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Real-Time 3D Model Generation and Outfit Simulation for E-Commerce Using MERN and Python

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ABSTRACT:

In the era of digital commerce, user experience personalization is a critical aspect of business growth. This research proposes a web-based virtual try-on platform built using the MERN stack (MongoDB, Express.js, React.js, Node.js) combined with Python-based 3D human model generation. Users can upload a single photo along with height and weight, and the system reconstructs a realistic 3D model. Selected outfits can be visualized on the 3D model for a highly immersive and personalized shopping experience. The backend leverages Python libraries like Open3D, Blender API, and TensorFlow for image-to-3D model generation and cloth simulation. Real-time rendering and intuitive UI make the platform seamless and scalable. This project showcases the integration of machine learning, 3D graphics, and web technologies to redefine online fashion retail.

Keywords — MERN Stack, 3D Reconstruction, Virtual Try-On, React.js, Python, Blender, Machine Learning, E-commerce Personalization, Image-to-3D, Real-Time Simulation In order to solve these problems, this project

INTRODUCTION

The absence of a physical trial before to purchase is a significant disadvantage of traditional online shopping. Consumers frequently have doubts about the fit, look, and style of clothing, which causes discontent and a high return rate. Virtual Try-On (VTO) technology, which mimics how clothing would seem on a person without requiring a physical trial, appears as a possible remedy to close this gap. presents an online Expense Tracker application that was created with React.js and is intended to assist users in effectively tracking and managing their financial activities. Through an easy-to-use and dynamic interface, the system gives users a platform to enter, classify, and monitor their income and expenses in real time. For centralized state management, the application makes advantage of React's Context API, guaranteeing uniformity and responsiveness throughout all components.

Before making a purchase, consumers may upload their images, have a realistic 3D model of themselves created automatically, and virtually try on several outfits thanks to this project's revolutionary E-commerce Virtual Try-On Platform.
The platform's front end is constructed with React.js, which guarantees responsiveness, dynamic rendering, and an extremely engaging user experience. The strong backend framework is made up of Node.js and Express.js, which manage API calls and coordinate data flow. Product catalogs, order histories, 3D models, and user profiles are all efficiently stored in MongoDB, a scalable NoSQL database. The system concurrently incorporates Python-based services to generate 3D models and carry out sophisticated picture analysis. From a single 2D image input, the platform creates a comprehensive 3D avatar using frameworks like Open3D, TensorFlow, and Blender's Python API. For further accuracy, user-supplied metadata like height and weight is added.
Our platform combines the power of contemporary web construction with state-of-the-art 3D deep learning techniques to provide a highly personalized, immersive shopping experience, in contrast to traditional static size charts or flat photos. In addition to enabling customers to make confident purchasing decisions, the incorporation of real-time 3D visualization pushes the limits of what is feasible for digital fashion in the future.

OBJECTIVES

Developing an intelligent, responsive e-commerce platform that enables users to create personalized 3D avatars and virtually try on outfits in real-time is the primary goal of the Virtual Try-On E-Commerce Platform with In-built 3D Modeling system. By combining AI-powered 3D reconstruction techniques with modern web technologies, the system aims to transform the online shopping experience, enhance customer confidence, and reduce product returns. Its core mission is to make fashion retail more immersive, personalized, and accessible to users of all backgrounds.Users can upload a single photo along with basic physical data (height, weight) into the system, which then generates a detailed 3D model that accurately represents their body structure. Selected

outfits are dynamically fitted onto the avatar, allowing users to visualize how garments would look and move on their virtual selves without the need for physical trials.The initiative integrates Python-based AI models to enable accurate 3D reconstruction, realistic cloth simulation, and adaptive fitting based on user-specific parameters. Over time, predictive algorithms can suggest optimal sizes, recommend styles based on user preferences, and further personalize the shopping journey.
The application leverages React's Context API and

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Three.js integration to maintain consistent state management, ensuring a smooth, interactive, and engaging user experience across all components.
The system also emphasizes creating a secure environment that protects user data and images. Future iterations of the platform will incorporate feedback mechanisms, allowing users to share experiences, suggest feature enhancements, and report technical issues, thus continuously evolving based on user input.

