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iStyleAR - Virtual Try-On Using Augmented Reality

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Abstract: ***In the age of digital transformation and online purchasing, customers are normally susceptible to difficulty in imaginingthewayclotheswouldappearandfitpriortopurchase. The present paper describes iStyleAR - Virtual Try-On Using Augmented Reality, the web-based Augmented Reality (AR) try- on, which allows users to virtually try clothes in real time with only a webcam. The system integrates Mediapipe Pose Detection, OpenCV, and a Flask server to properly superimpose apparel images on the body of the user. The frontend is a responsive React application, based on Firebase authentication, that offers aninteractiveinterface,i.e.outfitswitchingbasedongesture sand avirtualwardrobepersonalizedtotheuser.Asaprototypethatis lightweight and can be accessed on the browser, iStyleAR shows howARcanmakeonlineshoppingmoreconvenientandpersonal styling possible without any specialized hardware. The future extensions are 3D garment visualization, smart size suggestions and enhanced e-commerce inclinations to enable the all-inclusive fashion experience.***
Index Terms: Augmented Reality, Virtual Try-On, Computer Vision, Mediapipe, OpenCV, E-commerce.

I. INTRODUCTION

A. Background

Augmented Reality (AR) technology has been changing world industries very quickly as it is used to add virtual layers over the real one, making it an immersive and interactive experience [1], [2]. AR has emerged as one of the most important innovations in retail and fashion industries, as it allows boosting customer engagement, decision-making, and eliminates operational inefficiencies [3], [5], [6]. The conven- tional way of shopping does not enable the user to preview on how the clothing will appear and fit to them before they make a purchase. Online buyers, especially, are affected because theycannotprovidetheirsenses withanyfeedback andcannot virtually try something. Long queues and small trial rooms in the offline stores usually make the acquisition of a productless gratifying.

Research has revealed that online try-on products have the potential to greatly decrease the level of returns and enhance customer satisfaction within the online shopping settings [5], [6].TheAR-basedproductsenableuserstoseetheclothes

This work is part of the Project Based Learning course at [MIT-ADTUniversity]. and accessories in real time, which is a more personalized and engagingexperience.Besides,thedailywardrobemanagement involving the use of AR should assist users in choosing appropriate outfits more effectively.

B. Motivation

The motivation of the AR Clothes Try-On System develop- mentistheinefficienciesofthetraditionalshoppingprocess andthepossibilitytodiscusstheapplicationofcomputer vision in the real life. Customers usually take a good amount of time shopping or fitting clothes yet they still feel not sure abouttheirfitorfashion[10],[11].Avirtualsystemofatry-on in the real-time could save time, decrease dissatisfaction, and boostconfidencetowardthedecisionsmadeduringpurchase.

Moreover, as e-commerce is becoming very popular, there isademandtohavedigitalsolutionsthatcanbeusedtocreate an in-store experience. This system provides an interactive interface, being hands free and incorporation of gesture based control, this system meets with the contemporary user expec- tations. Other than shopping, the system can be deployed in personal styling and experimenting with outfits as well.

C. Proposed System Overview

The proposed project presents an AR-style Clothes Try-On System that can be executed with Python, OpenCV aswell as CVZone packages. The system operates based onpose detection and MediaPipe [4], [7] which is used to detect thekeybodylandmarksliketheshouldersandthetorso and then dynamically overlay clothing pictures to provide a virtual try-on.

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Popping through various apparel products can be achieved by simply using hand gestures which makes the process easy and enjoyable. The prototype uses a common computingdevice,demonstratingthatARandcomputervision can be used to improve the virtual fitting experience without requiring special equipment.

D. Objectives and Contributions

Themainobjectivesofthisprojectinclude:

- Development of a real-time AR Clothes Try-On System using computer vision and gesture recognition.
- Implementation of dynamic overlay techniques for accu- rate positioning and scaling of virtual clothes.
- Creation of a user-friendly interface that allows intuitive navigation between apparel items using gestures.
- Laying the groundwork for integration with e-commerce platforms, enabling seamless virtual shopping.
- Exploringfutureenhancementssuchas3Dgarmentsimu- lation,real-timemeasurements,andpersonalizedavatars.

Thekeycontributionsofthisworkarethedemonstration ofapracticalARapplicationforvirtualtry-on,validation of pose-based clothing overlay techniques, and illustration of potential e-commerce integration. This system provides an accessible,cost-effectivesolutionforusersandopensavenues for further research in AR-driven fashion applications.

E. Organization of the Paper

Theremainderofthispaperisstructuredasfollows:Section 2 reviews related work and existing AR virtual try-on tech- nologies. Section 3 details the proposed system architecture and methodology. Section 4 presents implementation details and experimental results, including system performance and user experience. Section 5 discusses the conclusions, future enhancements, and potential applications in e-commerce and personal styling.

