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# CHROMAWEAR: An AI Assisted Personalized Fashion Design Recommender System for Diverse Skin Tones to Enhance Fashion Choices

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***Abstract***

*In the age of fashion, we receive the same question every day: What should I wear today to look nice? The fashion industry is always changing, welcoming inclusivity and diversity. Still, despite the advancements, there are difficulties meeting people's varied needs, especially with regard to skin tone. This research work presents a personalized fashion design recommender system with artificial intelligence support to improve the fashion choices of people with different skin tones. Unlike traditional techniques of physically trying on garments, the skin tonner system uses digital representations to revolutionize the experience of putting on clothing. The system makes customized fashion recommendations by analyzing skin tone and taking into account color palettes, fabric textures, and clothing styles that fit well with the individual's complexion. Through augmented reality and machine learning, the skin tonner system analyses skin tone and body shape to generate abstract digital overlays of clothing for users to interact with in real-time. With the use of numerous algorithms and models, such as the Decision Tree algorithm for recommendation and the K-Means Clustering algorithm for skin tone shade detection, the proposed system seeks to assist the user in selecting what color clothing will suit the individual best on appropriate occasions. We go over the design, implementation process, and assessment criteria of the suggested system, highlighting its potential to transform the fashion business by advancing inclusivity and giving people the power to make educated fashion choices.*

**Keywords:** Artificial intelligence (AI), fashion design, recommender system, skin tone, diversity, inclusivity

## INTRODUCTION

The fashion industry is well known for being dynamic and ever-changing to accommodate consumers' shifting tastes and preferences. Nevertheless, despite significant progress in fostering tolerance and diversity, some groups of people continue to have difficulty locating clothing options that meet their unique requirements. Skin tone is one such important factor that is vital in choosing appropriate color schemes and clothing designs. Conventional fashion advice frequently ignores this element, resulting in less-than-ideal selections for people with different complexion tones. People in the west who value dressing well are often seen by us and serve as an inspiration. This influences how we interact with one another and allows us to flaunt our personalities, which is one of the best methods to boost self-esteem [1]. These

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days, everyone firmly believes that wearing clothing that are neat, well-fitting, and clean ultimately helps them feel good and optimistic. Our civilization is greatly impacted by fashion. The most significant item that individuals think about on a daily basis is clothing. Like when someone complements us on our stylish attire, we feel good about ourselves and want to wear it again. When they do not, though, we tend to be our own worst enemies and self-critical thinkers. Because happiness is the key to success and there is nothing better than dressing for success, this is what drives us to maintain a joyful and depressive-free culture. With the introduction of increasingly wearable devices into our lives, the language of clothes has become more complex and individualized [2]. Men and women of all ages are devoting more time to selecting the appropriate attire in order to look more put together and impress their family, friends, coworkers, and superiors. But it might be annoying and time-consuming to choose the appropriate outfit for the situation. Checking whether each skin pixel is within a certain color range or values in certain coordinates of a color space is one easy way to do this. Skin color segmentation uses a variety of skin color spaces [3], including RGB, HSV, YCbCr, YIQ, YUV, etc. A new threshold that is proposed is based on the RGB, HSV, and YCbCr values combined. The research is motivated by the realization that tailored fashion advice that takes skin tone variance into account is needed. It is possible to create a system that can evaluate skin tone features and offer customized fashion recommendations by utilizing artificial intelligence (AI) and machine learning techniques. This would enable people to make educated and self-assured fashion decisions. The system will be developed using various machine learning techniques and algorithms along with a website. It will be useful for the user to easily get the recommendations of the outfits he/she might be searching for and thus will save time. The main goal of this research is to create and deploy a personalized fashion design recommender system with AI assistance that precisely addresses a range of skin tones. The system is an outfit recommendation system; it will help the user to select the outfit by recommending user using various factors. The system aims to help the user in deciding what kind of clothing or colors will best suit him/her by making choices based on different data-points collected from a dataset which changes as the user uses this system.