MODULES AND ALGORITHM

A. Modules

a. User Authentication and State Management:

To maintain user session management and provide smooth data synchronization across all components, this module makes advantage of React's Context API. In order to provide a real-time interactive shopping experience, it manages user login, profile creation (including input for photo, height, and weight), and state updates for 3D model rendering and outfit selections without requiring page reloads.

b. 3D Model Generation Module:

Upon uploading a photo, this module triggers a Python-based microservice that uses advanced AI algorithms to reconstruct a detailed 3D avatar of the user. The module processes image input, applies pose estimation, mesh generation, and texture mapping to create a realistic virtual model tailored to the user's physique.

c. Virtual Try-On Module and Outfit Management:

After users peruse the available ensembles, the system automatically fits the selected item of clothing onto the 3D avatar that has been created. Using physics-based cloth simulation, this module ensures that outfits appear naturally draped, adjusting to different poses and body types in real time.

d. 3D Visualization and Interaction Module:

To render 3D avatars and clothes interactively, the platform incorporates Three.js into the React frontend. Users can see several viewpoints, change outfits instantaneously, and rotate, zoom, and pan their models, all of which increase their confidence when making purchases.

e. AI-Based Outfit Recommendation System (Planned Integration):

Future versions will incorporate an AI recommendation engine that suggests outfits based on body shape, previous selections, seasonal trends, and user browsing behavior. This module aims to enhance personalization and user engagement.

f. Feedback and Continuous Improvement Module:

The system architecture includes a feedback mechanism where users can submit ratings, reviews, and suggestions regarding their virtual try-on experiences. This feedback will drive future updates, model training, and product improvements, creating a user-driven platform evolution.

B. Algorithm

The algorithm for 3D model generation and outfit simulation relies on a combination of computer vision, machine learning, and physics-based modeling. The core process is outlined below:
Initially, the uploaded image undergoes preprocessing using Convolutional Neural Networks (CNNs) to detect body landmarks and estimate skeletal structure. Advanced pose estimation models like OpenPose or MediaPipe are employed to extract key points.

These key points are used to generate an initial mesh through the Skinned Multi-Person Linear (SMPL) model, which approximates the user's body shape based on known statistical body data. Using Blender's Python API, the mesh is refined and textured to resemble the user's skin tone and features.

Cloth simulation is conducted using a physics engine that models fabric behavior over the generated body mesh. When an outfit is selected, it is virtually "draped" over the avatar using collision detection and dynamic physics simulation to ensure realistic fitting and movement.
The results will consist of:

Realistic 3D avatars generated from 2D images with high fidelity.

Dynamic cloth fitting based on body movement and selection.

(Future scope) Outfit recommendations powered by a trained deep learning model analyzing user history and preferences.

The goal of this AI-augmented, real-time system is to create an immersive shopping experience that boosts customer satisfaction, reduces return rates, and personalizes the fashion e-commerce journey.

METHODOLOGIES

C. Data collection and preliminary processing:

In this stage, users fill out forms with their images and provide basic physical characteristics like gender, height, and weight. To guarantee correctness and clarity, this data is validated (e.g., checking for entire physical data, verifying image format). To ensure correct organization and preparedness for 3D model reconstruction, the image and metadata are safely kept in a secure file storage service and a MongoDB database.

D. Data Preprocessing and Normalization:

The gathered data must first go through preprocessing before any 3D modeling or simulation can take place. To guarantee uniform scaling throughout the 3D avatar models, user settings are normalized and image data are converted to standard resolutions and aspect ratios. The photos are prepped for mesh reconstruction using computer vision techniques including posture estimation and segmentation. Accurate and effective 3D creation is ensured by this systematic preprocessing.

E. 3D Model Generation and AI Model Training:

At this point, the system uses AI-driven algorithms to create the 3D model. Methods like the Skinned Multi-Person Linear (SMPL) model for body mesh construction and Convolutional Neural Networks (CNNs) for key point extraction are used. In subsequent iterations, machine learning models will be continuously trained to increase avatar realism using an expanding collection of measurements and photos, improving facial/textural accuracy and fitting precision.

F. Virtual Try-On and Outfit Simulation:

After the 3D model is created, customers can choose which outfits to virtually try on. Real-time fabric simulation methods are used to fit each clothing onto the user's avatar after it has been produced beforehand using 3D garment models (.glb/.fbx files). Realistic movement, collision handling, and fabric draping are all modeled by physics engines. In order to provide an even more customized virtual fitting room experience, future iterations will incorporate dynamic fitting adjustments based on posture or little variations in measurements.