II. LITERATURE REVIEW

Augmented Reality (AR) has emerged as one of the most transformative technologies in retail, entertainment, and edu- cation, offering a bridge between digital and physical experi- ences.Inthefashiondomain,AR-basedvirtualtry-onsystems havebeenextensivelyexploredtoallowcustomerstovisualize apparel and accessories before making purchase decisions. This literature review presents a comprehensive analysis of existingresearchandindustrialsystemsrelevanttovirtualtry- on technology, pose estimation, gesture-based controls, and garment simulation, followed by a comparison highlightingthe innovation introduced by our proposed model.

A. HistoryofAugmentedReality

Augmented Reality (AR) is a developed concept that has grown to be a practical technology merging both real and virtual worlds. The initial research described AR as a sys-tem which integrates real and virtual objects into a three dimensionalspace,whichisinteractive,andsynchronisesthese contents in real time [1]. Subsequent studies built on thisbasis and examined the use of AR in various fields, such as education, entertainment, healthcare, and human-computer in- teraction [2]. These researches defined the significance of AR as a platform of improving user experience with immersion and interactivity.

B. ARUsesinFashionandRetail

ARisoneinnovationthathasbeenappliedintheretail and fashion industries to create a point of contact between the online shopping and the physical shopping process. Virtual try-on systems enable customers to see what they are putting onvirtually,whichenhancestheirconfidenceandreducesthe ratesofreturns[3].Anumberofscholarshaveinvestigatedthe influence of AR on customer engagement, purchase intention, and brand loyalty and found that the interactive visualization approach elevates satisfaction and consumer trust over a long period [10]. Recent research also points out that the AR-based applications can tailor the shopping experiences and sustainability of retailing through minimising the wastage of product testing [6].

A real-time user-centric AR try-on system of clothing proposedbySharmaetal.isanexampleofhowARmay be used to help users experience the visualization of garments in motion, thus making the process of their selection easier[3].Inthesameway,BatoolandMousystematicallyreviewed virtual fitting rooms and found that the main challenges were thecorrectsizeestimation,simulationoffabricsandscalability [5]. Chen et al. emphasized the increased role of artificial intelligence in enhancing realism and personalization in the AR-based fashion systems [6]. All these works demonstrate how the AR technology is reshaping the fashion industry with the help of immersive digital experiences.

Figure1:ImpactofARIntegrationonE-commercedemon- strates a comparative analysis of two key measurements of business growth, which include Conversion Rate Increase (percent) and Cart Value Increase (percent). The conversion rateswereincreasedby20to35percentandtheaverage cart values were increased by 10 to 25 percent between 2022 and 2024.

The positive trends in both indicators are consistent and provide evidence that the adoption of AR is one of the directfactorsthataffecttheconfidenceofconsumersandtheir readiness to spend. Virtual try-on tools allow the customer to see the appearance of clothes, accessories, or make-up in real- time, which not only makes the products more attractive but also prompts the customers to shop impulsively and make a better-informeddecision.Inthecaseofe-commerceplatforms, suchenhancementstranslateintoquantifiableincomeincrease andimprovedretentionofcustomers.Theclusteredbarchartis useful,asitshowshowARtechnologiesserveasanimpetusto enhance psychological (trust and engagement) and economic (conversionandpurchasevalue)aspectsofonlineretail[12].

C. Technical Advancements in Pose Detection and Gesture Recognition

Thecomputervisionandposeestimationarecriticalin the performance of AR try-on systems. A real-time multi- person 2D pose estimation method was presented by Cao and others based on Part Affinity Fields that has become a basisof correct virtual overlay applications [4]. This model was later optimized to run on CPU-based systems by Osokin, and the real-time AR became achievable without special high-end GPUs [7]. Wu et al. have created a gesture recognized virtual fitting system which enables the user to intuitively interact withclothingitemsbymovingtheirbody[8].Gavgiotaki et al. surveyed AR interfaces based on gestures and foundthat gesture-based AR interfaces increase accessibility and engagement with users [9].

