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Enhanced Virtual Trial Rooms for Excellent E-Shopping Experience

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***Abstract*— EnVTR(Enhanced Virtual Trial Room) initiates a Clothes Trial Room as a service framework to enhance the online shopping (E-shopping) environment. The framework enables the seamless fitting of clothes into the virtual Trial room, according to the 3D model's Body Measurements. Customers can vigorously engage in trying different clothes and get to know how they will look on them. What size would fit them best? It gives a diligent experience that enhances and upgrades the E-Shopping Experience by trying a variety of clothes within this integrated platform. This system also offers styling suggestions with the help of AI according to the clothes, as well as permits tried clothes links, which is a faster way to buy clothes. Through this innovative approach, customers have a real-time experience of trying clothes, from home, knowing the perfect standard size they fit into, and also get fashion and styling-related pieces of advice from AI, which can enhance their Online shopping experience. The project emphasises the potential of virtual Trial Rooms to bridge the gap between online shopping and real-world product interaction by enabling customers to visualise and try products virtually and know the standard fit size before purchasing in a dynamic Online Shopping Industry.**

***Index Terms*— Virtual Trial Room, Augmented Reality (AR), Artificial Intelligence (AI), 3D Garment Simulation, Size Prediction, Real-Time try-on.**

I. INTRODUCTION

The 21st-century era is highly technological; every sector is developing and upgrading its standards for various software technologies. In the past couple of years, the online shopping sector has grown very fast. The current generation, especially the Gen-Z generation, is very interested in trying new things, and they explore very much in the fashion industry, so the retail sector significantly facilitates online shopping for clothes sitting at their home.

However, one problem still exists that is customers can't try on their fits to experience how they fit and look on them and which size they fit into, which is a major challenge. This challenge produces high returns in fashion shopping over the internet, which is not good for the retailer's business and customers' experience. The EnVTR project is a powerful solution designed to provide a smooth and real-time online shopping experience, reducing the gap between online shopping and real-world products. This platform includes a variety of clothes options integrated from different online shopping platforms to get a trial on with AI styling recommendation, a containerised integrated development environment (IDE) that facilitates features like Pose Estimation, 3D garment stimulation, Homography Transformation, and Size Prediction Capabilities.

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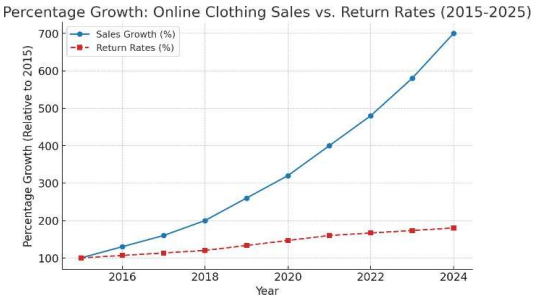

Fig. 1. Graph of Online Sales vs Return Rates in the last 10 years

The augmentation of cloud computing and web-based technologies has enabled customers to expand their fashion or styling alternative networks, offering a wider variety. Virtual trial rooms within a virtual learning environment serve as essential spaces for conducting simulated legal trials and providing real-time experiences. OpenCV is one of the most widely used computer vision libraries, which enables the user's live video in applications for body detection, making real-time superimposition of virtual clothing possible. Machine Learning Regression Models are used to refine predictions for accurate body measurements and size estimation, compared to the standard size chart. Additionally, pose detection and body proportion detection are crucial in EnVTR; for this, we use the mediapipe tool. To support faster online shopping after trials, an e-commerce integration algorithm retrieves real-time product details and displays information such as price, availability, discounts, and the buying process. To facilitate AI-driven styling recommendations, we employ an algorithm that suggests the most complementary fashion attributes based on the outfit and its design.

The e-commerce industry is blooming, but the major challenge is the high percentage of returns. To reduce this return rate, the EnVTR model features facilities such as improved size estimation, providing a real-time experience to the user before purchase. EnVTR helps customers make better purchasing decisions and reduces unnecessary returns.

II. Literature Survey

The need for innovative ideas to improve the digital shopping process has come primarily as a result of the rapid expansion of purchasing goods through the Internet. Being able to actually try on clothes before purchasing is one of the biggest issues with selling clothing online, and often contributes to increased return rates. To address this problem, virtual trial rooms (VTRs) have been developed,which use computer vision, augmented reality, and artificial intelligence (AI) to generate a realistic tryout experience. This review of the literature examines the advantages and disadvantages of virtual dressing technologies, pose estimation, AI-powered recommendations, and e-commerce integration in enhancing online fashion shopping.