G. User Interaction and Real-Time 3D Visualization:

React.js and Three.js are used to render the processed 3D data in the browser for high-performance WebGL-based visualization. Users can rotate, zoom in, and try on various clothing in real time while interacting with their avatar. The frontend offers a smooth and engaging purchasing experience by dynamically updating model appearances without the need for page reloads.

H. Feedback Loop and Continuous Learning (Future Scope):

To improve system intelligence and user experience, a feedback loop will be put in place where users can score how accurate outfit fittings are and offer recommendations for clothing styles or model realism. The AI models' retraining cycles will use this input to enhance subsequent 3D reconstructions, clothing simulations, and outfit suggestions. Over time, the system will adapt to real-world user expectations and fashion trends thanks to the continuous learning approach.

EXISTING SYSTEM

A. Customary Internet Buying Without Virtual Try-On:

Users usually use sizing charts, written descriptions, and static images when making judgments about what to buy on traditional e-commerce sites. This approach lacks personalization and frequently leaves customers unsure of how a product will fit or seem on them. Users are forced to guess sizes and styles when they can't virtually try on clothes, which frequently results in unhappiness, a rise in product returns, and a decline in confidence when it comes to online buying.

B. Lack of 3D Model Personalization:

In general, current e-commerce systems do not have the ability to customize 3D models according to user characteristics like weight, height, or body shape. Consumers are unable to envision how clothing will fit their particular body shapes. A generic shopping experience that ignores the various needs of real-world consumers is the result of the lack of customized avatars.

C. Absence of AI-Driven Outfit Suggestions:

Without knowing a user's physical attributes or preferred styles, the majority of online retailers make product recommendations based on broad trends or their browsing history. AI systems that evaluate body information or past purchases to suggest apparel that best fits a customer's build, size, or style are rarely integrated. Consequently, users miss out on individualized fashion advice and specialized purchasing experiences.

D. Limited Visualization and Interactivity:

Conventional e-commerce platforms only use 2D pictures or, at most, 360-degree mannequin views. They don't have real-time 3D interaction features like dynamically changing clothes on a customized model or rotating or zooming in. Users' confidence in making decisions is reduced since they are unable to picture how clothes will fit, move, or act due to diverse textiles.

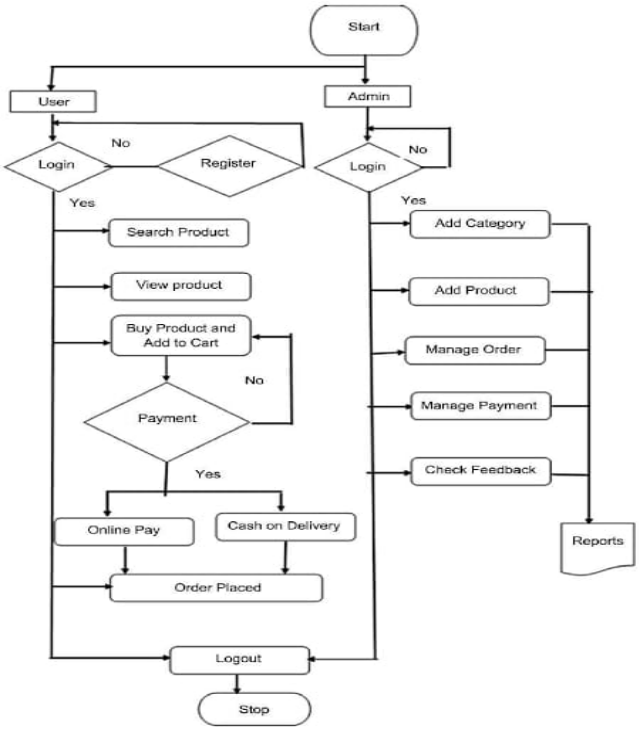
E. Lack of Real-Time Virtual Try-On Insights:

Current solutions don't provide real-time alerts or simulations based on problems with outfit fit (such as incorrect size forecasts or tightness in

specific areas). Users are unable to get instant feedback on how an ensemble would look on them. Instead of an informed, interactive purchasing experience, the absence of dynamic, real-time insights results in a trial-and-error shopping strategy.