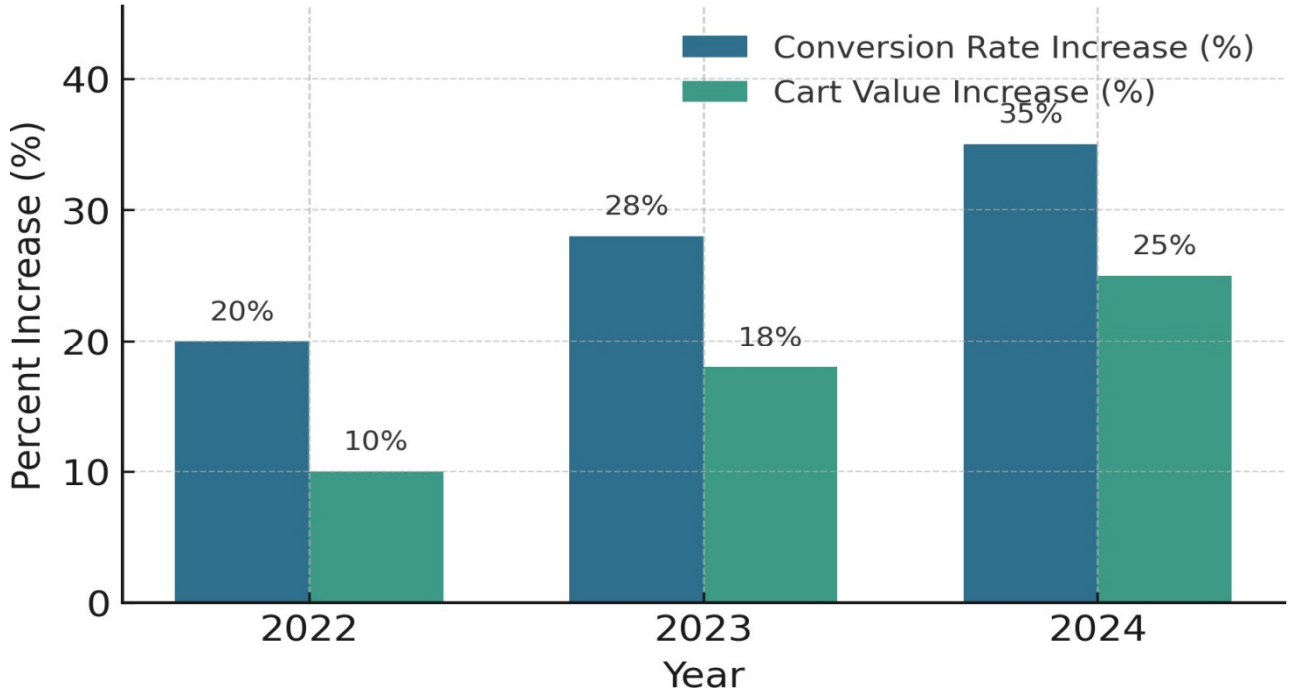


Fig.1.ImpactofARIntegrationonE-commerce

D. Summary and ResearchGap

Theliteraturethathasbeenreviewedindicatesthatthereisa steadyadvancementinAR,posedetection,anduserinteraction systems. Nevertheless, some of the solutions which are in place are still based on use of high-performance equipment, 3D modeling, or pre-calibrated environments, which restrict accessibility. Further, the majority of implementations are based on the visualization or the interaction and not on the seamless integration of the two.

To deal with these constraints, the system that is proposedin this research paper will be a composite of a pose estimator and gesture recognition so that it can permit a live AR clothes experimentalintheformofaclothestry-onwiththehelp of Python, OpenCV, and CVZone. The rationale behind this strategyisthatitneedstobealight,affordableandinteractive solution that can be used in personal styling as well as e- commerce.

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III. METHODOLOGY

The methodology of our AR-based Clothes Try-On System outlines the step-by-step approach undertaken to develop a functional prototype capable of allowing users to virtually try ondifferentclothesusingposedetectionandaugmentedreality techniques. The methodology encompasses the overall system design, the tools and libraries utilized, the data preparation process, the human pose detection mechanism, the dynamic clothesoverlayprocedure,gesture-basedcontrols,and the algorithmicflowofthesystem.Eachofthesecomponentswas carefully implemented to ensure a seamless and interactive virtual try-on experience while maintaining feasibility within theconstraintsofaproject.Thefollowingsubsectionsprovide a detailed explanation of each aspect of the methodology.

A. System Architecture Overview

The AR Clothes Try-On System that is proposed will allow theusertohaveavirtualtry-onexperiencewithjustawebcam and computer vision algorithms. The architecture is based ona modular design that comprises of four major components, image acquisition, pose detection, clothing overlay and scal- ing, and gesture-based control. Fig. 2. Block diagram of the AR Clothes Try-On system showing major modules and data flowindicatesthesystemarchitectureasawholewiththeflow of data being captured by the real-time video to render virtual apparel on the body of the user.

Thisstartswithalivevideofeedtakenwiththehelpof the webcam on the user. The body landmarks of the user are identified in every frame by MediaPipe Pose Estimation thatis combined with the CVZone library. These areas, mainly the shoulders, torso and arms are used as pointers in the graphical documentation of the virtual clothing image. The clothing overlay algorithm is dynamically adjusted to the location and sizeoftheapparelimageaccordingtotheidentifiedkeypoints, which guarantees that the variation is realistic in accordance with the movements of the user.

