HairVista AI

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Certificate

We accept the work contained in the report titled "HairVista AI", written by Hafsa Javed and Kashf Kamal as a confirmation to the required standard for the partial fulfillment of the degree of Bachelor of Science in Artificial Intelligence.

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Abstract

Hairvista AI is a revolutionary web-based application that can be easily used by women. It provides a way for them to find hairstyles, and they could try different colors, and all these are based on a personalized facial analysis; thereby, it accentuates their natural beauty. Hairvista AI, in the period of virtual personalization which is reconstituting the beauty and fashion industry, acts as a digital beauty adviser providing intelligent and easily accessible recommendations. It allows users to send a picture of themselves and then get instant feedback on their face shape and skin tone, after which the user would get custom hairstyle and hair color suggestions. This virtual styling assistant not only reduces the time and money involved in beauty and fashion but also empowers the user by teaching them how to choose styling based on what suits them rather than following trending styles or going for expensive consultations.

The Hairvista AI system is trained with the help of deep learning technology and uses convolutional neural networks (CNNs) for analyzing facial features, thereby categorizing face shapes and revealing skin shades through the process of color analysis. Moreover, it applies the Gemini 2.5 Flash image technique to create real-life-like visual try-ons for the users, thus, enabling them to see different styles and hues on their pictures. This combination of face analysis and high-precision simulation guarantees personalized, and confidence boosting style choices.

Hairvista AI is a strong meeting point of the three traits: AI, computer vision, and human-centered design. The app not only helps the user by guiding through the journey of their own styles that match their distinctive traits and likeness but also makes the choice of the hairstyle simpler and more comfortable as the beauty is based on science and personalization. Being an innovative platform in the beauty-tech arena, Hairvista AI is a player in the future of fashion with the collaboration of top-notch AI and user-friendliness, turning the selection of hairstyles and hair colors into a smart, inclusive, and very personalized experience.

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Acronyms and Abbreviations

AR	Augmented Reality
ViT	Vision Transformer
MTCNN	Multi-task Cascaded Convolutional Neural Network
GANs	Generative Adversarial Networks
UML	Unified Modeling Language
CNN	Convolutional Neural Network

Chapter 1

Introduction

Artificial intelligence is already changing the world of human experience and is the engine driving all things that humans do: whether this is the personalization of shopping or the real-time analysis of health issues. However, in the case of the beauty industry, great innovation hasn't been done specifically in the area of hairdressing and hair coloring. The process of sort-out of the desired look can in truth be defined as a guessing game, where the trends are not taken into consideration in relation to beautiful faces, skin colors, or taste." There are many conventional consultations, which are expensive, not focused on one man, but a greater need of more intelligent reactions demands a totally new beauty.

Except for the rule in hairvista AI, we do not create yet another virtual try-on app, but instead develop an intelligent beauty guru who uses deep learning designed by a stronger learning manner and even a human personal intuition concept, incorporating a much more precise facial features analysis and a realistic approach in hairstyles and hair color with the usage of Gemini 2.5 Flash Image Model.

Hairvista AI will provide professional recommendations that will not at all seem like a computer was fed with them, but a counseling stylist gave them.

This novelty consists in an effective combination of a powerful addition of the computer vision system with generative AI. However, our proprietary algorithms do not just find faces, but find the finer figure that makes them stand out. According to one of the experts in beauty, he would need to be confident about his or her face shapes to get the right hairstyle [1]. They do not merely affix hairstyles, but paint them in a realistic three-dimensional way with all texture and movement. The result? It is a revolutionary application, and not only is it a mirror saying what you can be, but also one that says what you should be according to the golden proportions of beauty.

Still, this is only a style by itself because our system smart will study your complexion, eye color, and undertones with a view to advising you on the hair colors you can use naturally and become beautiful depending on the color of your complexion whenever you use our system. In fact, human skin is a multi-layered substance; and every different substance has a varied difference based on the amount of substances such as carotene, hemoglobin, and melanin contained in each multi-layered substance. Hence, on images of human skin color, the basic color of each human skin based on the amount of light either reflected, scattered, or absorbed per human being in every image [2] becomes a challenging task to model as per each human being because this model currently runs with the development of high-resolution generative models and models color transition in a new-fashion way as it accumulates highlights, shadows, and shine as they are in real life. Either you are thinking of altering with a small touch of change or with a concrete transformation of current beauty and outlook as you are originally born with, this technology will ensure that you are indeed up-to-date with fashion and customized as well.

Hairvista AI is a movement. We are leaving the era of rule by the world in your hands when a world is covered in a blanket of ideals of beauty and impossible ideals. To make a radical pixie cut, electrifying balayage, a vintage long cut it does not matter what it is our neural network is your hairstylist and will prove to you that no matter how loud the color is and how unreal the cut is, it merely accentuates your finest features instead of trying to mold into the latest fashion.

The future is a smart, personal and affordable hair styling. Hairvista AI is where science and style intersect and no two pieces of advise are alike.