## LITERATURE SURVEY

In recent times, the fashion business has seen notable changes, with a heightened focus on diversity, inclusivity, and sustainability. Nonetheless, a number of issues still exist, such as the dearth of accessibility and representation for people of different skin tones. Conventional fashion advice systems sometimes ignore the subtleties of unique traits like skin tone in favor of generic preferences.

Garude *et al*. proposed and discussed about utilizing a comprehensive approach, incorporating algorithms such as Random Forest, SVM, Threshold-based, Linear Regression, and K-means clustering [4]. Upon user photo upload, gender-specific custom filters are applied, extracting skin tone using CNN, specifically the RESNET model for feature extraction. Bayesian Network handles complex joint probabilities. The system employs Decision Tree algorithms, leveraging Random Forest for cloth recommendations. Threshold-based algorithms detect human skin color using RGB, HSV, and Ycbcr values. Linear regression recommends outfits based on mirror responses. K-means clustering refines skin tone analysis. This integrated approach ensures precise and personalized outfit recommendations tailored to individual skin tones for various occasions. The research work critically analyzes existing methodologies, emphasizing the need for multi-parameter systems. Simulation with a dataset of 1030 outfits demonstrates promising skin tone detection accuracy and efficient execution times. The system offers a practical solution at the intersection of fashion, machine learning, and user preferences.

Kolkur *et al*. delved into the applications of Color models for human skin detection: RGB, HSV, and YCbCr, employing threshold algorithms to simplify image isolation, feature extraction, and noise reduction [5]. RGB represents color through Red, Green, and Blue intensities, HSV separates color into Hue, Saturation, and Value components, and YCbCr distinguishes luminance from chrominance. They propose algorithms to enhance skin detection, addressing challenges like lighting variations and background interference. This comprehensive approach contributes valuable insights to computer vision and image processing, offering effective methods color models for human skin detection: RGB, HSV, and YCbCr amidst varying conditions and potential interferences.

 

Patil *et al*. discussed and introduced a system that focuses on aiding users in selecting outfits that complement their features and occasions through image processing [6]. Motivated by the impact of attire on self-esteem, the system utilizes face detection and recognition, employing HAAR classifiers and Microsoft Azure's Machine Learning algorithm. Analyzing skin tone, face structure, and user preferences, the system recommends suitable outfits from a database. The architecture involves admin tasks, user interactions, and image processing stages, with HAAR classifiers detecting faces and Azure classifying skin tones and face shapes. Implementation details cover HAAR feature extraction for face detection and Azure classification for skin tone analysis.

Atharv discussed about the issues and challenges in outfit selection and proposed a system that maximizes the utilization of clothing in a user's wardrobe [7]. It reviews existing systems, including Myntra, Your Closet, Magic Closet, and others, highlighting their strengths and weaknesses. The proposed system incorporates features such as image processing, deep learning, fuzzy logic, and knowledge graph to provide personalized clothing recommendations. The system aims to address issues like monotony in wardrobe choices and lack of time for fashion exploration. The paper concludes with a proposed system architecture that integrates various approaches for optimized clothing combinations and personalized recommendations.

Yuan *et al*. discussed in their paper about three virtual try-on versions: Depth-Overlay (DO), Avatar-Overlay (AO), and Hybrid Version (HV). Most participants preferred DO, citing it as the closest to physical try-ons, providing a good perception of color matching to skin tone [8]. Some liked AO for its overall outfit visualization but disliked its inability to show personal fit. HV users appreciated assessing outfits and checking match with hairstyle and face but found the avatar's skin tone mismatch problematic. Visual quality analysis favored DO and HV. Challenges included body rotation detection, body customization accuracy, and skin tone mapping issues, particularly in the neck region.