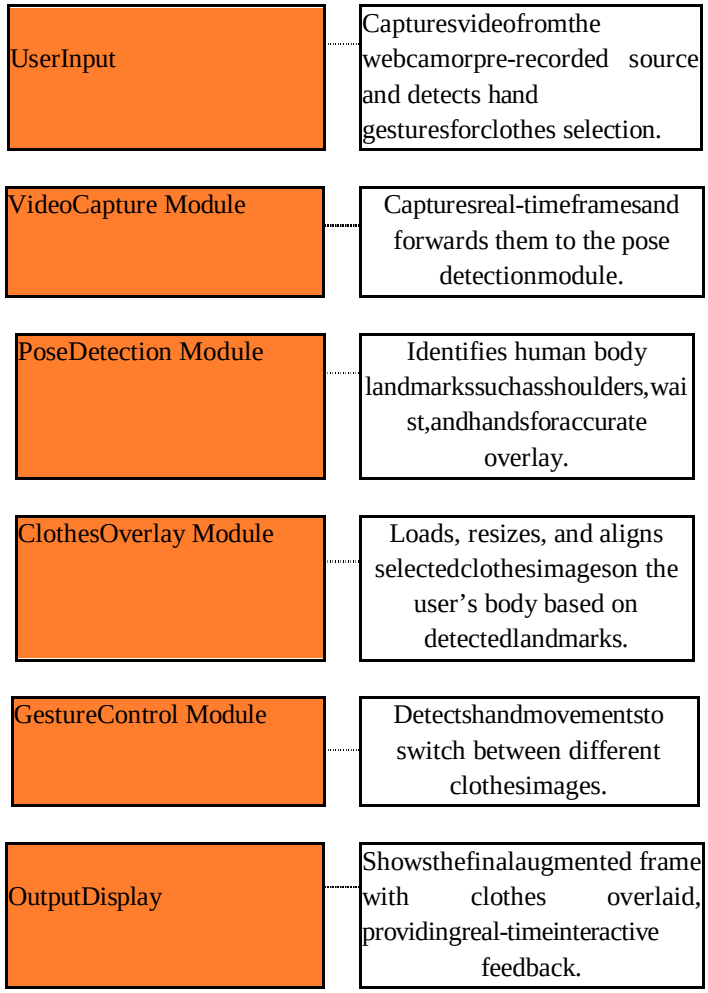


Fig.2.BlockdiagramoftheARClothesTry-Onsystemshowingmajormodulesanddataflow.

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B. Tools and Technologies Used

The system is developed with the help of Python, based on the combination of libraries, which are the best in terms of computer vision and augmented reality tasks:

- OpenCV: OpenCV is a library used in acquiring and manipulating images in real-time and rendering overlays.
- MediaPipe: This is an efficient and lightweight pose esti- mator to detect human body landmarks.
- CVZone: Provides a middle ground that makes the process of pose tracking, gesture recognition, and image overlaying simplified.
- NumPy: Processes mathematical operations of coordinate scaling and image transformation.

All these libraries combined allow users to perform quickly andwithlightweight,whichcanbeusedinreal-timeeven on middle-range hardware, without external depth sensors or even high-performance.

C. Pose Detection and Mapping

The virtual try-on functionality is anchored on pose esti- mation. MediaPipe Pose model recognizes 33 human body landmarks per frame, which consist of shoulders, elbows and hips [Fig. 3. Pose Tracking Body Landmarks]. In this project, theemphasiswillbeontherightandleftshoulderpoints, on which the horizontal axis of the overlaying of the clothing willbebased.Thedistancebetweentheshoulderandthewaist landmarks is used to determine the vertical scaling.

Thestepsthataframefollowsareasfollows:

- Landmark Detection: Landmark predicts the position of body parts of the user in 2D at every video frame.
- Scaling Calculation: The distance between shoulders in Euclidean space is used to calculate the proportional width of the image of the clothing.
- Positioning: The coordinates of the shoulder that serve as the top-left corner of the apparel image are computed to allow a natural positioning.
- Overlay Rendering: The sized clothing image is overlaid on the area of the torso of the user with image blending capabilities of the OpenCV.

This makes the virtual clothes act in the same way as the user adjusts the position or facing.

D. GestureRecognitionandInteraction

In order to have a feel-less and hands free interaction, we incorporated gesture based controls with the hand-tracking abilitiesofCVZone.Thesystemcanidentifytheuseofcertain hand gestures (e.g., lifting the right or left hand) to perform various functions, e.g. changing between various pieces of clothing or changing display settings.

- Right-handraise:Followingclothes.
- Left-handraise:Pastclothing.
- Bothhandsraised:Resetoverlayorexitmode

It is an interactive system that allows interaction with the system without use of a keyboard or mouse, which boosts its accessibility and interaction.