1.1 Project Overview

Hairvista AI is a software that applies Artificial Intelligence (AI) techniques in analyzing the user's facial image and accordingly gives recommendations on hairstyles and hair colors that would suit the user depending on their face shape and skin tone. The proposed system utilizes a custom trained deep learning network that identifies and extracts the user's face shape and skin tone from the input image. In order to achieve a realistic and aesthetic output, the process of visualization calls for the use of Gemini 2.5 Flash Image, through which the suggested hairstyles and hair colors are applied and fitted on the user's image. The rationale behind this is to achieve a more accurate and natural output by separating the analytical part, which includes the tasks of recognizing the shape of the face and the skin tone, from the generation part, involving the fitting of the hairstyles and hair colors. This app zeros in on the reality that people do not possess the most appropriate hairstyle or color to suit their face shape, while they can view those styles that would be appropriate for them through this app. This not only improves the decision-making power of the user in selecting their hairstyle and color, since it would be displayed in reality through AI integrated with image smart processing. The process involved in this system is explained below:

The very first step is login or creation of an account utilizing their logins. Once logged in, they would be required to upload an image. This data is then utilized by the system.

The image that is uploaded is then processed to extract certain key features of the person's face, including the face structure and skin color. These characteristics are then used to identify the image, and the name corresponding to the image is then retrieved. Gemini 2.5 Flash are used to make personalized suggestions. For this purpose, suitable hairstyle "Suggestions are offered based on the user's facial shape, and suitable colors for the hair" suggestions are made based on complexion. Suggestions for hair styles and colors are then shown through realistic images. The user is finally able to save her they preferred these recommendations in relation to their account for future access.

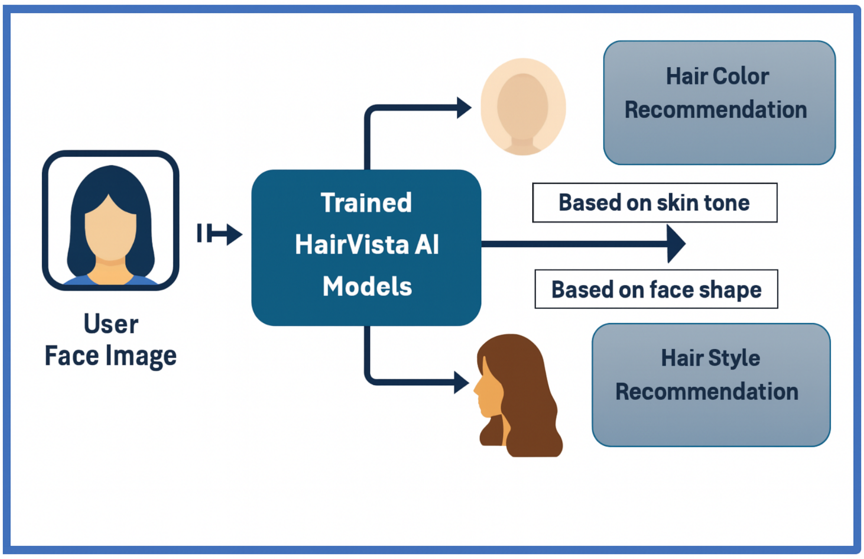

Figure 1.1: Working of Model

1.2 Problem Statement

The choice of hairstyle or color that will look good on the person may not even be an objective decision due to the many factors involved. But what the larger user base lacks is access to experts or intelligent systems that might give them appropriate advice on the matter.

Online services offering recommendations on hairstyle, color, and other factors rely on manual choice options and rudimentary filtering functions. These options lack personalization, which requires AI analysis. Besides, most of these apps contain static templates or use augmented reality to generate responses with a lack of realism. Apps purporting to utilize AI, GANs, in particular, often yield a filtered, artificial impression of images, which may lack sufficient rigor in model development, facial details, or variability.

A number of popular applications, including YouCam Makeup, ModiFace, Style My Hair by L'Oréal, and Virtual Hairstyler, claim to offer a simulation of hairstyle or color change. In most of these applications, they use general styles without considering the facial structure of the individual using them. Results obtained from these applications may seem unreal, filtered, and unrelated to a person's natural identity.

There exists an evident gap with regard to accessible intelligent systems that:

- Automatically determine the facial shape and skin type of the user,
- Realistically imagine hairstyles and colors,
- Make recommendations based on AI analysis of user's facial features.

Hairvista AI seeks to fill this gap by incorporating deep learning techniques, face shape recognition, and skin analysis to offer a realistic preview and intelligent hairstyle and color recommendations. Unlike previous solutions that were incapable of offering personalized recommendations suitable for each user's facial features, Hairvista AI applies Gemini 2.5 Flash Image model to generate personalized outputs that adapt naturally to each user's unique features, offering a professional-grade and achieve a high scalability beauty recommendation system..

While efforts have been made in the field of hairstyle recommendation, there are several research papers suggesting the challenges involved in the process, which are not addressed. In the research titled "Design and Implementation of Hair Recommendation System Based on Face Recognition," authors Zhuocheng Liu, Yuhao Dong, and Junchao Sha state that:

"It is proved, through comparisons of several sets of experiments, that there is a good effect of hairstyle recommendation algorithm, and hairstyle recommendation is a very complex process. The human hairstyle recommendation is still a process requiring rich experience and, particularly, virtual experience. Thus, hairstyle recommendation remains a very complex figure and task. There are several approaches in this field, but they are not employed for hairstyle recommendation, so hairstyle recommendation method is not exactly correct." [3]

1.3 Project Objective

The main objective of this project work is to develop a smart system with the ability to analyze facial features, particularly identifying the user's facial shape and complexion. For this purpose, the system will utilize the results of the analysis to automate and improve the process of recommending hairstyles and colors to the user. A fully functional web application will be delivered to enable users to simulate various hairstyles and colors on their faces and thereby make the process more interactive and fun to work with. At the same time, the application will facilitate clients to save their recommendations for further retrieval and usage. Ultimately, the system should provide users with improved satisfaction and earned trust due to style recommendations that are unique to individual facial features.Ultimately, the system should provide users with improved satisfaction and earned trust due to style recommendations that are unique to individual facial features.