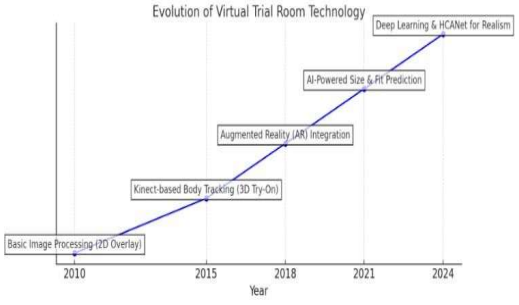

Fig. 2. Timeline for the evolution of Virtual Trial Room Technology

Research Paper	Key Contributions	Limitations / Research Gaps
Virtual Trial Room using Kinect Sensor [12]	Used Kinect sensor for skeleton tracking and 3D virtual try-on experience. Improved body measurement analysis.	Lacks realistic cloth simulation; fails to accurately represent fabric draping and stretching. Limited to structured clothing with simple fitting.
AR-Based Virtual Try-On Solutions in Retail [13]	Integrated AR to enhance online shopping by allowing real-world product visualization. Enabled virtual placement of items to improve customer confidence.	High computational requirements lead to scalability issues. Struggles with real-time performance on mobile devices due to hardware constraints.
AI-Powered Fashion Recommendations and Size Predictions [14]	Used deep learning to predict clothing size and personalized outfit recommendation. Reduced return rates by improving fit accuracy.	Inconsistent size prediction across different brands due to a lack of standardized sizing models. Struggles with new users who have no prior purchase history.
Deep Learning-Based Clothing Fit Prediction [15]	Combined collaborative filtering and deep learning to offer personalized fit recommendations based on customer attributes and product characteristics.	Struggles with complex and loose-fitting clothing styles. Does not accurately model fabric textures, transparency, and movement.
Hierarchical Cross-Attention Network (HCANet) for Virtual Try-On [16]	Introduced a hierarchical cross-attention mechanism to improve garment alignment with body posture. Enhanced realism in virtual try-on images.	Further improvements needed for high-quality texture rendering. Does not fully address challenges in handling diverse clothing materials and lighting conditions. Privacy concerns related to body image processing.

Fig. 3. Summary of Research Gap

The application of Augmented Reality (AR) in virtual trial rooms has significantly enhanced the online shopping experience by enabling customers to virtually put on clothes before making a purchase. Early virtual trial room systems utilised image processing methods and depth sensors to overlay clothes on users' pictures. A virtual trial room using a Kinect sensor for skeleton tracking and placement coordinates was presented in one of the pioneering works in this area. By using this method, the system was able to overcome conventional 2D overlays by analysing body measurements and offering a 3D virtual try-on experience. These techniques sought to

address security issues related to in-store fittings, lessen dependency on physical fitting rooms, and enhance the general online shopping experience for customers by incorporating depth sensors and augmented reality [12].Augmented and virtual reality (VR/AR) technologies are changing the retail sector by providing greater appeal & realistic experiences while shopping. Shops face many obstacles, such as managing their stock, showing an array of goods, or assuring consumers make educated choices. Augmented Reality (AR), which provides realistic images of how clothing items can fit, allows customers to visually place products in their real-world environments. AR has become a viable solution. Large-scale physical displays are no longer necessary thanks to this technology, which also enables businesses to present a wide range of product variations at little extra expense. Prominent corporations like Nike and IKEA have implemented augmented reality-based virtual try-on. Prominent corporations like Nike and IKEA have implemented augmented reality (AR)-based virtual try-on solutions, showcasing their efficacy in increasing consumer confidence, reducing product returns, and maximising the use of shop space. Extended reality shopping is expected to become common in the future, as seen by the combination of 5G, IoT, and AI-powered inventory management, which is improving real-time product visualisation and accessibility in virtual trial rooms [13]. AI-powered fashion recommendation engines are changing the way we shop online. The way we shop online is being revolutionised by AI-powered fashion recommendation engines that use your preferences, size and past purchases to select outfits that fit you. Additionally, AR Tryon technology uses the magic of deep learning to allow you to see yourself in clothes, which is very helpful when you are unsure about purchasing without trying it on. All this great technology is making customers a lot happier, leading to fewer items being sent back, and that's good news for running fashion stores smoothly and being green. As AI gets better and we get smarter with data, shopping for clothes on the web is getting smarter, feeling like it was made just for you [14]. In addition to AI-powered recommendations, deep learning and computer vision techniques have been employed to refine virtual dressing experiences. Fashionable online shopping with customised size and fitting suggestions gets significant benefits as accurate fitting predictions improve customer satisfaction and reduce return costs. Traditional cooperative filtering methods often struggle with limited data because they rely on previous-order information to identify alternatives. Deep learning-based content-collaborative methods were created to address this problem by improving the accuracy of predictions through the combination of specific item information and customer characteristics.

