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Try On: Virtual Dressing Room

D. I. De Silva, M.P. Gunathilake,V.P.T. Nisal,

W.L.D.N.N. WIjethunge, P.P. Lokuge, J.W.J. Withana

Department of Computer Science and Software Engineering,

Sri Lanka Institute of Information Technology, Malabe, Sri Lanka

Abstract:-In response to the challenges faced by individuals with hectic lifestyles who prefer online shopping for clothing and accessories, a cutting-edge solution, *TryOn*, has been designed to alleviate these concerns. Harnessing advanced technologies such as augmented reality and artificial intelligence, this app offers users a transformative experience by digitally simulating the process of trying on clothing and accessories in a real-world dressing room.By leveraging the capabilities of augmented reality, users can virtually assess the fit of the clothing, ensure that the colors align with their expectations, and evaluate the stylistic aspects before committing to a purchase. This innovative approach empowers users to make online purchases with increased confidence, knowing precisely how the chosen items will look and feel on them.With this practical solution, the study aims to enhance the online shopping experience, making it more relaxing and less stressful for individuals navigating busy schedules. The *TryOn* app provides a valuable tool for informed decision-making, transforming the way users interact with online fashion retail.

Keywords*: virtual dressing, online shopping, augmented reality, artificial intelligence, real-time try-on, skin analysis, customize by gesture*.

1. Introduction

In the modern, fast-paced world people live in, there has been a growing trend in the popularity of the apparel industry and online shopping for clothing and wearable items. This shift can be attributed to people's increasingly busy lifestyles, leading them to prefer online shopping over traditional physical stores. However, the transition to digital retail comes with its own set of challenges, such as issues related to clothing fit, color accuracy, design inconsistencies, and the hassle of returning items. In response to these common problems faced by online shoppers, the study introduces *TryOn,*an innovative solution that harnesses the capabilities of artificial intelligence (AI) and machine learning (ML).

The research focuses on implementing groundbreaking solutions to revolutionize the virtual fitting experience. By incorporating Python and OpenCV libraries into a web application and integratingaugmented reality (AR) based fitting functionalities, the study aims to provide accurate and dependable virtual fittings for online shoppers in real-time. This AR-based approach enables users to virtually try on clothing and wearables.

As part of this comprehensive approach, the study also integrates skin tone detection into the 'TryOn' platform. This addition allows the system to identify and analyze the user's skin tone, a crucial factor in clothing selection and personalization. By combining AR technology with skin tone analysis, this research paper strives to offer personalized clothing recommendations and create an immersive and tailored shopping experience.

As a guide to the research, the following research questions were addressed:

- What is the effectiveness of Python, OpenCV, and AR integration in virtual fitting with skin tone consideration?
- How can virtual try-on be enhanced with real-time AR-based fittings?

- What is the impact of machine learning, skin tone detection, and AR fitting on the virtual dressing room shopping experience?

The following section provides a discussion of the previous studies related to virtual dressing rooms. Section 3 presents how the study was conducted, including the technological framework used for the development. Section 4 presents the findings of usability testing and the wide range of functionalities available in the solution. Section 5 presents the concluding remarks, including the future work that can be carried out related to virtual dressing rooms.

2. Literature Review

There are several virtual dressing room applications available on the market. However, the majority of them just offer simple try-on experiences and have very few features. *TryOn*, strives to address these constraints by incorporating a wide range of cutting-edge capabilities, such as real-time fitting and size adjusting using the camera, skin tone recommendation, apparel customization, hand gesture-based navigation and a virtual wardrobe. To demonstrate the superiority of *TryOn*, a comparison will be made with existing virtual dressing room applications in terms of accuracy, usability, and user pleasure to show how great it is.

