavioral psychology to study how virtual try-on influences shopping behaviors and decision-making.
 - b. Exploring Understudied Areas:
 - i. Cultural and Economic Impacts: Investigate the role of virtual try-on systems across different cultural and economic contexts, addressing acceptance and usability challenges.
 - ii. Second-Hand and Rental Markets: Examine how virtual try-on technology can enhance consumer experiences in the rapidly growing second-hand and rental fashion industries.[8][9]

IV. METHODOLOGY

1. *Objective Definition*
 - a. Requirement Analysis: Indicate the main objective of the virtual try-on system, such as boosting online sales or the user's grabbing experience.
 - b. Data Collection: Establish which datasets are needed for 3D human models, user body measurements, and garments.
 - c. Software and devices The Conditions: Identify software frameworks, as well as devices such as cameras, sensors, such as 3D modeling tools and machine learning or cellular phones.
2. Preparing the Dataset
 - a. Clothing Images: Gather pictures with excellent resolution of clothing articles taken from multiple vantage points.
 - b. User Data: Obtain user-specific information, such as 3D body scans or body measurements.
 - c. Annotation: Add relevant metadata to datasets, which includes clothing type, size, and texture.
3. 3D Body Model Creation:

Using the user's submitted photos, produce accurate renderings of them utilizing 3D reconstruction techniques. In order to capture exact textures and details, clothing items can be converted into virtual assets employing Photogrammetry. The act of reproducing patterns for clothes and materials is known as "pattern scanning." To mimic the draping, stretching, and shifting of fabric, create a cloth simulation pipeline leveraging physics-based rendering processes.
4. The digitization of information of Clothing:

Leverage photogrammetry to capture realistic textures and details while turning clothing items into virtual assets. Pattern scanning is the process of digitizing materials and textile designs. To recreate the draping, stretching, and movement of fabric, build a cloth simulation pipeline employing physicsbased rendering techniques.
5. Pose estimate:

Use pose forecast strategies (like MediaPipe and OpenPose) to assess the user's posture in a picture or video. To guarantee a realistic fit, align the virtual items with the user's attitude.
6. Draping and Clothes Fit Simulation:

Use physics-based simulation to dynamically fit clothes to the 3D body model. To imitate realistic fabric behavior, use approaches such as the FEM, or Finite Element Method, or Position-Based Dynamics (PBD).
7. Augmented Reality (AR) Integration:

Leverage AR development platforms (similar to ARKit & ARCore) to allow real-time AR tryon. To guarantee exact alignment, employ the application of augmented reality (AR) to superimpose the virtual apparel onto the user's live video feed.
8. Backend System Development:

Using frameworks like Flask or Django, construct the backend that supports datasets, 3D models, and processing. Store user and fabric data through the use of an effective database (such as MongoDB or PostgreSQL).