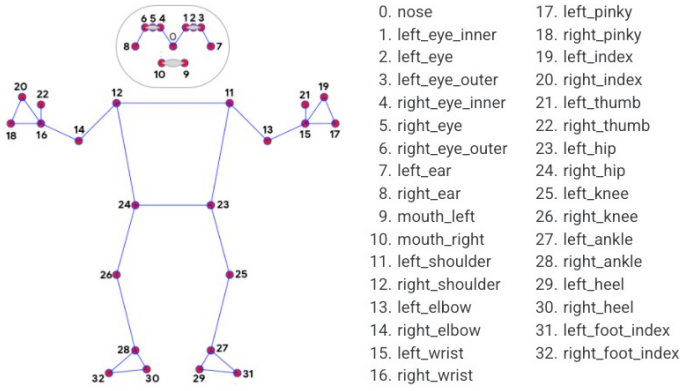


Fig.3.PoseTrackingBodyLandmarks

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E. SystemWorkflow

The system flow of the AR clothes try-on platform is designed to ensure smooth and real-time interaction between user input, pose detection, and clothing overlay. The modular design breaks the process into clear sequential steps, enabling scalability and easier debugging [Fig. 4. System flow of AR Try-on]. The main steps in the algorithm are as follows:

- Capture Video Frame: The system continuously cap- tures frames from either a pre-recorded video feed or a live camera input. Each frame serves as the input for subsequent posedetectionandoverlayoperations.Highframeratecapture ensures minimal latency, allowing real-time interaction.
- DetectHumanPose:UsingtheMediapipeposedetection framework, the system identifies key landmarks on the user's body, including shoulders, wrists, and torso points. CVZoneis leveraged to interpret these landmarks, providing accurate positions in the pixel space of the frame. Accurate detection is crucialforrealisticscalingandpositioningofclothingitems.
- Calculate Clothing Size and Offset: Based on the positions of landmarks such as the left and right shoulders,thesystem dynamicallycomputesthe widthand heightfor thevirtualgarment.Additionaloffsetsarecalculatedtoensure proper alignment with the user's body, taking into account differences in posture, rotation, and camera angle.
- OverlayClothing:Thecalculateddimensionsandoffsets are applied to the selected clothing image, which is then overlaid onto the frame using CVZone's transparent PNG overlay capabilities. The overlay process ensures the clothing moves naturally with the user's body and adjusts dynamically with movements.
- Gesture Detection and Clothing Selection:Thegesture control module monitors the position of the hands to detectleft or right selection gestures. When a gesture is validated,the clothing overlay updates to the next or previous item inthecatalogue.Visualfeedbacksuchasfillingellipsesindicates gesture recognition to the user.
- Display Result: The final processed frame, with the virtual clothing correctly overlaid, is rendered on the screen. This step repeats continuously for each frame, providing a real-time AR experience.
- Optional Enhancements: Advanced features, such as integrationwithe-commerceplatforms,canbeincludedatthis stage. For example, the system can link the selected clothing itemtoanonlinepurchasepageorvirtualwardrobeforsaving preferred items.

F. WebIntegration

iStyleARsystemincorporatesasmoothlinkagebetweenthe engine of augmented reality and the web platform to provide the real-time virtual try-on experience. The web interface is builtonReact19andVitetobequicklyrenderedandTailwind CSS and Framer Motion to have a clean, responsive, and animated user interface. All API responses are processed with the help of Axios which provides the flow of data between the frontend and backend effectively.

The backend is implemented using Flask (Python), that serves as an interface between the web client and the AR processing module. Once the user triggers the Try On feature via the browser, the live feed provided by the webcam is sent totheFlaskserverwhichrunsOpenCVandMediapipePoseto processthebodylandmarkswhichincludeshouldersandhips. Thebackendsuperimposesthechosenpieceofclothingimage (PNGtransparency)onthevideoframeoftheuserusingthese keypoints and creating a lifelike effect of virtual fitting, using the cvzone tool.

Firebase provides the power of user authentication, storage, anddatamanagement.FirebaseAuthisresponsibletosecurely authenticate and create an account, Firestore includes user wardrobe metadata, and Firebase storage is used to store uploaded clothing resources. This integration enables guest and registered users to use virtual wardrobes, social sharing, and outfit feeds in both the form of trending outfits.

Lastly,theentiresystemisdeployedwiththehelpofNetlify asafrontendandFlaskserverasabackendprocessing.Thear-chitectureallowsareal-time,web-basedARexperiencewhich integrates computer-vision processing and a web interface, making web-based fashion visualization more accessible and natural.