Fit Analytics[1]offers a virtual try-on experience using cutting-edge 2D image-based technologies, where users upload full-length photos to visualize themselves in different outfits. This approach might be appropriate for those who want to take their time and carefully assess various clothingoptions without the pressure of real-time fitting. However, the system has notable weaknesses. Firstly, Fit Analytics relies on static images uploaded by users, which limits the real-time interactivity and flexibility of the fitting experience. This lacks the capability for customers to view how apparel fits and appears on their bodies in real-time using the camera and lack of real-time fitting may result in less accurate and engaging virtual try-on experiences, as users cannot fully assess the fit and style of clothing in a dynamic and interactive manner

Fittingreality.com[2]introduces a unique virtual room feature that allows users to visualize clothing on a digital model via their web browser. To get started, users create a personalized Shape-id by uploading three photos of themselves in specific outfits or by using Microsoft Kinect technology. However, the platform lacks real time fitting experience, rendering clothing items as 2D images, which may limit users' ability to assess how garments truly fit and look on their unique body shapes.

Virtual Model[3] stands out as a social network platform that leverages user-generated 3D clothing designs applied to a standard female 3D mannequin. This approach offers users the flexibility to rotate and examine the model from various angles, enhancing their virtual try-on experience. However, *TryOn* surpasses this by delivering an enhanced and more personalized virtual try-on experience.

Zeekit[4] boasts a range of impressive features, including the creation of lifelike 3D models of users' bodies based on measurements and preferences, providing a virtual dressing room experience that guarantees precise fit and alignment. Users can experiment with different angles and styles, reinventing the online shopping experience. However, Zeekit's system falls short in comparison to the concept of real-time fitting using the camera, which allows for dynamic adjustments. This feature enhances the virtual try-on experience, offering users a more versatile and personalized way to make informed clothing decisions.

AstraFit[5] utilizes cutting-edge 3D cameras and laser technology to revolutionize virtual changing rooms. Users stand before a 3D camera or a depth-sensing smartphone, which meticulously maps their body shapes, generating a highly detailed digital model serving as a personalized virtual mannequin. When selecting garments from a digital collection, users benefit from precise measurements that ensure an ideal fit and appearance, seamlessly aligning their unique body shapes with the chosen clothing. However, a notable limitation of this system is its inability to dynamically modify clothing styles and colours in a digitally enhanced, real-world setting. Users may find themselves unable to experiment with customizations and adjustments to garments, which can restrict their ability to personalize and fine-tune their choices during the virtual try-on experience. Because there aren't many possibilities for dynamic alteration, users' creative freedom may be constrained, which could affect how satisfied they are with the system as a whole.

StyleMe[6] is another virtual fitting and styling system which enables customers to create personalized avatars based on their basic measurements and body shape selections within the virtual fitting room, allowing for a tailored online shopping experience. Creating avatars and entering their measurements may result in user input errors and a less fluid experience compared to real-time video camera-based size detection.

Zara's AR App[7] undoubtedly offers a fascinating fusion of online and offline shopping by enabling users to interact with 3D models of clothing ranges. It does, however, have some glaring flaws. First off, the Zara app mainly focuses on showcasing fashion trends using virtual models and lacks sophisticated features like size and skin tone detection, which may cause sizing issues and restrict customization. The software also doesn't offer real-time fitting via the camera, which makes it less helpful in ensuring users get the ideal fit. The lack of virtual clothing alternatives further restricts the system's capacity to accommodate user preferences and provide an easy-to-use mix-and-match experience.

Existing virtual dressing room applications often provide a limited try-on experience for fashion enthusiasts, they fall short of meeting the specific demands of users seeking a comprehensive online platform. Virtual try-ons, individualized advice, social interaction, and AR technologies should all be easily integrated into a more comprehensive online platform. Users should be able to manage their virtual wardrobe in real-time in addition to virtually trying on clothes. Moreover, such a platform should prioritize recommendations based on their skin tone and preferences. Consequently, there is a clear need to develop a new virtual dressing room system that encompasses all these essential features, providing users with an unparalleled and tailor-made fashion experience that current systems fail to deliver.