These algorithms capture common patterns using neural networks with global and entity-specific variables while taking into account individual tastes. These innovations increase style customisation and reliability by accurately suggesting size and fitting through mapping customer and item data onto an unused area. This increases personalisation and credibility of fashion e-commerce [15]. Based on these developments, Hierarchical Cross-attention Network (HCANet) offers a new approach to improving virtual try-on accuracy and realism. HCANet effectively captures long-range global interactive correlations between person and clothing representations by employing a hierarchical cross-attention (HCA) block. This technique solves common issues, including flowing and inaccurate patterns of clothing, by increasing symmetry between garment patterns and forms of a person's physical shape and stance. Unlike traditional methods, which have difficulty maintaining visual unity, HCANet improves realism by using an organised focus strategy.

A continuous refinement process is additionally made possible through the hierarchical layout of the program, which ensures that, regardless of the array of complex conditions encountered in apparel manufacturing, the generated online test results retain microscopic details. HCAnet sets a new standard for photorealism in online fashion retail by improving accuracy and visual fidelity, helping to create a more convincing and engaging virtual shopping experience. [16].This evaluation of current research suggests that virtual fitting rooms and AI-style tools are significantly better, but some technological imperatives need to be addressed. Speed, correct attack of body shape, format prediction and male or female record defence are several areas that need more work. In this study, the focus continues with AR to decorate digital trial experiences in real time. Overall, the goal is to make online shopping more convenient, reliable and useful for consumers.

III. WORKING

An EnVTR is a modern solution designed to improve the online shopping experience by allowing users to try on clothes digitally before making a purchase. One of the biggest challenges in online shopping is the inability to physically try on outfits, leading to uncertainty in size, fit, and style. By using augmented reality (AR) and artificial intelligence (AI), this system creates a virtual fitting experience where users can see how an outfit would look on them in real time. Through body mapping and computer vision, the system can accurately analyse body measurements and display a digital preview of the selected clothing.

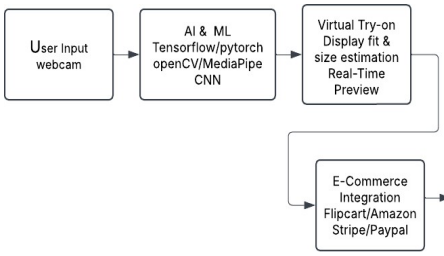

Fig. 4. Working process of the System as per the Functionalitie

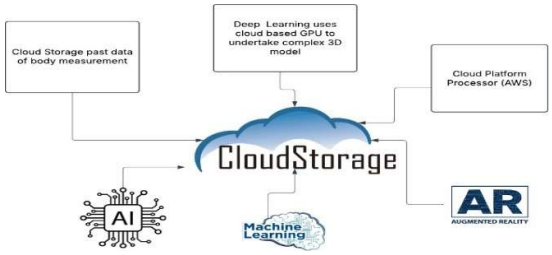

Fig. 5. Interconnection between cloud storage and Technologies used

The EnVTR is based on an online clothing system that has plenty of data and a variety of data. here, we use Cloud platforms like AWS and Google Cloud to reduce the load of the device. It allows the user to try on a variety of outfits virtually on a digital platform by minimising the device's processing. Cloud computing plays a major role in AI-driven EnVTR. Used for the adjustment of the fit and 3D scanning. The Deployment of lightweight models using Tensorflow for efficient processing of data.

Cloud-based Augmented Reality and AI processing is a major part of EnVTR. AR covers the part of virtual clothing on a user's live 3D image. It adjusts the cloth or an outfit to fit the user's body measurements and actions or movements. These tasks are all processed in a real-time environment, which is possible by cloud processors with minimal device load.