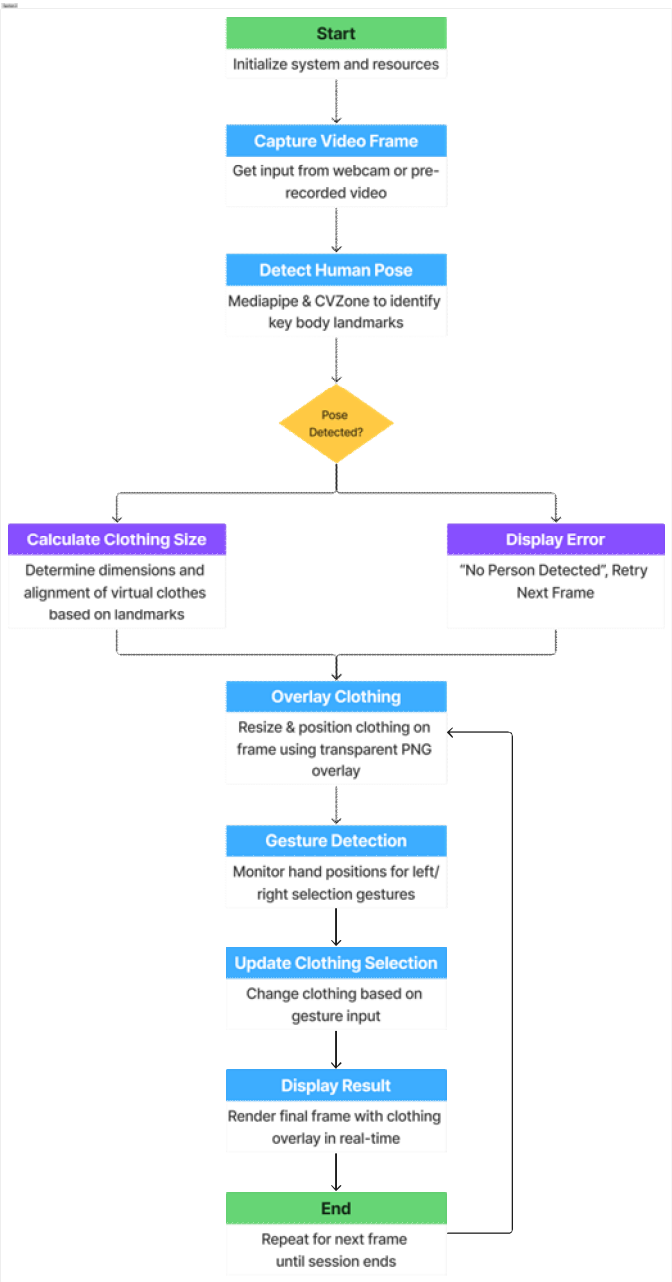


Fig.4.SystemflowofARTry-on

IV. RESULTS AND DISCUSSION

The proposed AR Clothes Try-On system was successfully implementedusingPython,OpenCV,andCVZone,leveraging MediaPipe for real-time human pose detection. The project achieved its primary objective of overlaying virtual garments dynamically over a user's body using accurate landmark mappingandgesture-basedcontrolmechanisms.Theproposed system was evaluated on three main parameters: pose detec- tion accuracy, real-time responsiveness (FPS), and gesture control reliability.

A. VisualOutputandSystemFunctionality

The system was able to capture the live video stream of the user and overlay the chosen images of clothes based on body posture and motion. The pose detection model was able to track 33 keypoints in real time, and specifically on landmarks of the shoulders and torso, in order to align apparel.

Thefollowingdeliverablesillustratetheimportantfunctions of the system:

- Clothing Overlay: The virtual clothing displays the proper position of the shoulder coordinates and real-time changes to the furtherness or proximity of the user to the camera.