To address the research gaps in the virtual dressing room system, several critical areas of investigation have been identified. First and foremost, longitudinal studies are essential to determine whether the application's recommendations and customization efforts translate into sustained satisfaction and better styling choices. These studies will help determine the system's long-term impact on users' fashion choices and preferences. Secondly, research should actively aim for greater diversity in user demographics, encompassing a wide range of fashion preferences, body types, and colour preferences, to ensure the system's effectiveness spans across a wide variety of users. Thirdly, collaboration with fashion experts and styling professionals is required for proving the accuracy of the system's outfit selections to build confidence among users and the fashion community. Finally, exploring innovative features like the use of hand gestures for navigating clothing items could enhance the overall user experience and deserves further research and development.

In conclusion, with its cutting-edge features like real-timefitting, skin tone recommendations, apparel customization, and a virtual wardrobe,*TryOn* has the potential to transformthe experience of using a virtual dressing room. While other applications have their merits, *TryOn* provides a thorough and highly customized try-on experience. The influence of TryOnon consumers' long-term fashion decisions can be determined via longitudinal research, and its attractiveness and authority will increase by expanding its user base and working with industry professionals. Enhancing user satisfaction can involve exploringinnovative features such ashand gesture-based navigation. *TryOn*represents a significantdevelopment in this area, and with continuing work in the mentioned areas, it may offer users an entirely unique and customized fashion experience. Table Iprovidesa comprehensive comparison between existing apps and *TryOn*.

3. Methodology

The *TryOn* web application has been developed with the primary objective of automating and enhancing the cloth and accessory selection process, alongside facilitating personalized accessory customization. Complementing this, the *TryOn* mobile application is designed to tackle a range of prominent challenges that patrons frequently encounter in both digital and brick-and-mortar retail settings. These challenges encompass:

- Limited skin tone matching capability.
- Absence of real-time fit-on functionality.
- Limited real-time customization features.

TABLE *II*. COMPARING TRYON WITH EXISTING APPLICATIONS

Apps	TryOn	Fit Analytics	Fitting reality	Virtual Model	Zeekit	AstraFit	StyleMe	Zara's AR App
Real-time Fitting (Camera-[illegible])	√	2D	2D	3D	3D	3D	3D	3D
Hand gesture navigation	√							
Adjustable with body size	√				√	√	√	
Skin Tone Recommendation	√							
Apparel Customization	√			√	√			
Virtual Wardrobe	√	√			√			√

The synergy between the *TryOn* web and mobile applications is geared towards elevating the online shopping experience by proactively addressing prevalent challenges, thereby enriching the overall journey for all users. The web application is meticulously structured around three integral components, each strategically designed to tackle identified issues and collectively deliver effective solutions.

Primarily, the virtual try-on feature stands out as a cornerstone, empowering users to remotely experience the fit of clothing items within the comfort of their homes. This immersive capability allows them to make informed decisions by visualizing the selected garments on their own person before finalizing a choice.

Complementing this, a customization feature enables customers to tailor clothing and accessories to their unique preferences. From altering colors to adjusting logos, this flexibility ensures a personalized touch to each chosen item.

Lastly, the skin tone determination and fashion recommendation component employs advanced algorithms to discern the customer's skin tone, offering tailored suggestions for the most suitable fashion choices. This data-driven approach adds a personalized dimension to the shopping experience, enhancing customer satisfaction.

The comprehensive system overview, depicted in Fig. 1, encapsulates the seamless integration of these components, reflecting the holistic approach undertaken by the TryOn platform to revolutionize and optimize the online shopping landscape.