1.4 Project Scope

During the processing of an image uploaded by an individual, the system would evaluate and determine the face shape and skin tone, together with other facial features, with the aim of establishing the hairstyle and hair color for the analysis. The major aim is to offer the real-visualized sample for persons to make proper decisions on dressing styles.

Within the first step, using the pre-processed label, faces and skin tone definition will be labeled, and the system will render the high resolution for simulation concerning hairstyle and hair color. Later, improvements in rendering quality, real-time feedback, and varying styles of hair possibility can be applied effectively in subsequent phases.

The project that has been currently developed has the aim of providing recommendations to females only regarding their hairstyles and color. Its dataset comprises a filtered frontal and angled face image, thereby training the model, and hence the current model may not work properly on the angled face images as well as the low-quality images.

The proposed project is meant for the industry of beauty and fashion, styling apps, and virtual salons, helping customers make decisions with the assistance of visuals, which, as a rule, demand additional expertise.

Chapter 2

Literature Review

This chapter will focus on conducting a literature review pertaining to the primary themes of the project at hand: face shapes classification; recommending hairstyles and colors; and generating images using Gemini-2.5-Flash-Image (Nano-Banana). This chapter will aim to examine the significance of the most pertinent advances in the technologies involved in this project as a function of Gemini-2.5-Flash-Image (Nano-Banana) for a realistic representation/alteration of images pertaining to hairstyles and colors, as well as point to the deficiencies in existing recommendation technology as it pertains to consumers.

There are a few publications that outline the study of facing feature analysis, recognition of the shape of the face, as well as the AI that goes into simulating the styles of the hair. Most of the current software available is only able to be utilized by input and filter systems that do not yield personal results. With the development of the latest technologies of deep learning and the latest developments within the creation of personal images such as Gemini-2.5-Flash-Image (Nano-Banana), the allowance of personal graphic representation fitting the user and their unique face shape is much improved.

Discussion on the comprehensive development status and functional capabilities offered by the Gemini-2.5 flash image models, which are utilized in the function concerning image editing, style image transfer, as well as generating natural image transformations on human faces. Additionally, the literature on the development potential of image recommendations via deep learning on the characteristics specified by the individual, such as skin color or face shape.

By the assessment and analysis of the limitations and strengths of the past literature, the total comprehension of past studies will lead to the development of an intelligent, flexible, and personalized recommendation system that will recommend the users regarding their hairstyles and colors based on the shapes and shades of their skin using the Gemini-2.5 flash image (nano banana) model.

Insufficiencies and Prospects in Existing Research

The limitations that are present in earlier implementations as described by the same study include:

- The development of data collection in the creation of hairstyles is an ongoing process. Due to the vast number of types and styles of hairstyles that exist in reality, quite a number of systems make use of very few choices hairstyles, limiting the scheme of generalization and versatility of the algorithm.
- In the event of picking out a hairstyle to a user, the hairstyle is in most cases simply laid on the original picture of the user without blended effects. This distorts and/or creates artifacts in. the finished product.

To solve such problems, the authors suggest additional research on the following lines:

- The use of Gemini-2.5 flash image (nano banana) model, which will be blended through the use of blending have the most natural or realistic means of mixing together the hairstyle of the user with theirs personal photographer and therefore erases distortion in order to make it look as natural as possible.
- Gemini 2.5 Flash Image can understand and merge images of various images sources. This encompasses the fact that the user can add objects to a pre-existing image, modify the filter through color scheme or texture in a room, and combine several images with one input prompt. [3]

Prior studies indicated that the hair processing systems would benefit from being more multifaceted and flexible, which could be accomplished by using an AI-based system like HairVista that not only covers the gaps identified earlier but also significantly improves the industry with its in-process functionalities. The AI-based systems have been characterized by the functionality with respect to increased amounts of data, greater capability to isolate more extensive features, and the production of output that is more realistic.

2.1 Facial Shape Classification

In the development of a personalized recommendation system for hairstyles and hair colors, face shape classification is an essential unit. The correct recognition of face shape would greatly help in the process of aesthetic recommendations for the individual and making sure they do not mismatch the structure of person's face. Several publications are available that talk about developing automated methods for classifying face shapes by using computer vision and deep learning methods. The traditional technique relied heavily on extracting geometric features like interdistances and angles among the main facial points (i.e., forehead width, cheekbone width, jawline length, chin angle, and face length) in order to classify the face into pre-defined shapes (i.e., oval, round, square, heart, diamond, oblong, and pear shapes). These features are determined on landmark points that are typically produced by a facial detection algorithm, which could be dlib, MTCNN, or open CV, a facial landmarks detector. These specific characteristics of the face are the midpoint between the two eyes, the width of the left and right eye, the distance between the inner correspondent of the eye, the distance between the eyebrows and the eye, the width of the face, the length of the nose, the width of the nose, the length of the mouth, the width of the mouth, the transition between eye and nose as well as nose and mouth distance. [3] .