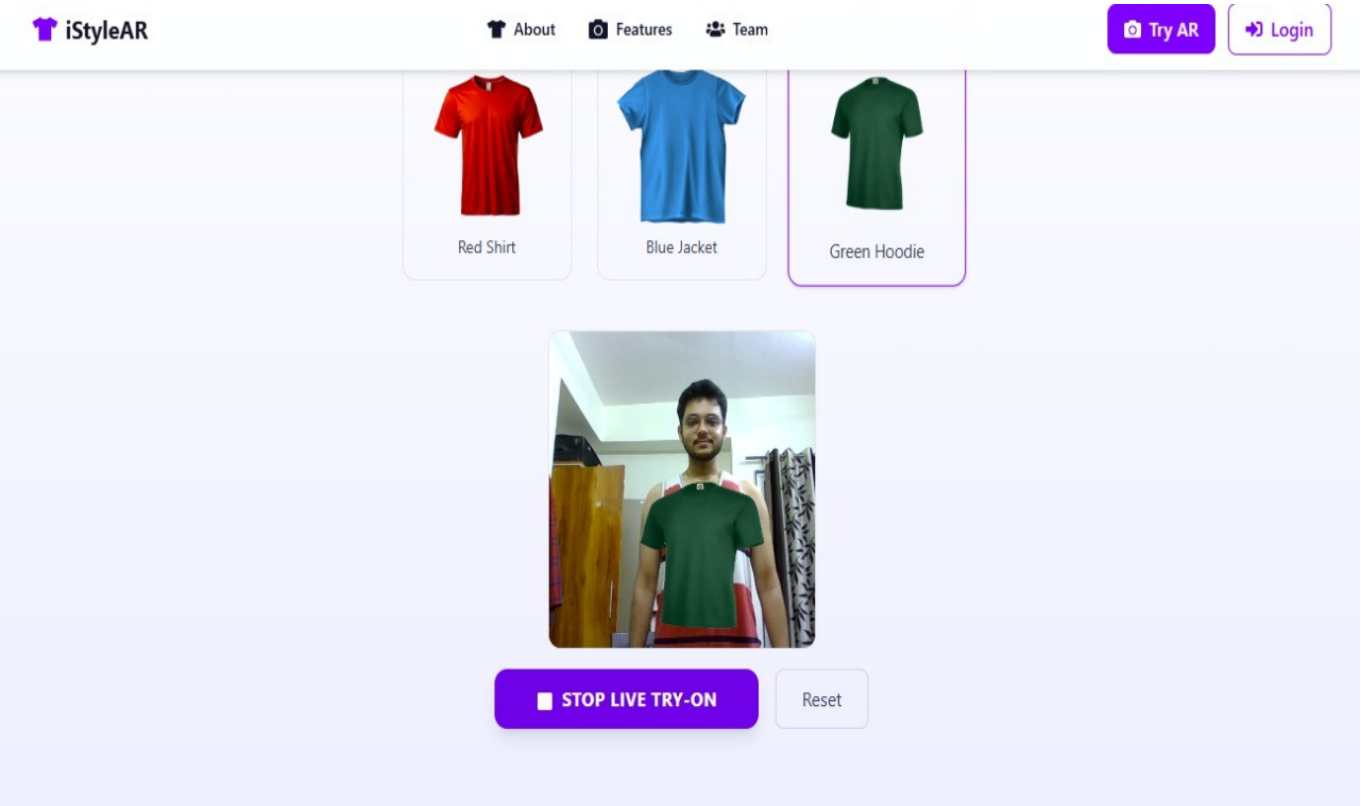


Fig.5.Web-basedARClothingTry-On

- Gesture Interaction: The gestures as designed were right- hand raise to next apparel and left-hand raise to previous apparel, which were identified accurately.
- Scalability: The system was able to accommodate several images of clothes (i.e. T-shirts, jackets) of different sizes and orientations without any significant delays.

The findings validated that AR overlay was stable and visuallyconsistentandcouldeffectivelyfollowthemovement of the user.

B. UserStudyandFeedback

To evaluate usability, a short user study was conducted among participants from different backgrounds (students, de- signers, and developers). Participants interacted with the sys- temandratedparameterssuchasvisualrealism,systemspeed, and ease of interaction. Thesummarizedfeedbackispresentedbelow:

- 90%ofusersappreciatedthehands-freegesturecontrol.
- 80%foundthegarmentalignmenttoberealisticand accurate.
- 90%agreedthesystemcouldbeusefulinonlineshopping or styling apps.
- A few users reported difficulties when using the systemin low-light environments.

Overall, the feedback confirms that the system is both practical and engaging for end-users, achieving the intended goal of providing a convenient and immersive virtual try-on experience.

C. ComparativePerformanceDiscussion

Compared to conventional virtual fitting systems that rely on3Dgarmentsimulations,theproposedapproachachieves comparable realism with significantly reduced computational requirements. Table I outlines a brief comparison between 2D and 3D try-on methods.

Parameter	2D Overlay(Our System)	3DSimulation-Based Systems
HardwareRequirement	Moderate(standardweb cam)	High(depthsen-sors or LiDAR)
ProcessingSpeed	Real-time(25–30FPS)	Low(5–10FPS)
ImplementationComplex-ity	Simple;2Dtrans-formations	Complex; meshgeneration andphysics
UserExperience	Interactive,responsive	High realism,slowe r response
FeasibilityforStudents	Highlyfeasible(open-source)	Difficult(requires GPUand modelingtools)

TABLEI
COMPARISONBETWEEN2DOVERLAYAND3DSIMULATION-BASED SYSTEMS

D. Summary

In conclusion, the AR Clothes Try-On system successfully demonstrates a feasible, cost-effective, and interactive proto- type using open-source tools. It delivers real-time garment visualization with intuitive gesture control. With further inte-grationof3Dmodeling,advancedAI-drivenfittingalgorithms, and mobile deployment, the system holds strong potential for retail, fashion, and personal styling applications.