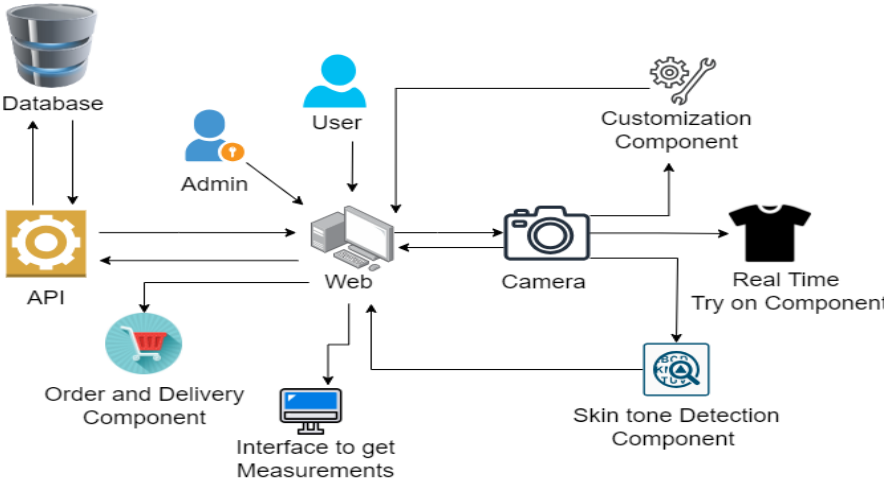


Fig. 1.Comprehensive system overview of the integrated *TryOn*platform

The *TryOn* web application distinguishes itself by providing advanced functionality surpassing conventional shopping apps, showcasing real-time clothing try-on capabilities. The intricacies of this feature are visually depicted in Fig. 2, highlighting the seamless integration of real-time try-on processes, seamlessly overlaying clothing onto the user's physique.

Fig. 2. Visualization of seamless real-time try-on integration

In addressing the intricacies of anatomical analysis within the application, a pivotal tool employed is the Python library *Mediapipe*. Developed by Google, *Mediapipe* is an open-source library that specializes in constructing machine learning pipelines for a diverse array of multimedia data encompassing audio, video, and 2D/3D data [8]. Renowned for its efficiency and versatility, *Mediapipe* offers pre-built solutions and tools catering to tasks such as pose estimation, hand tracking, face detection, and more [9]. Its design facilitates the seamless integration of real-time machine learning-based features into applications, particularly prevalent in fields like computer vision and human-computer interaction.

Mediapipe proves invaluable in enabling developers to incorporate sophisticated features into their projects effortlessly. The library's capacity for in-depth body analysis is exemplified by the provision of landmarks for every joint, meticulously facilitating the tracking of shoulders and the precise positioning of clothing. The distances between these landmarks are leveraged to calculate the overlay image scale, ensuring a seamless adaptation of clothing images to accommodate various body sizes. This automated resizing guarantees a perfect fit tailored to users based on their individual body size.

Fig. 3 provides a visual representation of the locations of *Mediapipe* landmarks, accompanied by their corresponding numerical values, elucidating the utility of this library in refining the precision and adaptability of the *TryOn* application.