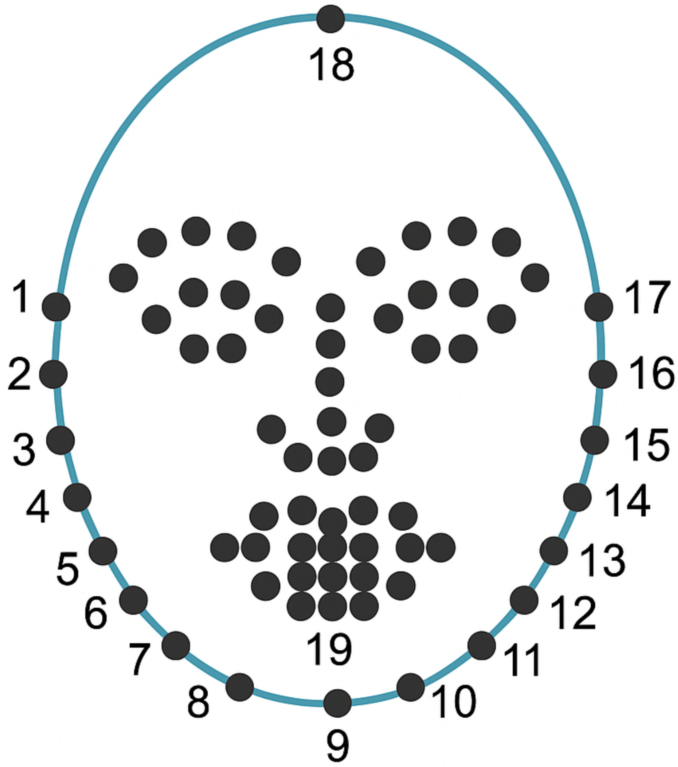

Figure 2.1: Extraction of Face Features

Nevertheless, the manually-crafted feature-based approach often did not achieve the right level of precision and did not effectively cover the whole range of different facial structures, camera angles, lighting, and skin colors. The Support Vector Machine (SVM) is one of the earliest and most popular machine learning techniques that have been employed to classify these geometrically extracted features. It operates on a three-step basis: head segmentation, face plane identification, and face shape classification. This technique represents the first time a fully automatic and non-contact system was able to classify face shape directly from 3D body data [4]. In such approaches, the parameters of the input patterns (ratios of width to height, jaw to cheek width, and so forth) are fed into an SVM classifier, which generates decision boundaries for varied face shapes. Though SVMs have excellent interpretability and fairly good performance capabilities for structured feature spaces, their performance is hindrances due to their dependence on artfully designed inputs and relatively small data samples.

However, with the advent of deep learning, the state-of-the-art method for conducting face analysis has become the use of Convolutional Neural Networks. Unlike previous approaches, the CNN method is able to learn features from images at the pixel level without the need for human intervention.The aforementioned models have proven to be considerably better not only in the aspect of classification accuracy but also in terms of being robust. Among architecture options, The inception v3 has been the one that applied in the face shape classification successfully. Tio et al. (2019) have conducted a remarkable investigation wherein Inception v3 was trained on a collection of celebrity pictures categorized by face shapes, and it was able to achieve around 84.4-84.8% accuracy. Among various models which incorporate CNNs, Inception v3 is one of them. It was initially developed to differentiate among 1000 classes using millions of images but it is still possible to accept the modification for custom image classification problems whereby retraining might be hassle-free [5] . The deep layers of Inception v3 have the ability to learn complicated patterns of shapes, as well as the contours and spatial hierarchies that characterize the slight differences in faces between the different shape groups.

Newer methods also use face detection models such as MTCNN and RetinaFace to first prepare the images and then classify them. These detection systems make certain that the face is accurately aligned and cut out which leads to more consistent input data. After a properly aligned face is secured, the CNN-based models (such as VGGNet, ResNet, or Inception) can conduct classification with more trust by concentrating on facial characteristics instead of non-significant background or rotation. The ongoing advancements in deep learning techniques have also improved the face recognition and alignment processes by exploiting the existing connection between recognition and alignment of faces through joint learning techniques like MTCNN, RetinaFace, STN, and CenterFace. These techniques have the capability to achieve simultaneous face recognition and key-point recognition of the face, which helps in accurate and efficient alignment of faces. Based on this key-point information of faces, it is possible to transform the captured faces to their standard aligned positions through geometric transformation techniques like affine and perspective transformation for improved recognition accuracy. [6]

Nevertheless, there is a considerable research gap in the incorporation of face shape classification into actual recommendation systems, especially those designed for aesthetic recommendation, including hair styles and colors. The current practice in most applications is centered on the selection criterion and rule-based approaches, which are not personalized or accurate. Through the integration of an accurate data-driven face shape classification system, as illustrated in this FYP, the recommendation system is optimized and personalized according to the individual's facial characteristics.