PROPOSED SYSTEM

The suggested solution for the Virtual Try-On E-Commerce Platform with In-built 3D Modeling is a complex, adaptable web application that combines machine learning, artificial intelligence, and contemporary web technologies to completely transform the online buying experience. This platform offers dynamic outfit simulation, tailored outfit recommendations, interactive 3D visualization, and real-time 3D model production from user photographs. Through the application of AI, it provides customers with a realistic, immersive, and highly customized shopping experience, assisting them in making wiser purchases and lowering return rates.



a. Real-Time 3D Avatar Creation and Outfit Simulation:

Users can create a detailed 3D avatar in real time by uploading their images and fundamental physical characteristics. Select clothing can be instantly visualized and realistically worn thanks to the system's dynamic creation and display of the user's model. To ensure they have the most up-to-date and accurate preview of their choices, users can instantly keep an eye on each outfit's fit, style, and overall appearance.

b. AI-Powered Personalization and Outfit Suggestion:

The system uses machine learning algorithms to examine user profiles, body measurements, and previous choices in order to suggest clothes that best fit the user's tastes, body type, and fashion sense. As a result of user interactions, the AI gradually enhances its recommendations, guaranteeing more pertinent and customized buying recommendations.

c. dynamic 3D Visualization and User Engagement:

Using Three.js technology, the application offers incredibly dynamic 3D visualizations that let users easily zoom in, rotate, and change the clothes of their virtual avatars. Users can experience a trial room setting that is almost tactile thanks to dynamic visual feedback, which increases their confidence while making purchases. The try-on experience's visual attractiveness and authenticity are further enhanced by realistic cloth physics simulation.

d. Predictive Analytics for Size and Fit Optimization:

To recommend the best size for various brands and styles, the platform uses predictive models that have been trained on historical data. The algorithm predicts possible fit problems and directs users toward better-fitting clothing based on user measurements and prior try-ons, reducing order returns and boosting customer happiness.

e. Visual Analytics for Real-Time Insights:

The system has dynamic, real-time data visualizations like outfit recommendation ratings, fitting heatmaps, and 3D garment overlays. To aid

with their decision-making, users can access comprehensive studies of outfit fit quality, compatibility scores, and visual comparisons between various options.

f. Easy-to-use Device and Interface Responsiveness:

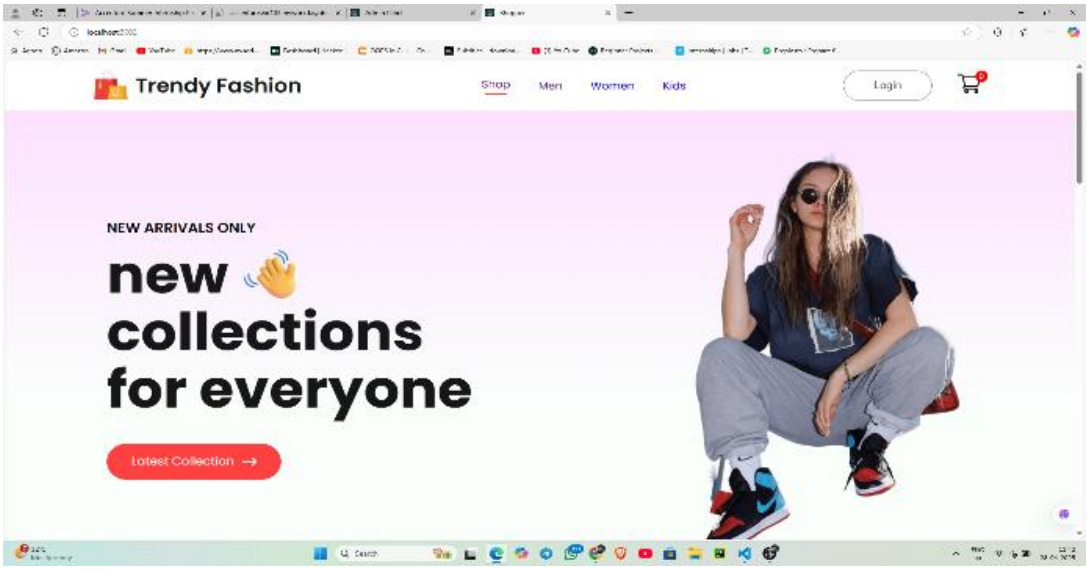
Users of all technological backgrounds can utilize the platform thanks to its user-friendly, straightforward interface. Users may enjoy the virtual try-on experience on PCs, tablets, and smartphones with ease thanks to complete responsiveness. To increase user pleasure and engagement, the design places a high priority on speed, accessibility, and simple elegance.