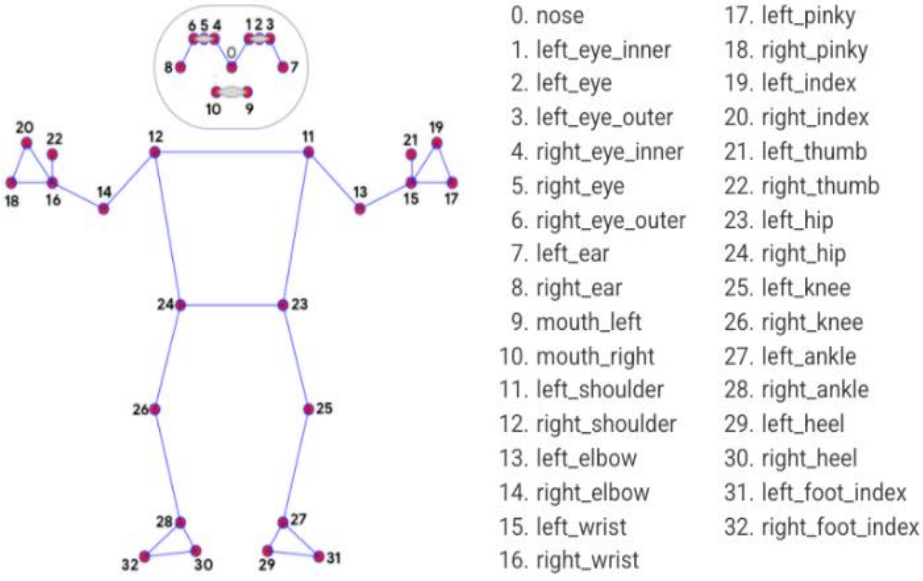


Fig. 3. Mediapipe pose landmarks *[10]*

The incorporation of hand landmarks holds a pivotal role in establishing an efficient gesture control system within the application. To enact this feature, the screen is logically divided down the middle; for instance, in a screen of 1280 pixels, the middle X coordinate is designated at 640 pixels. When hand landmarks, identified as 15 and 16 in Fig. 3, traverse this dividing line, it prompts a transition in clothing. Leveraging the right hand facilitates navigation to the front side, while the left hand enables navigation to the back side.

To operationalize this process, the application assembles all pertinent images from the database, organizing them into an array. During navigation to the front side, the array position increments by one, and conversely, navigating to the back side decrements the array position by one. This dynamic interaction between hand gestures and the array structure effectively governs the clothing change mechanism.

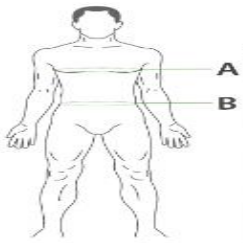
Beyond reliance on the *TryOn* web application alone, users are encouraged to contribute their personal measurements as input. Additionally, specifying gender is paramount, as diverse measurement parameters are applied based on gender distinctions. These user-provided measurements form the cornerstone of the application's capacity to recommend the most fitting clothing size, aligning with the unique body dimensions of each user. The essential measurements are detailed in Table II.

TABLE III. KEY USER MEASUREMENTS FOR PERSONALIZED SIZE RECOMMENDATIONS

Primary Measurements in Inches	Description
Chest girth	Length around fullest part of chest
Waist girth	Length around waist
Hip girth	Length around fullest part of hips

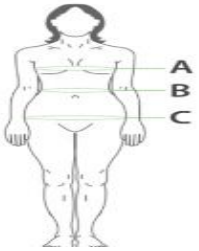
When users specify their gender within the application, the system dynamically adapts its measurement considerations. For male users, the application prioritizes two key measurements: chest girth and waist girth. Conversely, for female users, the application incorporates three critical measurements: chest girth, waist girth, and hip girth. The inclusion of gender-specific measurements is paramount in refining the precision of the clothing size recommendation process, ensuring individualized and accurate results.

To achieve this level of precision, the application references dedicated size measurement charts tailored for both men and women, as depicted in Fig. 4. These gender-specific charts serve as foundational tools in aligning recommended clothing sizes with the unique anatomical characteristics of each user, contributing to an enhanced and personalized user experience.



MEN'S CLOTHING SIZE

	(A) CHEST SIZE (IN)	(B) WAIST SIZE (IN)	
X SMALL	33 - 35	26- 28	
SMALL	35 - 37	28 - 30	
MEDIUM	38 - 40	30 - 32	
LARGE	40 - 42	32 - 34	
X LARGE	42 - 44	34 - 36	
2X LARGE	44 - 46	36 - 38	
3X LARGE	46 - 48	38 - 40	
4X LARGE	48 - 50	40 - 42	



WOMEN'S CLOTHING SIZE

	(A) CHEST SIZE (IN)	(B) WAIST SIZE (IN)	(B) HIP SIZE (IN)
XX SMALL	30 - 32	22- 24	31- 33
X SMALL	32 - 34	25 - 27	34 - 35
SMALL	34 - 36	27 - 29	35 - 38
MEDIUM	36 - 38	30 - 32	39 - 41
LARGE	39 - 41	33 - 35	42 - 44
X LARGE	41 - 43	36 - 38	45 - 47
2X LARGE	43 - 45	38 - 40	47 - 50
3X LARGE	45 - 47	40 - 42	50 - 52