2.2 Skin Tone Classification

Skin tone analysis is thus a significant factor in personalized systems such as those in beauty, healthcare, as well as virtual try-on applications. The correct tone of the skin identification makes it possible for the systems to provide not only general but also personalized recommendations for hair, make-up, and accessories based on the individual's color. Traditionally, skin color detection was carried out through simple thresholding or clustering approaches based on intensity values of RGB or HSV color spaces. Nonetheless, such approaches generally fail in terms of generalization skills.

However, there has been a recent paradigm shift in research related to deep learning-based methods that promote resilience and flexibility. Convolutional Neural Networks have been increasingly used for extracting high-level features from specific facial areas in order to learn invariant representations under illumination or background variations. For example, Thong et al. in 2023 proposed a multi-dimensional metrics approach in estimating apparent skin colors beyond a basic tone. It has been paramount to acknowledge that "light," "medium," or "dark," as labeled as a skin tone type, may be inadequate in understanding the complexity of skin tones.[7]

Further, some research uses face segmentation methods to identify skin regions, thereby decreasing the noise caused by non-skin areas. Some pretrained models, namely EfficientNet and MobileNetV2, have been applied for skin tone classification, especially for mobile-based models, for efficient results.

In addition, the question of fairness in AI has become a major concern. Algorithms are evaluated now to determine how well skin tone classification models work for people with different skin colors, as a way to reduce biases in algorithms. Recently, the Fitzpatrick scale has been incorporated in the field of computer vision and it is playing a crucial role in determining fairness in algorithms and accuracy of models based on skin type. On the one hand, Fitzpatrick labels provide us with a starting point for the assessment of algorithmic fairness but on the other hand, we observe that the Fitzpatrick scale does not represent the full variety of skin types. Two to five annotators apply a Fitzpatrick skin type label to each image based on Scale AI's dynamic consensus process [8]. This is particularly important in systems that make recommendations, as the consequences of biased categorization of skin tones might result in suggestions that are either unequal or culturally insensitive.

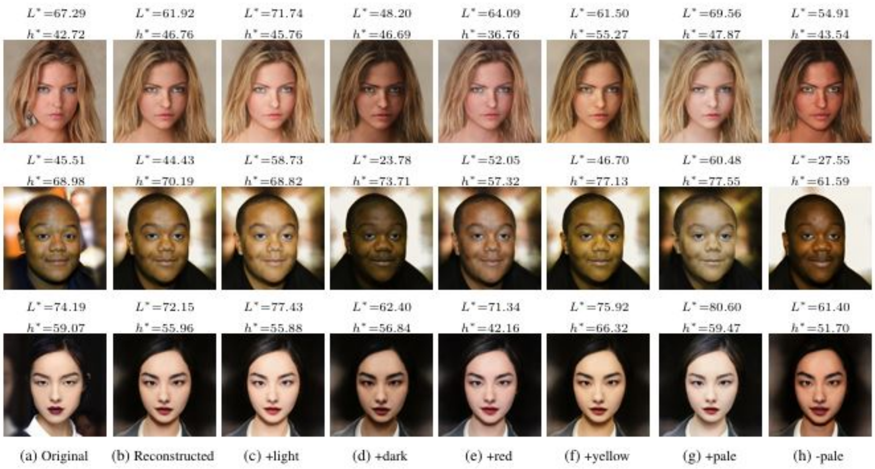

Figure 2.2: Skin tone analysis on the basis of facial regions after segmentation.

2.3 Hairstyle Recommendation

Hairstyle recommendation systems have transformed from basic manual approaches to sophisticated AI-driven pipelines, providing personalized recommendations based on facial and hair attributes.

The early stages of research relied on systems that manually mapped facial features, predominantly face shape, to hairstyle categories through rule-based logic. Even though these solutions were straightforward, they could not be adjusted according to the user's needs or the trends in hairstyles, as they were not dynamic at all. Thus, they were limited in this respect.[9]

Figure 2.3: Hairstyle Transfer Samples

The CelebHair dataset offered by Chen etal. was a major development in the area of machine learning for hair-related tasks. This dataset contains approximately 202,599 pictures, on which certain human facial characteristics such as face structure, nose length, and eye spacing are marked. The researchers were able to get this stack of pictures from CelebA. They made use of landmark detection, spatial transformer networks, and deep Convolutional Neural Networks (CNNs) to classify hairstyles and, using Random Forest models, connect them to facial metrics. The dataset made it possible to train classification models for hairstyling tasks that were more robust and scalable. This was a big step towards the eradication of the data scarcity and limited features of the earlier datasets that had been the roadblocks in the way of the development of such models. [10] .