Centralised cloud storage is used to store past data of customers' preferences, body measurements, and past trials, which helps in the Machine learning regression model used to predict the size of cloth in a faster way, depending on body measurements, by using Firebase or MongoDB for faster and quicker access to data. Cloud-based GPUs are used to undertake complex 3D models based on deep learning. Due to Cloud-based data storage, brands or retailers don't need expensive local hardware and can easily increase their scale as per demand. Cloud storage provides secure cloud storage through encryption that protects the sensitive data of users using Firebase authentication for secure login.

The EnVTR uses AI and ML to issue personalised styling recommendations and Accurate Outfit artistry. Tensorflow

and PyTorch are Deep learning libraries that train AI models that analyse current fashion trends and suggest outfits and styling parameters based on customers' preferences. Computer vision Techniques with OpenCV and Mediapipe avail in body detection and size estimation to know selected outfit fits the user correctly or not.

It has a feature of Seamless, faster E-commerce site integration for more variety and a smooth shopping adventure. As per the price, the model suggests that the e-commerce websites purchase the fit.

IV. Proposed System Design

A. Objectives

- Enhance and upgrade the online shopping experience.
- Provides users with a real-time experience by trying on clothes before purchasing of clothes.
- Reduce return order rate due to customer satisfaction with real-world experience and cloth size estimation.
- The system can be integrated with any platform.
- Suggest better styling recommendations as per the clothes that are facilitated by AI.

B. Problem Statement

Implement the virtual trial room for an e-commerce website that enhances and upgrades the online shopping experience using 3D model Estimation that has features like providing the experience of the virtual trial of clothes, Predict the standard size as per the body measurement, Suggesting the AI styling recommendation as per the clothes that user tried and provide integrated links of the clothes of different platforms as per the cost.

C. System Overview

The web application is developed to automate the cloth selection process as per the user category and maintain the preferred stock. The web application focuses on solving some of the main problems that customers face when they buy clothes online.

- Can't match clothes sizes when ordering online.
- Not a good product quality
- Doesn't suit the Garment to the Customer and their style.

The frontend of any application plays an important role; the UI directly interacts with the user to develop a user-friendly application. Modern web technologies like HTML, CSS, and JavaScript are required to maintain interactivity with the user and styling, and structuring of the application. Frameworks like three.js and WebGL are used to create 3D content on the web browser. For the backend, machine learning models are used to predict the size and shape of the body. Libraries like Scikit-Learn and TensorFlow are used for recommendation, and OpenCV is used for web cameras to scan the body.

V. System Architecture

The Web application is divided into the following components to provide solutions for above mention problems. This application allows users to interact with the system and select the clothes as per their choice and category, male/female, offering some features such as virtual try-on experiences powered by 3D body modelling and pose estimation. Some computer vision algorithms extract the user's body measurements and promote accurate size recommendations. This platform recommends the different categories of clothes, and different colours and suggests different shopping platforms then users can directly buy the product through these recommended links.

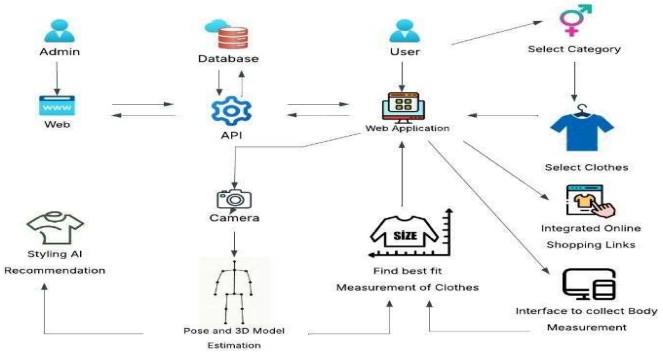

Fig. 6. Proposed System Architecture

VI. Algorithm and Mathematical Representation

A. AR-based Virtual Try-On Algorithm

An AR-based technology or algorithm allows the user to imagine how the clothes will look on the body. Real-time images of the user. first step, the algorithm is capturing the user's image to make predictions. Create poses using techniques like OpenCV, which helps to align Virtual clothes on the user's body. 3D clothes are worn after identifying the exact shape of the body, overlaid on the user's body.
Equation:

$$Ct=T\ (M,\ P(UT),\ ST)\quad (1)$$

Where:

- CtC_tCt = Transformed clothing model at time ttt.
- MMM = 3D clothing model.
- P(Ut)P(Ut) P(Ut) = Currency estimation function.
- UTU_tUt applied to the user's image/frame, which locates body landmarks.
- TTT = transformation function that maps the clothing model on the user's body, mmm landmark
- StS_tSt = Scaling and Distortion Adjustment. The timing of dynamically fitting clothes is based on User's movement.