V. CONCLUSION

The paper described an Augmented Reality (AR) Clothes Try-On System created with the help of Python, OpenCV,and CVZone to create an interactive and lifelike virtual try-on experience. The system is successful in integrating pose de- tection and gesture recognition into dynamic clothing overlay and hands-free navigation between clothes. The system shows that it is possible to make AR-based fashion visualizationboth efficient and accessible without the use of high-end or specialized equipment, as it has stable performance and canbe rendered smoothly.

Virtualtry-ontechnologydrivenbyARcanbecomea great way to shop online because it can greatly increase user interaction,purchaseconfidence,andlowertherateofproduct returns.Thegapbetweenonlinebrowsingandin-storetrialcan be filled by the proposed system to emphasize how AR could revolutionize fashion retail ecosystem using personalized and interactive experience.

On balance, this work provides the basis of the future research and development of the augmented reality applica-tionsinthefashionretail.Itwillshowhowtheintersection of computer vision and AR can develop meaningful user- centered innovations to reinvent digital shopping experiences and personal styling.

VI. ACKNOWLEDGMENT

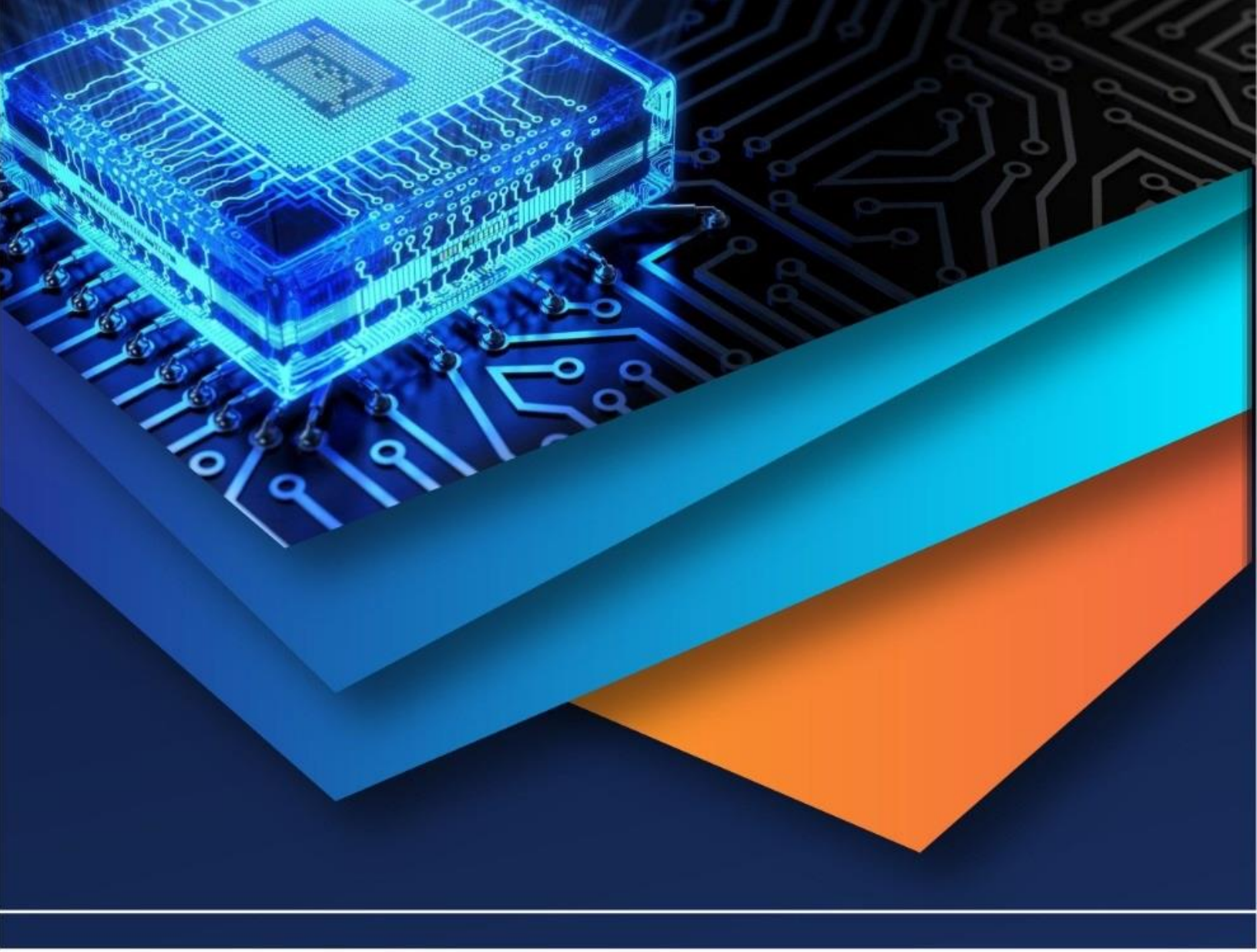
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