Siddhesh *et al*. proposed and discussed about Augmented Reality (AR) based system. The GUI, built in Java Swing, facilitates user interaction by capturing images [9]. They discussed about the process which involves Image Preprocessing with sub-modules for Transformation, Filtering, and Background Removal. Face Detection and Skin Tone Detection follow, leading to Outfit Selection based on the identified skin tone. They proposed about an innovative feature that includes Outfit Fitting on the user's body. They gave idea about Leveraging Augmented Reality technology, this system enhances user experience through real-time image capture and interactive processes, offering comprehensive image processing stages from face detection to outfit fitting for a seamless and personalized recommendation system.

Bhure *et al*. discussed in their paper about the introduction that addresses the complexities of fashion outfit recommendations and the global demand for an intelligent personalized fashion recommender using multimedia mining [10]. Manual garment recommendations face challenges due to a lack of cohesion between customer information and merchants. Their emphasis was placed on objective indicators for evaluating fashion technology. Their proposed solution aims to provide convenient, individualized fashion analyses and recommendations for specialists and customers. Their literature review covers various recommendation approaches, including distance transformation, tensor factorization, CNN-based feature transformation, and ontology-based systems. Human detection and tracking methods in dynamic scenes were also discussed.

The discussion by Ying and Tao focuses on developing an outfit recommendation system leveraging deep learning and ResNet-50 as a feature extractor [11]. Using a novel dataset from Polyvore.com, outfits are judged based on ResNet-50 features using a binary classifier. Their system achieves an 84% accuracy in outfit classification. According to their study, the outfit recommendation component generates and evaluates outfits, providing users with top-rated suggestions. Their methodology emphasizes the general applicability of the model, focusing on outfit composition rather than user-specific characteristics. Their proposed system demonstrates effective outfit judgment and recommendation capabilities, contributing to the intersection of computer vision and fashion research.

 

Liu *et al*. discussed about the challenges in online clothing purchasing, where customers face difficulties in finding preferred items [12]. They introduced an algorithm known as Advanced User-Based Collaborative Filtering (AUCF) to enhance the traditional User-Based Collaborative Filtering (UCF) method used for recommendations. The AUCF algorithm addresses issues such as sparsity in data, low efficiency, and poor precision. Their proposed algorithm incorporates user item linked lists, improves similarity calculations, and introduces item frequency factors to enhance recommendation coverage. Their experimental results using Tmall.com data show that the AUCF algorithm improves precision, recall, and coverage compared to the UCF algorithm, demonstrating its effectiveness in online clothing recommendation systems.

## ROLE OF AI IN FASHION

Design, production, marketing, and retail are just a few of the areas of the fashion industry that AI technologies have the potential to completely transform, as shown in the Figure 1. Supply chain optimization, trend forecasting, virtual try-on experiences, and personalized suggestions are all made possible by machine learning algorithms. Customization and inclusion may be made easier with AI integration into fashion design processes, which will increase consumer happiness and brand loyalty [13].

Skin tone is a major factor in selecting appropriate color schemes and outfits that accentuate a person's inherent qualities. While some colors might make a person look better, depending on their skin tone, others can look boring or clash. Therefore, taking into account the variation of skin tones is crucial when making customized fashion recommendations that satisfy each person's own aesthetic tastes.

## METHODOLOGY

### Data Collection and Preprocessing

The first step in creating the AI-assisted fashion recommender system is gathering a variety of datasets that include pictures of people in different skin tones [14]. To make supervised learning tasks easier, skin tone labels have been added to these datasets. In addition, a variety of styles, colors, and textures are represented in the fashion photographs gathered to train the recommendation algorithm.

### Skin Tone Analysis

Image processing methods including color segmentation, histogram analysis, and machine learning classifiers are used to precisely assess skin tone. Features pertaining to the distribution of melanin, undertones, and general complexion can be extracted using these techniques. Through quantification of these attributes, the algorithm is able to group people according to their skin tone.


**Figure 1.** Role of Artificial Intelligence (AI) in Fashion.

 

**Fashion Recommendation Algorithm**

To provide individualized fashion recommendations, the fashion recommendation system combines deep learning algorithms, collaborative filtering, and content-based filtering. The recommendation model incorporates features derived from the user's fashion choices and skin tone assessments [15, 16]. To provide pertinent recommendations, the system takes into account variables including fabric textures, apparel styles, color compatibility, and current fashion trends.