OUTPUT

With an emphasis on real-time financial management, the Expense Tracker with In-built AI system offers users an easy-to-use and incredibly responsive web interface. In order to ensure that users can easily make well-informed financial decisions, the outputs are made to make it simple to enter income and expenses, present individualized financial insights, and support predictive analytics. The user experience is considered in the design of every screen and module, guaranteeing smooth device interaction.

A. Homepage Interface:

The homepage provides customers with a contemporary, eye-catching appearance and serves as the main landing page. Navigation choices including Home, Sign Up, Login, and Financial Insights are available. Emphasis is placed on important features like cost tracking, budget creation, and AI-driven recommendations. A summary of the app's features is also provided on the site, enticing users to participate in goal-setting and real-time financial monitoring.

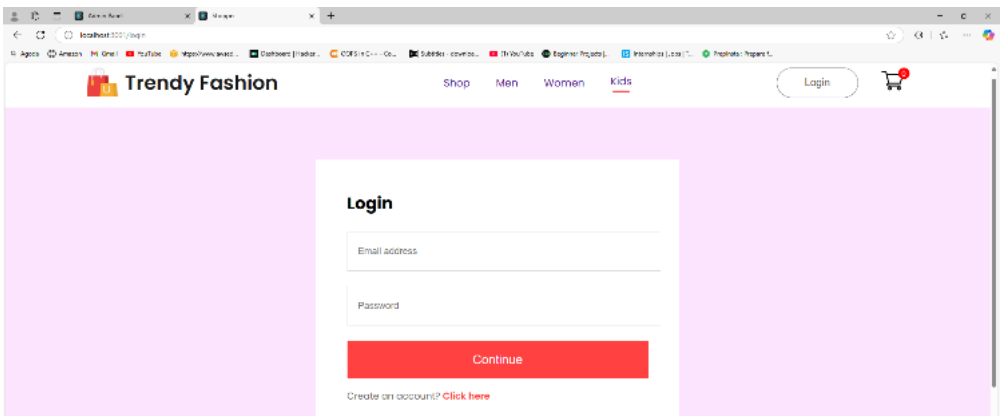


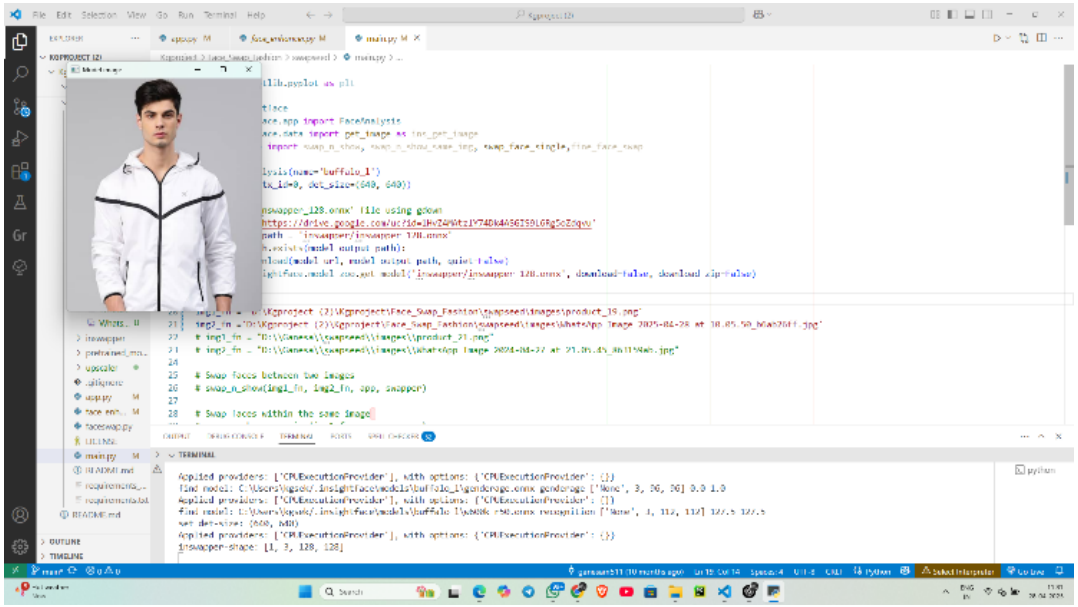
B. User Login and Registration Page:

Secure authentication methods are incorporated into the design of the login page. Users are redirected to their individual financial dashboards based on their login credentials. By entering the necessary information, new users can rapidly register on the registration page. A smooth and safe login or sign-up process is guaranteed by appropriate validation tests, which also preserve the confidentiality and integrity of user data.