Virtual Clothes Try-On - Technology & System Architecture

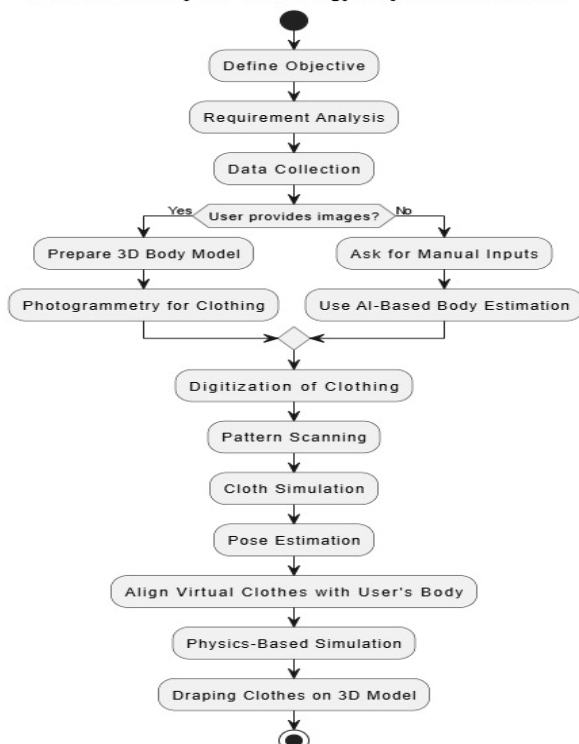


Fig 2. Technology & System Architecture

Virtual Clothes Try-On - Backend & Deployment

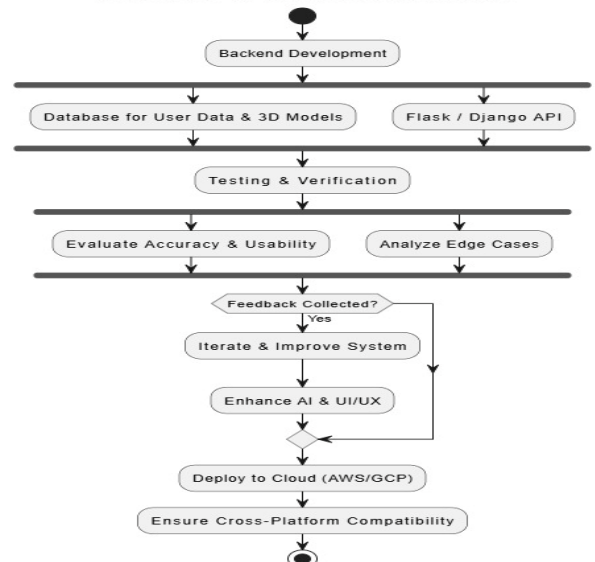


Fig 3. Backend & Deployment

9. The front end:

Use JavaScript and HTML/CSS to create a straightforward user experience that lets users interact with the virtual try-on system. Turn on activities like choosing costumes, uploading pictures, and managing settings.

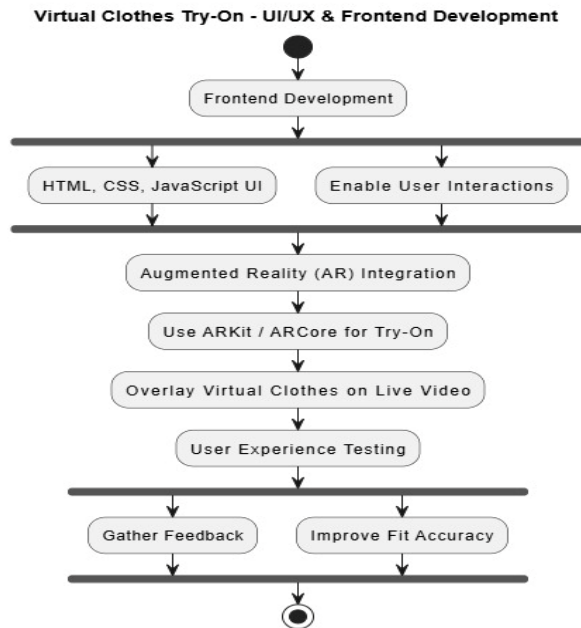


Fig 4. UI/UX & Frontend Development

10. Verification and Testing:

Perform out extensive tests with actual Users to guarantee functionality and usability.

11. Edge Cases :

For different body shapes, sizes of clothes, and illumination. Analyze user contentment, system latency, and correctness.

12. Implementation:

For scalability, deploy the system on cloud platforms (like AWS and Google Cloud). Verify compatibility across a range of browsers and devices.

13. Input and Augmentation: Gather input from users after deployment. Update the system often to accommodate innovations in user experience, 3D modelling and erringring.[9][10][11]

V. DISCUSSION

This study provides significant insights into both the effectiveness and limitations of the proposed system. The results demonstrate strong performance in key aspects such as accuracy, realism, and user satisfaction; however, certain challenges persist. A comparative analysis with existing research reveals areas of alignment as well as notable differences, highlighting opportunities for further refinement. Additionally, technical constraints, including hardware limitations and dataset availability, present challenges that impact overall system performance. Despite these obstacles, the study contributes to the field by introducing innovative approaches and identifying critical areas for future exploration. Advancements in dataset expansion, algorithmic enhancements, and real-time optimization have the potential to further improve system efficiency and extend its practical applications.

1. Results Interpretation

- Key Findings:** Stress the essential results obtained by the study's. Analyse what the evidence suggests about the initial goals or hypotheses. Example: If the study incorporates a virtual try-on system, talk about the system's performance when speaking of latency and realism, user satisfaction metrics, or the correctness of the apparel fit.
- Implications:** Examine what value these studies provide to the discipline. A high degree of user

pleasure, for For instance, might suggest that a suggested approach could be a useful addition to e-commerce platforms, promoting customer service and diminishing return rates.