Fig. 4. Size charts [11]

In the realm of facial analysis, the application utilizes a specialized tool known as *haarcascade_frontalface_default.xml*[12], which holds significance in computer vision and image processing applications, specifically designed for face detection. Comprising a collection of predefined patterns or Haar cascades, it functions as templates for recognizing frontal faces in images or video streams, leveraging Haar-like features. These cascades, in conjunction with machine learning algorithms such as the Viola-Jones object detection framework, contribute to the identification and localization of faces within visual data. Widespread adoption of this file is observed in various software and libraries, including OpenCV, enabling face detection capabilities in applications spanning from facial recognition to AR [13].

This tool scrutinizes facial features, allowing the application to seamlessly incorporate accessories, such as sunglasses, onto the user's face with a natural appearance. Notably, these accessories dynamically adjust in both size and position, aligning with the user's facial contours. The user retains control over these adjustments through intuitive hand gestures, enhancing the interactive and personalized nature of the AR experience.

The system's customization feature extends to the alteration of sunglass colors, utilizing the RGB color format. To initiate this process, users are prompted to display both hands in front of the camera; without the detection of both hands, this function remains inactive. Subsequently, the hand tracking module identifies and isolates the user's hands and individual fingers, as illustrated in Fig. 5. Upon presentation of one finger on the left hand, control seamlessly transfers to the right hand, allowing users to fine-tune the red color values as desired. Displaying two fingers on the left side enables adjustment of the green color values, while presenting three fingers on the left hand modifies the blue color values. With a range spanning from 0 to 255, these color adjustments provide users with real-time feedback on how the sunglass color complements their facial features, as exemplified in Fig. 5. If satisfied with the color, users have the option to request sunglass frames matching their preferred hue.

Fig. 5. Sunglass colour customization

Beyond color modification, users also possess the capability to alter the style of the sunglasses through hand movements, mimicking the action of putting them on their face. This intuitive approach facilitates the exploration of diverse sunglass styles until the user finds the one that aligns with their preferences.

To execute this, the technology stack encompasses specialized tools like the *react-webcam*library, facilitating seamless image capture, while HTML Canvas is employed for meticulous pixel-level data processing. JavaScript plays a pivotal role in real-time skin color detection, leveraging its versatility for accurate analysis. Moreover, the system goes beyond detection, offering real-time T-shirt color recommendations based on the captured data, making it a comprehensive and user-friendly solution.

Implementing a sunglass customization component utilizing 'haarcascade_frontalface_default.xml' and OpenCV, the application enables the overlay of customized sunglasses onto detected faces. This feature integrates the *CVZone* library [14], currently undergoing active development and garnering a substantial user base along with a robust community of contributors. *CVZone* stands as an open-source resource, released under the permissive MIT license, rendering it a versatile tool for seamless sunglass overlays and diverse computer vision tasks.

A distinctive attribute of *CVZone* is its exceptional user-friendliness. The library offers a straightforward and intuitive interface catering to a broad spectrum of common computer vision tasks. This accessibility proves

particularly advantageous for individuals new to computer vision, while seasoned developers can appreciate the ease with which advanced computer vision features seamlessly integrate into their projects. The versatility of *CVZone* is another notable asset, demonstrating adaptability across a myriad of computer vision tasks, ranging from fundamental image processing operations to the execution of intricate AI models. Consequently, *CVZone* serves as an invaluable resource across diverse domains, encompassing web development, mobile app development, robotics, and gaming.

In addition, *CVZone* excels in high-performance implementations, positioning it as an optimal choice for real-time applications where minimizing latency is paramount. This performance optimization enhances its suitability for demanding tasks, including video processing and AR, thereby fortifying its prominence in the field of computer vision.

Within the *TryOn* web application, users enjoy the capability to curate their own private virtual wardrobe, seamlessly integrating favourite shirts and sunglasses through the virtual try-on feature. In the application's fitting component, a prominently displayed button labelled 'Add Wardrobe' facilitates the straightforward addition of up to five shirts in a single session. Once added, these selected items become part of the user's personalized wardrobe collection, affording them the option to seamlessly purchase any preferred clothing item.