C. Module for Avatar Creation and Outfit Try-On:

With this module, users may create their own 3D avatar instantaneously by uploading a photo and entering physical information. After that, users can virtually try on several outfits on their model. Clothing is guaranteed to fit a variety of body shapes with ease thanks to an AI-assisted fitting engine. The process is quick, participatory, and entertaining because to its mobile-friendly layout, dynamic outfit selection, and simple forms.





D. Virtual Fitting Room and 3D Dashboard:

Users are taken to a thorough 3D dashboard with their avatar after logging in. Here, visitors can view various views, zoom in, rotate the figure, and try on various clothing. Visual outfit compatibility scores and real-time fitting insights, including tightness or looseness signs, are shown. The dashboard is the focal point of the customized purchasing experience, with AI-driven suggestions suggesting comparable styles or better-fitting substitutes.

e. Real-Time Notifications and Outfit Fit Alerts:

Based on anticipated stretch, size mismatch, or comfort concerns, the system instantly notifies users when an outfit might not fit properly. on addition to appearing as pop-ups, notifications are also displayed on a special dashboard alerts panel. Predictive analytics is used in these notifications to assist consumers make better decisions, reducing returns and increasing satisfaction.

f. Wishlist, Purchase Integration, and Style Goal Tracking Module:

Users can create style goals (e.g., "Build a casual wardrobe" or "Find a beautiful party dress"), save their favorite outfits to a wishlist, or buy them right away. The algorithm keeps tabs on how well these objectives are being met and makes outfit recommendations based on user preferences over time. Progress bars, highlighting of seasonal trends,

and AI-powered style advice are examples of visual cues that keep users interested and on track.

CONCLUSION

An inventive and astute strategy to transform the online buying experience is the creation and deployment of the Virtual Try-On E-Commerce Platform with Built-in 3D Modeling. The system's architecture, technological stack, and anticipated future improvements lead to the following important conclusions:

a. Increased User Engagement and Shopping Confidence:

By enabling consumers to see precise real-time garment fit visualizations, the platform increases user confidence when making purchases. The combination of dynamic outfit simulation, interactive model control, and 3D avatars creates a highly personalized and engaging buying experience for users, bridging the gap between online and physical retail.

b. Integration of Real-Time Insights and Predictive Fit Analytics:

By incorporating AI-driven predictive modeling and real-time simulation, the platform enhances users' ability to select properly fitting outfits, spot size inconsistencies, and receive tailored fashion recommendations. This leads to smarter purchasing behavior, reduced return rates, and a more satisfying shopping journey.

c. Secure User Data Handling and Personalized Experiences:

The platform ensures that user images and physical attributes are securely managed through robust authentication and encrypted storage mechanisms. Customized 3D dashboards and individual style recommendations maintain a clear, organized, and personalized interface for each user while preserving data integrity and privacy.

d. Intelligent Automation for Better User Experience:

The platform reduces manual browsing and guesswork by utilizing AI-driven recommendation engines, automatic outfit modifications, and real-time cloth simulation. A seamless, entertaining, and intelligent shopping experience is created for users by the ability to examine suggestions, alter clothes with ease, and receive automated fit notifications.

e. Potential for Future Innovation and Expansion:

The system establishes the foundation for upcoming innovations including voice-activated outfit selection using Natural Language Processing (NLP), multi-angle virtual try-ons, AI-based style coaching, and Augmented Reality (AR) mirrors. The platform might become a whole AI-powered fashion ecosystem through integration with data from wearable devices or fashion trend forecasts.

f. User Deployment and Interactive 3D Visualization:

The final stage emphasizes deploying all generated data and simulations in a highly interactive, user-friendly 3D interface built with React.js and Three.js. Every user — whether casual shoppers or style-focused customers — can easily access real-time avatar rendering, outfit previews, and purchase recommendations. Designed for fast performance and full mobile responsiveness, the platform ensures a consistent, immersive virtual fitting experience across all devices.

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