B. AI Styling Recommendation Algorithm:

This algorithm is used to enhance outfit suggestions for Clothing items. It analyses features such as algorithms colour, fabric and pattern as per the user's occasion. the CNN algorithms are used to process and analyse images and visual data.
Equation:

$$Vt=t(m,p(ut),at,st)\quad (2)$$

Where:

- VtV_tVt = Last virtual try-on visualisation at time ttt.
- MMM = 3D clothing model.
- P(Ut)P(U_t) P(Ut) = Currency estimation function. YutU_tUt applied to the user's image/frame.
- AtA_tAt = precision align function. Overlay clothing based on anatomical landmarks.
- StS_tSt = for scaling and distortion function, Dynamic fitting as the user moves.
- TTT = transformation function that is applied to Pose, alignment and scaling for clothing models.

C. Body Measurement & Size Estimation:

This algorithm is used to predict the size of clothes that align with the user's body. The first step is capturing the real-time image of the user via a web camera or digital camera. It will scan the user's body through its height and weight. This algorithm uses Pytorch or Mediapipe to detect the position. Then it will categorize the body size into Measurement standards like S, M, L, and XL.
Equation:

$$S=f(M(B), C, R) \quad (3)$$

Where:

- SSS = Predicted clothing size (S, M, L, XL).
- M(B)M(B)M(B) = Body measurements extracted from the user's body scan BBB.
- CCC = Standard size chart for comparison.
- R = Regression model for refining predictions.
- f = Final size estimation function that combines measurements, chart comparison, and regression output.

D. E-commerce Integration Algorithm:

Direct purchases of suggested apparel and accessories are made simple for users by the E-commerce Integration Algorithm. Important information like pricing, stock availability, and any discounts is displayed when a user chooses an outfit because the algorithm uses platforms like Shopify or WooCommerce API to retrieve real-time product facts. After the user makes a purchase, the money is safely transferred using reliable providers like PayPal or Stripe, guaranteeing secure transactions. Following a successful payment, the order is verified and the user is given tracking information to monitor the status of their delivery. Users may make purchases straight from the site thanks to this method, which makes shopping easy and hassle-free.

VII. Future Scope

The EnVTR system has a lot of space to grow in the coming years. As technology improves, the platform can become even more accurate and friendly for users. Future versions can use advanced 3D body scanning so clothes fit more realistically and match every body shape better. The system can also include smarter fabric modelling, helping users see how different materials would actually move and look on them.AI can be expanded to act like a personal fashion assistant, giving more thoughtful styling tips based on the user's taste and current trends. EnVTR can also connect with many shopping websites, allowing customers to try outfits from different brands in one place. Another interesting possibility is adding social try-on features, where friends can shop and try clothes together virtually.Overall, the future of EnVTR lies in becoming more realistic, more personalized, and more interactive, making online shopping feel much closer to a real-life fitting experience.

VIII. Conclusion

The EnVTR project closes the gap between physical and real-time online shopping experiences. In this, we have used Augmented Reality (AR), Artificial Intelligence (AI), Deep Learning and 3D garment simulation. This increases the accuracy and realism of virtual try-on. This project effectively overcomes the limitations of existing software. In the literature survey, we found that although virtual trial room technology has advanced over the years, it still has some limitations such as inaccurate size estimation, unrealistic garment simulation, inconsistent size recommendations. The proposed EnVTR system uses AI-driven size estimation, real-time body mapping through pose estimation and cloud-based processing to create an efficient and scalable virtual try-on experience. EnVTR offers various beneficial features like real-time virtual fitting compatible for every body shape, real time improvements are also provided, we have also used deep learning models for personalized recommendations, it includes seamless integration with e-commerce which is also beneficial for suppliers. This increases customer confidence and creates a user-friendly virtual shopping experience. This project benefits both

customers and suppliers. By providing data storage and using privacy-focused AI models to protect user information while allowing personalization. Future improvements will include fabric behavior modeling, real-time rendering, and more deep learning models for personalized recommendations, thereby refining the virtual try-on experience. EnVTR framework sets a new benchmark for interactive, efficient, scalable and engaging virtual shopping ecosystems.

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