The color recommendation process commences with image capture facilitated by the *react-webcam*library, translating the captured image into an HTML <img> element. To determine the average color, a meticulous pixel-level processing procedure ensues. This involves the creation of an HTML5 canvas element, serving as a platform for extracting detailed pixel data from the image. Through computational analysis and statistical algorithms, the system computes the average color tone or palette from the pixel data, enabling the generation of color recommendations based on the captured image.

Crucial to the determination of average skin tone is the Euclidean distance, which involves comparing the average color to the colors of available T-shirts. To facilitate this measurement, the application employs the Euclidean distance function—a vital tool provided by the scikit-learn library, abbreviated as *sklearn*. This widely-used Python library offers a comprehensive set of tools for machine learning and data analysis. Utilizing the Euclidean distance metric [15], this function serves as a primary utility to assess the similarity or dissimilarity of data points. The formula leverages variables R1, G1, and B1 to represent the skin color RGB components, while R2, G2, and B2 signify the RGB components of the clothes. The distance is calculated using the following formula:

$$\text{Euclidean Distance} = \sqrt{(R_1 - R_2)^2 + (G_1 - G_2)^2 + (B_1 - B_2)^2} \quad (1)$$

4. Results and Discussion

TryOn delivers a comprehensive suite of services meticulously crafted to elevate the online shopping experience for users. Encompassing a myriad of features, including virtual try-on leveraging cutting-edge AR, skin tone detection, clothing recommendations, clothing color customization, wearables color customization, and more, *TryOn* seamlessly integrates these services to streamline the online shopping process, alleviating the common challenges associated with e-commerce.

At the core of this innovative solution lies the virtual try-on facility, a pivotal component harnessing the capabilities of AR technology. This transformative feature empowers buyers to virtually try on diverse clothing items, providing them with invaluable insights to make well-informed decisions regarding the fit, style, and overall suitability of a particular garment.

Furthermore, the integration of hand gesture navigation represents a paradigm shift in user experience. This groundbreaking functionality enables users to effortlessly navigate through application pages using their device's camera, enhancing usability and convenience to unprecedented levels.

The skin tone detection and recommendation feature further enriches the buyer's journey by offering personalized guidance in selecting clothing that harmonizes with their unique skin tones. This not only elevates the aesthetic satisfaction of shoppers but also significantly diminishes the likelihood of returns, as customers are more likely to be content with their purchases.

In addition, the wardrobe and customization facility stand as invaluable tools, empowering buyers to compare and assess their existing clothing collection. This aids them in making astute decisions about which garments to add to their wardrobes, fostering a sense of curated personal style.

Ultimately, upon selecting their desired items through the application, customers can seamlessly conclude their purchases utilizing a variety of online payment methods. This meticulous approach not only streamlines the buying process but also ensures a gratifying and seamless online shopping journey for every user.

5. Conclusion

The virtual dressing room application, *TryOn*,stands as a revolutionary solution that seamlessly amalgamates cutting-edge technology with an intuitive and user-friendly design. By offering real-time fitting and size adjustments through the camera, personalized skin tone recommendations, customizable apparel features, hand gesture-based navigation, and the inclusion of a virtual wardrobe, *TryOn* adeptly addresses critical challenges inherent in the online clothing shopping experience. This sophisticated platform empowers users to make well-informed and highly personalized fashion choices, ensuring a virtual try-on experience characterized by precision, efficiency, and engagement.

Potential avenues for future development include the refinement of these features through expanded user trials, further optimizing the user experience. Additionally, efforts could focus on enhancing accessibility by integrating *TryOn* with diverse e-commerce platforms, thereby broadening its reach and impact. In essence, *TryOn* emerges as a potent tool poised to bridge the divide between consumers and the fashion industry, elevating the online shopping experience to new heights while facilitating early detection and resolution of fashion-related issues.

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