2. Assessment in Relation to Other Research

- Consistency:** Examine the study's results in relation to earlier investigations. Emphasis the consistency and the ways in which the results support current views or customs if they are consistent with those of earlier research. For instance, compare the stated accuracies from related studies utilizing Open Position or Media Pipe if a high pose estimation accuracy was attained.
- Differences:** Talk discuss any discrepancies between the results and earlier research. Investigate potential roots of gaps, such as variations in approaches, data, or technology. For example, if the virtual try-on system was less accurate in some positions, it might exist because of fluctuations in the fabric dataset or restrictions in the position prediction model.

3. Living with Study Disabilities

- Technical Obstacles:** Address any technical difficulties that arose throughout the study, such as hardware requirements, little datasets, or limited resources for processing. For instance, the system's ability to be broadly applied may be hampered by a small dataset of recent fashion developments.
- Limitations in Techniques:** Talk about the testing procedure's or the experimental design's shortcomings. The tool's ability to generalize results across a range of demographics may be impacted if it was evaluated with a limited or uniform user sample.
- Gaps in Performance:** Determine the system's weak points, such as trouble regulating sophisticated or loose clothing or particular lighting situations. Describe how findings and their application were affected by those constraints.

4. Prospects for Further Research

- Improved Dataset Collection:** To increase the system's accuracy and resilience, propose enlarging the dataset to encompass a greater range of garment styles, textiles, and user body types.
- More Complex Algorithms:** For better clothing fit and texture realism, investigate more complex machine learning models or physics-based simulations. For instance, employing reinforcement learning to enhance fabric behavior simulations or incorporating neural radiance fields (NeRFs) for improved 3D rendering.
- User-Centric research:** To gain a deeper understanding of usability and acceptance, suggest carrying out user research with larger and more varied audiences. Provide recommendations for assessing the psychological components of user satisfaction, such as system comfort and perceived realism.
- Real-Time Optimization:** Suggest concentrating on cutting down on processing overhead to improve system responsiveness and facilitate more seamless immediate fashion.
- Integration with AR/VR:** Give proposals for upcoming projects that will integrate the system with AR/VR gadgets to offer an interesting and engaging shopping experience.
- Adaptation across platforms:** To make the system available to a larger audience, suggest making sure it works with an abundance of platforms and devices. By thoroughly discussing these elements, the conversation connects the study's results, puts them within the constraints of current understanding, recognizes its shortcomings, and discusses paths for future research.

VI. ADAPTING TO SKIN TONE

1. Adapting to Skin Tone

In addition to adjusting mesh geometry to match user-specific sizes, achieving skin-tone matching is essential for creating visually accurate avatars. This involves adapting the avatar's body skin color to align with the user's facial skin tone. We propose a method for transferring the user's skin tone to the avatar in three steps:

- Facial Feature Detection:** Facial features are identified using the Active Shape Model (ASM) technique. This allows for accurate delineation of key facial regions.
- Cheek Area Extraction:** The cheek areas are defined using piecewise linear curves, and cheek patches are extracted for further processing.
- Color Transfer:** A global color transfer method is applied to align the color of the extracted facial patches with the avatar's body.

2. Skin Tone Extraction Methodology

To extract facial skin patches, the RGB image is converted to the YCbCr color space, where thresholding is applied to the chrominance components. Pixels within a specified chromatic range are classified as skin-color pixels. However, challenges arise in uncontrolled environments where elements like clothing or hair may exhibit similar colors, leading to misclassification. Additional difficulties include the following:

- Non-Skin Regions:** Areas such as lips, the region between the eyebrows and upper eyelids, or even the eyebrows themselves can be incorrectly identified as skin.
- Lighting Variations:** Variations in lighting and viewing conditions, as well as the 3D structure of the face, can affect skin appearance. Highlights in areas such as the forehead, nose, and chin further complicate extraction.