**User Interface Design**

When users interact with the fashion recommender system, the user interface is meant to be simple to use and entertaining. Users can upload images, enter style preferences, and receive customized fashion recommendations based on their skin tone using an interface on a web page or mobile application. The suggestion process is made more transparent and trustworthy by the inclusion of explanations and visualizations.

## PROPOSED SYSTEM

**System Architecture**

Figure 2 shows the overall structure of the proposed system. The proposed system has various operations like skin tone detection using K-means algorithm and recommendation of clothes using decision tree.

- The first step of the system is to ask the user to upload their information as their photograph and then the system extracts their skin tone type.

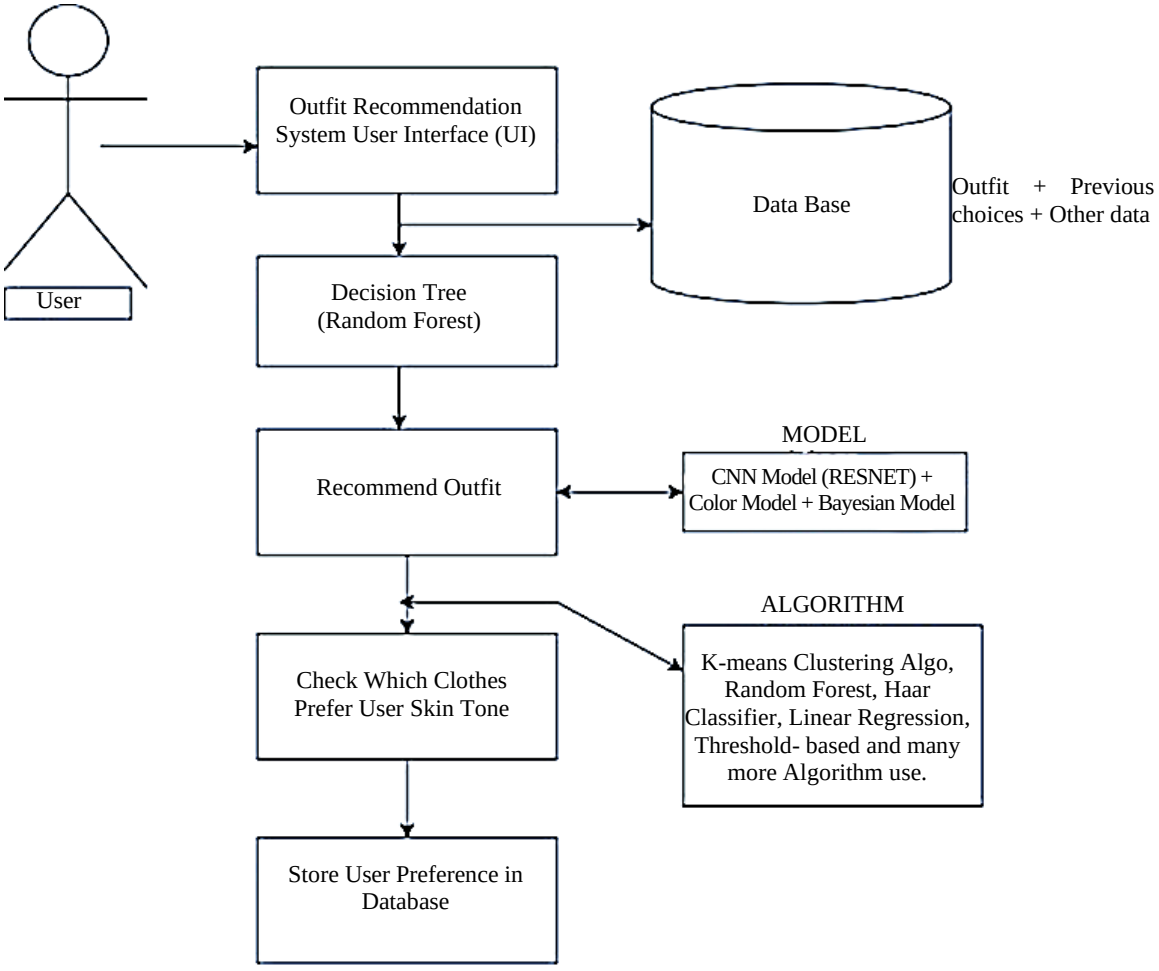


**Figure 2.** System architecture.

 

- The system then makes use of the user's previous choices and current trends. The system also takes occasion and gender to apply custom filters.
- The decision tree is used to map the users' entered occasion and size as a tag and display the subset outfit matching with that tag from the entire outfit dataset.
- By combining all the parameters like skin tone, occasion, current trends and size, the system recommends appropriate clothing to the user.
- After recommending clothes to the user, the system checks which outfit the user prefers and also it takes feedback from the user.
- System stores user's preference in its database for future use. Next time when the user accesses the system, it will consider the user's previous choices for recommendation.

**E-R Diagram**

A model for identifying entities to be represented in a database and displaying the relationships between those entities is called the Entity Relational Model. As shown in Figure 3, the enterprise schema specified by the ER data model graphically depicts a database's overall logical structure.

**Use Case Diagram**

Figure 4 shows a use case diagram that illustrates how users or other systems interact with the system in a visual way. In the context of trying clothes using skin tonner system recommendation system, here is a simplified use case diagram illustrating the main interactions and functionalities.