On the other hand, the K-Hairstyle (2021) database is a huge collection of high-resolution annotated images consisting of 500,000 images with hair segmentation masks and different hairstyle labels, which makes it possible to give strong training for classification, dyeing, and style transfer tasks for instance. Such datasets can provide better classification and recommendation of hairstyles among a wide variety of types and demographics with the help of deep learning models, such as EfficientNet, MobileNetV2, or Random Forest regressors. [11]

Hairstyle recommending systems have progressed with the proposal of a hair analysis pipeline by Kim et al. in 2018. Their model performs hair detection and segmentation as well as hairstyle classification using deep neural networks for unconstrained images. This approach enables holistic analysis of both facial and hair features, improving recommendation relevance compared to earlier rule-based systems by working directly from input images rather than static templates. [12]

These contemporary systems improve personalization significantly and address scalability through deep learning pipelines. Moreover, the systems are also capable of preview and source hairstyles with dynamic characteristics from a vast number of styles. Nonetheless, several drawbacks exist that include: a vast number of systems using carefully compiled data that lacks proper representation for many ethnic and textured hairs, and computationally complex generative modules that are not applicable on a mobile platform for normal use cases. Moreover, although face and hair alignment and perception are addressed by a majority, fewer systems take into consideration user preferences for style and fashion trends as a recommendation module.

However, these technologies are still the first steps in the evolution of AI from rule-based systems to fully integrated, scalable, and smart platforms that can dynamically create and suggest hairstyles in a more engaging and personalized way.

2.4 Hair Color Recommendation

In early techniques related to hair color manipulation, rule-based techniques and color filters were used on segmented regions of hair. Although simple and easy to implement, these techniques produced unrealistic output, especially because of improper lighting and texture modeling.

In recent developments, a GAN framework was incorporated for hair recoloring based on conditional inputs, including the RGB hair masks and the color vectors selected by users.

Figure 2.4: Samples of Hairstyle transfers

The technique was able to preserve the lighting effects and texture of the hair through image to image translation with the Pix2PixHD framework.[13]

The HairCLIP model brought in a novel approach for text-assisted hair coloring. It combines CLIP embeddings with GAN inversion to do color and style changes according to the commands given through natural language such as “make hair pastel pink.” Through latent manipulation in StyleGAN, HairCLIP allows user-interactive and semantically meaningful recoloring.[14]

Recently, the new technique introduced in HairDiffusion introduced a novel application for hair color editing using latent diffusion models. The technique introduced a Multi-stage Hairstyle Blend strategy that allows for independent control of both the hair color and style within the diffusion latent space. A learned warping module aligns the targeted color with the image area where the hair is located. A CLIP-Refer approach for a multitint dataset fine-tuned in a reference model allows for multitint editing. The current model has a better real-world application compared to the earlier GAN models. [15]

These innovations transform the paradigm from still, unbelievable hair dye filters to customized, AI-based coloring systems. By utilizing GANs, CLIP-based semantic control, and attention modules, contemporary hair color generation tools are already capable of performing real-time, interactive, and visually coherent transformations, making them suitable for recommendation and virtual try-on platforms.

2.5 Applications of Gemini 2.5 in Image Generation

Nowadays, the models for generating images have made a tremendous leap forward in terms of their power; however, in one aspect, they are still not very good, and that is the editing part. The said capability includes it being possible to apply exact corrections with text, convert colors, modify styles, etc. However, it would still be the same character shown through different ages with various pictures taken from different perspectives. Thus far, Google has removed this restriction with the introduction of the Gemini 2.5 Flash Image Model and a completely new way of dealing with these kinds of edits through a new type of interaction with the models, as no single image generation model has been able to perform all tasks simultaneously until now.

Gemini2.5 models consist of transformers with sparse mixture of experts (MoE) models. They have multiple ways of taking the input: it can be text, vision, or audio. In each token of input, there's a constraint on how many model parameters that would be activated based on specific token features with the use of dynamic routing to select and activate specific model parameters or "experts" for that token. In that regard, it would be possible for the overall capacity of the model to be entirely unaffected by the amount of computation and also by the corresponding expense related to handling every token. Thus, changes within the structure of the model directly affected the performance level of the new Gemini2.5 model compared to that of the previous gemini1.5pro model. It has been revealed that both large transformer models and Sparse MoE models do suffer from instability problems and inconsistencies during the pre-training period. [16]

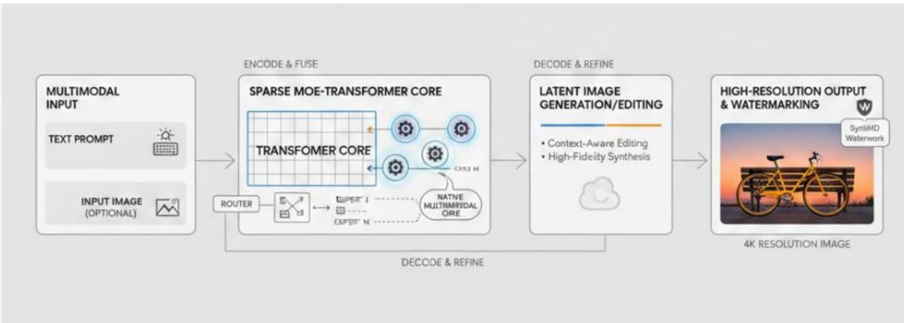

Figure 2.5: A multimodal system that fuses text and images to generate high-resolution watermarked images.

The Gemini-2.5-Flash-Image (Nano-Bana) has been a game changer in the field of image generation and has made things like facial image manipulation, hairstyle and color change even easier. Classic GANs are based on a conflicting partnership between the generator and the discriminator, whereas the Gemini-2.5-Flash-Image relies on a multi-modal vision model with gigantic image-and-text datasets which permit it to closely and accurately decode the semantic links of facial features, hairstyles, and the corresponding visual qualities.