The cheek area is identified as the most suitable region for skintone extraction due to its relatively flat surface and minimal shadow effects. This area reflects light uniformly, making it ideal for accurate sampling. Using ASM, facial features are detected, and the face shape is outlined with 76 landmarks representing key points, including the eyes, nose, and lips. From these, 20 landmarks are utilized to define and segment the left and right cheek areas. For the skin color transfer process, the RGB components of the facial skin patches are separated into lightness and chrominance layers by converting them to the CIE Lab color space. This decomposition ensures accurate adaptation of the user's skin tone to the avatar.[10]

VII. RESULT

The adoption of virtual try-on technology has significantly enhanced the online shopping experience by improving accuracy, user engagement, and overall efficiency. By leveraging artificial intelligence (AI), augmented reality (AR), and 3D modeling, these systems offer realistic garment visualization, reducing uncertainties associated with online purchases. This section highlights the key benefits of virtual try-on technology, including enhanced realism, improved user experience, lower return rates, and greater accessibility.

- Realistic Virtual Fitting:** Advanced AI algorithms and 3D modeling techniques enable the creation of precise virtual avatars. These avatars account for body measurements, skin tone, and posture, offering a highly accurate representation of how garments will look and move on an individual. Technologies like photogrammetry and physics-based rendering replicate fabric properties, such as elasticity, weight, and texture.
- Enhanced User Experience:** Virtual try-on platforms feature user-friendly interfaces and augmented reality (AR) support, making them accessible even to non-tech-

savvy users. Integration with social media and virtual sharing features allows users to gather feedback on outfits from friends and family before making a purchase.

- Reduced Return Rates:** Retailers report reductions in product return rates by as much as 20-30% due to virtual try-on options. Accurate visualization helps users identify potential fit or style issues before committing to a purchase.
- Scalability and Accessibility:** Cross-platform compatibility ensures users can access virtual try-on features on smartphones, desktops, or AR glasses. Inclusive systems represent diverse body shapes, sizes, and cultural attire.[11]

VIII. CONCLUSION

Virtual try-on technology has emerged as a revolutionary advancement in the e-commerce and fashion industries, enhancing the online shopping experience through real-time garment visualization. This study explored both two-dimensional and three-dimensional techniques, highlighting the advantages of adaptive avatars, artificial intelligence, and interactive optical displays in improving user satisfaction and garment fit accuracy. The findings suggest that overlaying virtual clothing directly onto a user's image provides the most confidence for purchase decisions. Additionally, the integration of AI, fuzzy logic, and logical reasoning contributes to a more personalized and realistic try-on experience, addressing challenges such as fabric behavior, body shape variations, and real-time responsiveness.

Despite its progress, the technology faces certain limitations, including dataset constraints, computational overhead, and variations in garment textures. Future research should focus on improving dataset diversity, optimizing real-time performance, and expanding compatibility across AR/VR platforms. Advancements in deep learning models and physics-based simulations could further refine garment visualization and fit accuracy. As virtual try-on solutions continue to evolve, they have the potential to transform the retail landscape by reducing product return rates, increasing consumer confidence, and offering a seamless, interactive shopping experience. By overcoming current challenges and leveraging cutting-edge AI-driven innovations, this technology will play a crucial role in shaping the future of fashion retail.

IX. FUTURE SCOPE

Virtual try-on technology is poised for significant advancements, enhancing realism, personalization, and sustainability in digital fashion. Innovations in 3D scanning, AI-driven recommendations, and physics-based simulations will improve accuracy and user experience. Additionally, integrating virtual avatars and promoting eco-friendly practices can revolutionize fashion retail. As technology progresses, addressing privacy concerns and algorithmic fairness will be essential for ensuring secure and inclusive virtual representations. The virtual cloth try-on technology has immense potential for growth and innovation in the following areas:

- Improved Realism and Accuracy:** Development of advanced 3D body scanning techniques for precise measurements and customization. Integration of physics-based simulation models to accurately represent fabric properties like texture, weight, and draping.
- Personalization and Inclusivity:** AI-driven recommendations tailored to individual preferences, styles, and trends. Expanding virtual try-on systems to accommodate diverse body shapes, sizes, and cultural attire. Integration with virtual avatars for metaverse applications.
- Sustainability Initiatives:** Promoting eco-friendly practices by enabling virtual prototyping for designers and brands, reducing physical waste in garment production. Encouraging on-demand production based on virtual trials, minimizing overproduction.
- Technological Advancements:** Utilizing deep learning models for improved garment rendering and motion dynamics. Enhanced data processing for real-time performance across devices with varying computational capacities.

5. *Ethical and Privacy Considerations*: Addressing privacy concerns related to body data collection and ensuring secure handling of user information. Developing unbiased algorithms to promote diversity and fairness in virtual representations.

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