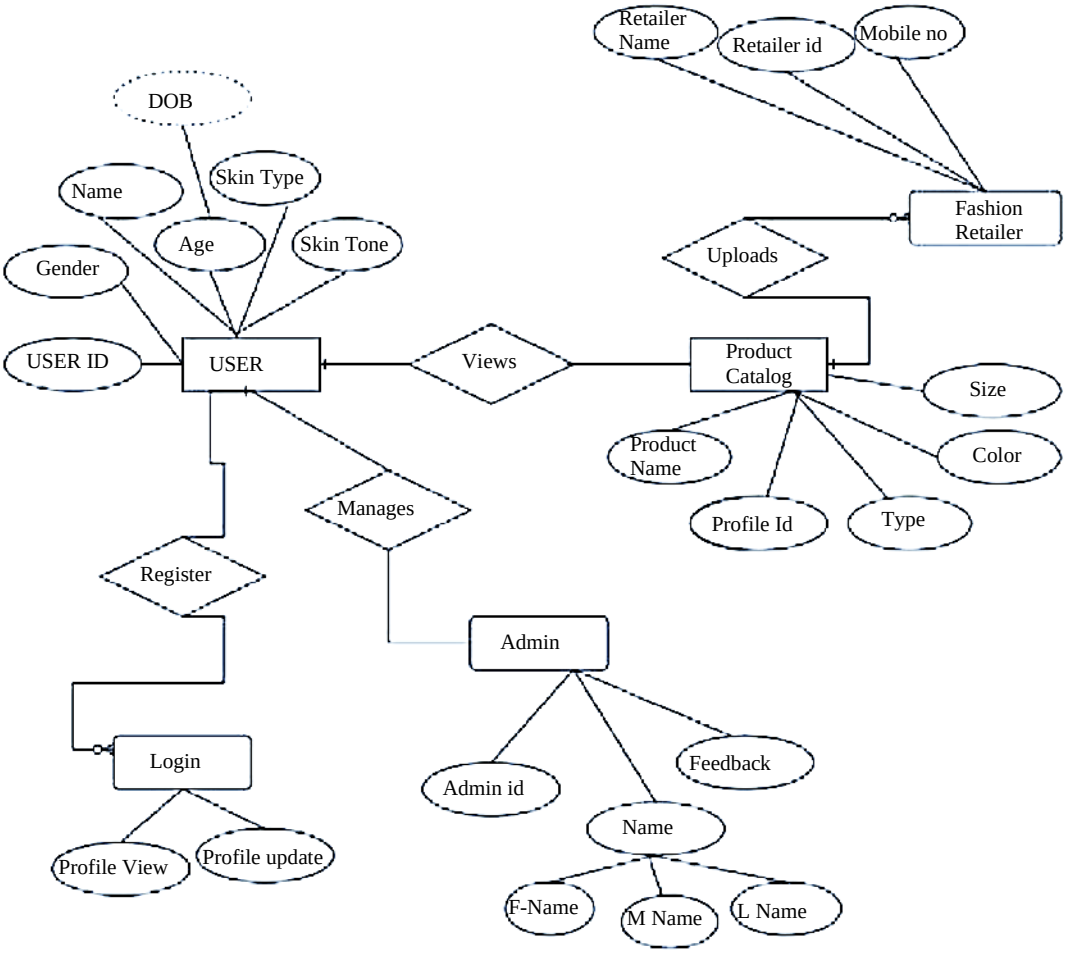


**Figure 3.** E-R diagram of the proposed system.

 