Gemini-2.5-Flash-Image uses two different methods of image creation: the diffusion method and the transformer method. The diffusion-based and transformer-based strategies likewise employ iterative refinement techniques to eliminate noise from images based on learned noiseless steps. The model morphs a decaying noisy latent representation of an image into high-quality photorealism, which entails gradually switching this image through numerous iterations until the end result is attained. By utilizing a single latent representation that encompasses facial geometry, texture, and style, Gemini-2.5-Flash-Image is capable of altering an image's localized traits (for instance, hair types, lengths, colors, etc.) without changing the person's identity or facial structure.

One major advantage of Gemini-2.5-Flash-Image is its skill in unifying text-given directives without any hitch. By understanding human language prompts (for instance, "switch hairstyle to shoulder-length waves" or "put on light brown hair color"), the machine provides controlled and bespoke transformations. Thus, the model is very much fit for beauty-tech applications that demand individualization and realism. Besides, the model is able to take in image-conditioned inputs, which allows the users or systems to set limitations according to face shape, skin tone, or current hairstyle.

The large-scale training of Gemini-2.5-Flash-Image has led to the generation of outputs that are not only highly realistic but also diverse and visually consistent to a great extent. Its generative power is not only on par with but also sometimes greater than that of most GAN-based systems, all the while steering clear of the usual GAN drawbacks like mode collapse, training instability, and loss of detail in fine facial features. Therefore, it is a remarkable breakthrough in the field of virtual hairstyle try-ons, beauty recommendation engines, and intelligent face-editing applications.

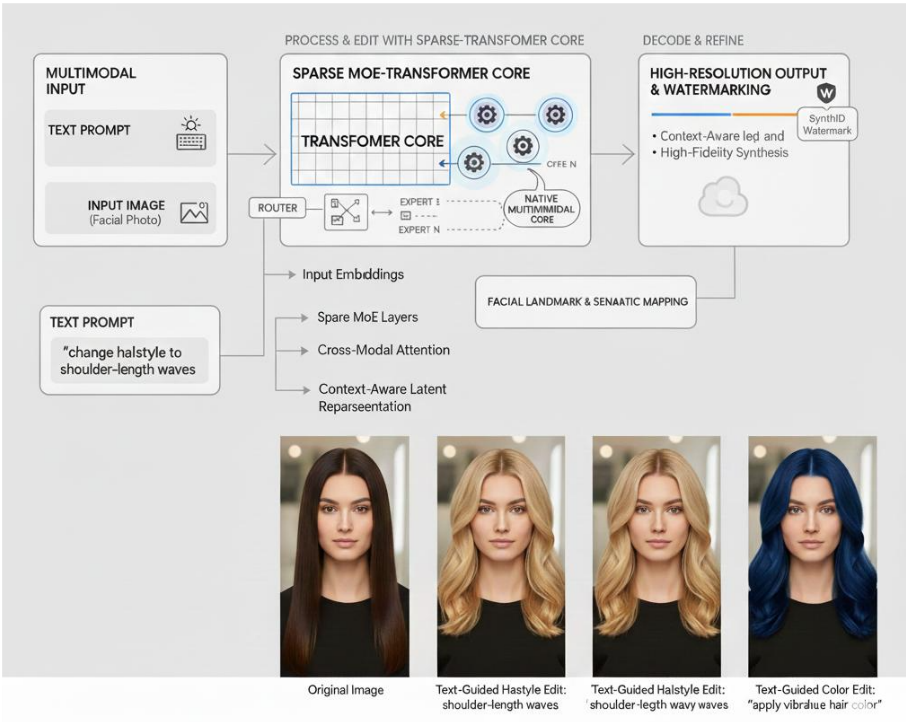

Figure 2.6: Text-guided face editing using a Sparse MoE-Transformer.

Table 2.1: Comparison of Key Papers

Year of Publication	**Name / Author**	**Methodology**	**Limitations**
2019	Non-contact 3D Face Shape Analysis (Sahar et al.)	Support Vector Machine for 3D face Geometry	Needs 3D scanning data; cannot be employed for mobile devices; somewhat less capable with variable lighting conditions Sensitive to image quality, pose variations, and depends greatly on correct landmarking results
2016	2D Classification using Traditional Machine Learning	Classification using LDA, KNN, SVM on Geometric features	Requires large amounts of annotated images; performance is reduced for low-resolution images of faces that are not properly aligned
2019	Deep Learning Approach for FaceShape Classification using Inception v3	2D Dataset-based face analysing using Inception v3	Minor loss of accuracy in cases of extreme head poses; errors in alignment influence the final results
2021	Face detection and alignment for shape classification	Integrated Face Detection and alignment pipeline for shape classification	Does not propose a unified model; FIQA and preprocessing are primarily considered
2022	Survey of face shape classification methods	Comparison of traditional ML, and deep leaning approaches for faceshape classification	Does not propose a unified model; focuses mainly on FIQA and preprocessing
2024	Dense Landmark detection and recognition in two steps	Dense landmark localization followed by CNN classifier	Computationally intensive; needs high-quality landmark identification for results to be accurate
2024	Deep Learning pipeline using retina face and CNN	Retina Face Detection, alignment and CNN classification pipeline	Needs GPU-based computing systems; diversity of datasets mandates generalization capabilities

Chapter 3

Requirement Specification

The recommended system draws on the technologies of deep learning and computer vision to give personalized recommendations regarding hairstyle and hair color. The Gemini Flash 2.5 image model is built in, making it possible for us to generate the most customized results in terms of hairstyles and hair colors.