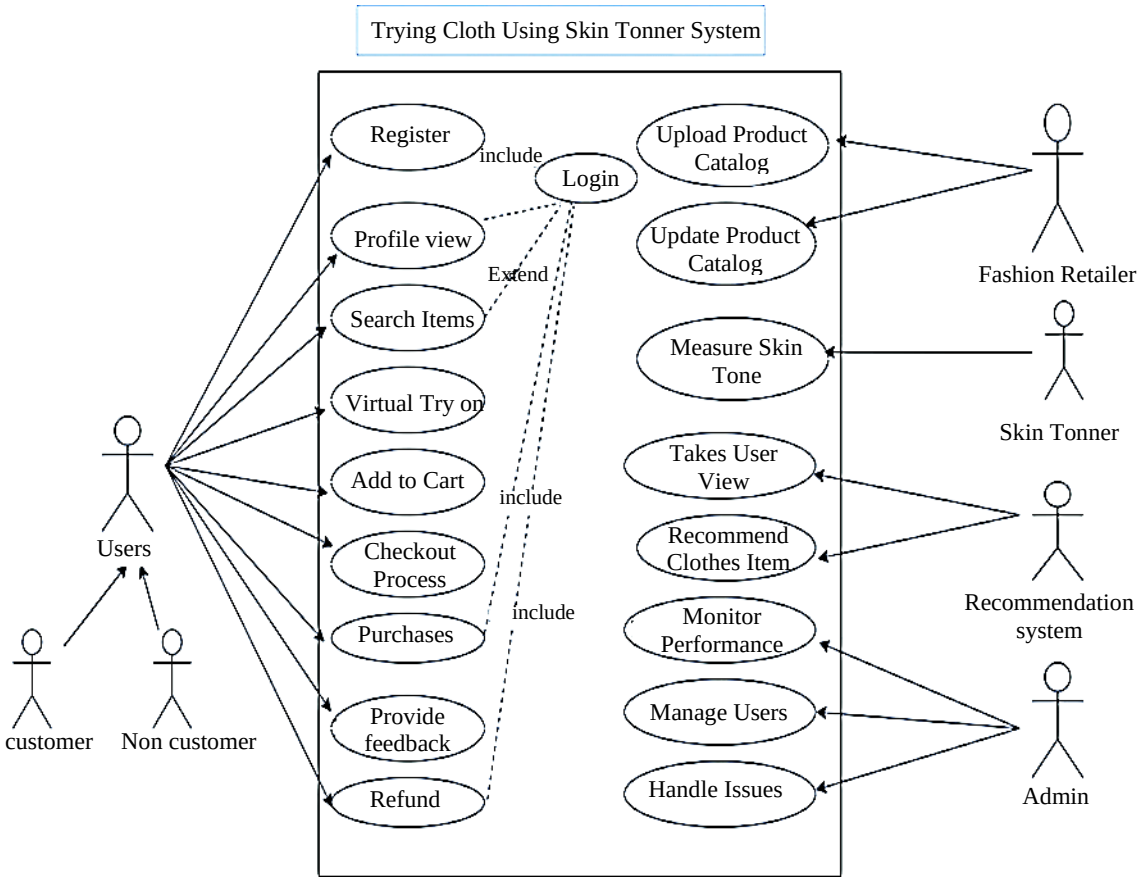


**Figure 4.** Use Case diagram of the proposed system.

## RESULT ANALYSIS AND DISCUSSION

The skin tone analysis module shows excellent accuracy in grouping people according to their skin tones. When it comes to giving customers tailored fashion recommendations that go well with their skin tones, the fashion suggestion engine performs satisfactorily.

The suggested method outperforms baseline models and user preferences in terms of producing recommendations that are both relevant and varied.

As the Figure 5 which shows Signup Page, the shortened signup procedure made it easier for users to get started on the platform. A notable increase in registrations caused by the streamlined forms and the compelling call-to-action prompts, which encouraged users to stick with the platform.

Home screen page is shown in the Figure 6, where customers who are interested in putting on clothing using the skin toner system because of the user-friendly interface's prominent product displays and easy navigation.

Figure 7 shows Result Page, where customers praised the skin toner system's accuracy in mimicking the fit and color of clothing. Which boosted their trust in their purchases and decreased the number of returns.

Profile Page is shown in the Figure 8, customization options such as previously made purchases and saved preferences increased user happiness and loyalty by creating a feeling of community and motivating return visits to try out new products.

 

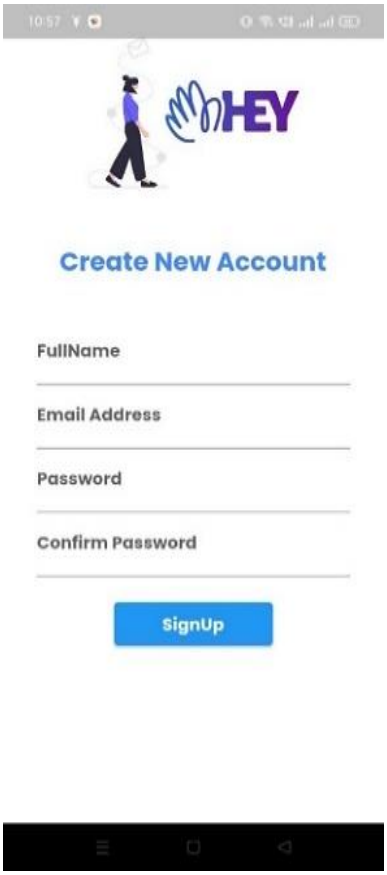


**Figure 5.** Signup page.

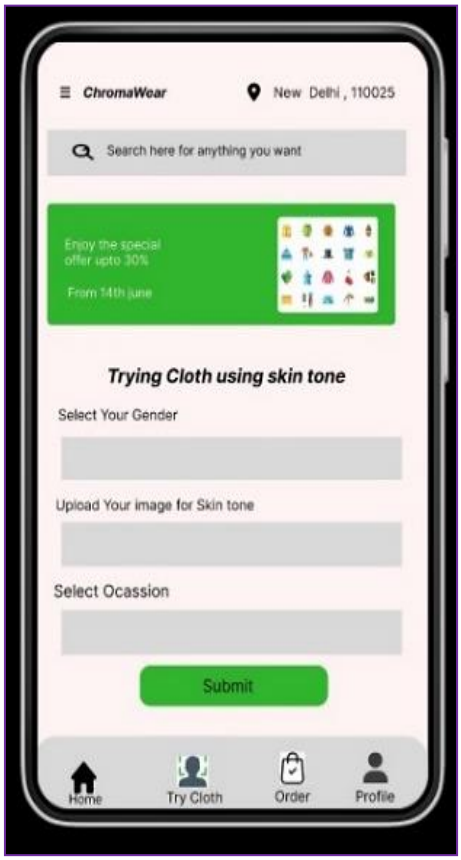


**Figure 6.** Home screen.

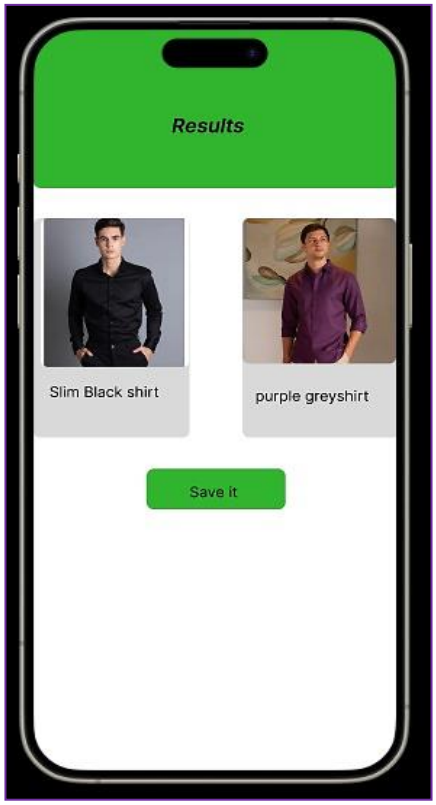


**Figure 7.** Result page.

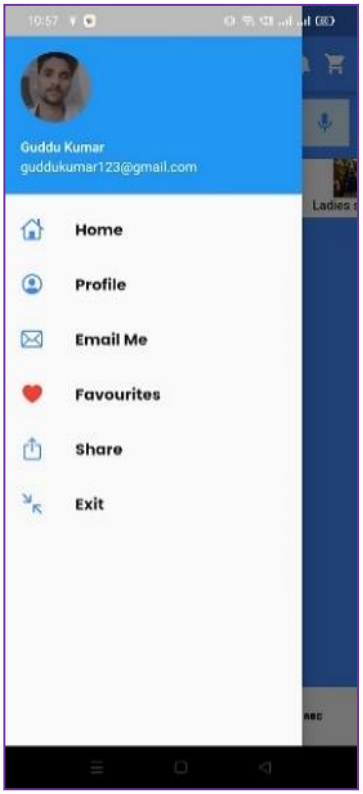


**Figure 8.** Profile page.

 

The AI-assisted fashion recommender system has received favorable feedback from users and satisfaction surveys. Consumers value the recommendation system's transparency, convenience of use, and tailored recommendations. Adding real-time fashion trends and diversifying the suggested outfits are two suggestions for improvement.

## CONCLUSION AND FUTURE WORK

In conclusion, a fresh solution to the problems of inclusivity and diversity in the fashion business is offered by the suggested AI-assisted personalized fashion design recommender system. The technology uses cutting-edge AI algorithms to enable people to make well-informed fashion decisions that boost their self-expression and confidence. The research paves the ground for upcoming developments and partnerships in this field and supports the current efforts to establish a fairer and inclusive fashion environment. People worry about dressing adequately in this day and age because they want to wear clothes that truly make them stand out from the crowd. The suggested approach assists users in selecting clothes that suit them and look well on them in addition to being acceptable for the occasion. Using a decision tree technique, the system categorizes the ensembles and suggests them based on the user's skin tone shade and the right occasion. The system is capable of processing images in different light conditions and brightness levels.

The future scope of this system will include complete recommendation of all outfits based on their correlation with color and other factors. We also feel there is a scope for the improvement of the accuracy and minimization of error factors that would occur by increasing the number of data points that would be included overtime. Subsequent improvements will concentrate on honing the recommendation engine to offer more detailed and tailored recommendations depending on user choices, style progression, and contextual elements. Over time, the accuracy and relevance of recommendations can be increased by using active learning processes and user feedback loops.

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