To detect face shapes, we employed the FaceShape dataset that categorizes faces into five different shapes: oval, round, square, heart, and oblong. We also made use of the Monk skin tone dataset for identifying skin tones in which various image kinds were included that made it easier to determine skin tones and consequently suggest the most suitable hair colors.

We used Flan-T5 to provide the most fitting suggestions for hairstyles and hair colors based on the established face shape and skin tone. The moment a user clicks on an option from the list provided, it goes to the Gemini flash2.5 image model API, which then creates the final output in terms of hairstyle or haircolor.

The models that have been trained are incorporated into a web application, where users can upload selfies or take new pictures. The system automatically detects their face type and skin color, After the user's face is cut out and colored the system gives the most suitable options for hairstyles and hair colors. The user is then shown these options tailored just for him/her, and thus is able to go through and pick one of the suggested styles without any hassle.

One of the earliest AI-based solutionsapplication to analyze faces shape, detect skin colors and propose customizations is this app. Depending on the user's skin tone and facial structure, the system provides the most appropriate styling options depending on the user's looks. Thus, the application is providing the user with next-gen styling that is realistic, inclusive, and truly personalized.

3.1 Existing System

3.1.1 Web Applications

At present, the market comprises a number of web-based as well as mobile applications, which can be considered as virtual beauty consultants or even virtual hairstyle try-ons. Despite this, most of the systems constrain themselves to a very limited range of functions, or, on the contrary, they do rely on the facial recognition technique to be personalized at all.

One of those is YouCam Makeup, which is quite a hit among the users, as it enables them to take up different hairstyles and colors virtually. Sadly, the suggestions, though, remain common and not user-specific, as they do not take into account the face structure and skin tone.

Another one is ModiFace that simulates hair coloring but does not use face shape or skin color analysis to make smarter recommendations. Actually, its previews are quite rudimentary showing only images overlapped one on top of the other, which do not portray the realness of texture or profundity.

In the same way, users of Hairstyle Makeover and other similar apps are provided with merely trivial hairstyle changes through the use of predetermined templates, thus lacking innovative and context-aware personalization methods. These applications operate on a static set of rules, wherein such rules decide the displayed content, rather than enhancing the content relevance based on particular users and their activities over time through the use of machine learning or other advanced technologies.

Personalization remains a problem that both online and conventional hairdressers encounter. To secure their clientele, hairdressers usually try to persuade their customers to become members by presenting them with membership cards as a means of drawing power. Membership marketing is a technique of marketing that grew in the 90s with the purpose of acquiring customer loyalty and securing long-term business profits by offering members special treatments and employing a specific marketing strategy to reach members. The customer who is loyal is the one upon which the entire system of steady profits in the hairdressing sector rests. [17]

In the past, a customer was thought to be loyal or likely to return if he/she had reached a certain level of spending. It was only after the customer had this milestone that he/she was then given membership and the right to be treated as a VIP or receive services promptly. Contrary to this, nowadays, consumers can get a place in a hair salon by simply purchasing a membership card and, in most cases, not getting any special treatment at all [17].

In addition, the great variety of hairstyles and colors to choose from has made it hard for hairstyles to find a good hairdresser. For example, a person looking for a short hair hairstyle may see more than 30,000 pictures. Likewise, when it comes to hair color, the person can choose from hundreds of shades. Customers are disoriented by this heap of information and, therefore, are in great need of smart filtering and personalized suggestion systems [17].

To put it briefly, even though there are virtual hairstyling tools and salon models that offer membership-based services, these tools and models still have not bared the fruit of providing the users with genuine intelligent, tailored, and realistic recommendations. Most of them depend solely on a set of rules or templates for recommendations without resorting to facial analysis or generative AI that is exactly where Hairvista AI intends to create a sizable difference.

3.2 Proposed System

Deep learning and computer vision take the lead in this application by offering personalized recommendations for hairstyles and hair colors. The combination of the Gemini Flash 2.5 Image API, face shape classification, and skin tone detection gives us an edge since the results of hairstyle and hair color are very real and customized.

The classification of face shapes involved training a FaceShape dataset, which consists of five categories of face shape: oval, round, square, heart, and oblong. For skin tone classification, we used the Monk skin tone dataset, which has a wide range of skin tone images, a 10-shade scale, and an inclusive range of human skin tones. This will help the model to accurately determine the different types of skin tone variations and recommend the best matching hairstyle and hair color.

The models that have been trained are integrated into a web application, in which users can get their selfies uploaded. The system efficiently detects the face shape and skin tone of the user. The analysis then leads to the Gemini Flash 2.5 Image API creating realistic hairstyles for trying and suggesting personalized hair colors that go with the user's unique features.

The current application is forecasted to be among the first AI-driven projects to present a merging of face shape and skin tone analysis along with the visualization of hairstyles and hair colors created using the Gemini Flash 2.5 Image API, thus leading to an extremely personalized virtual styling experience.

3.2.1 Benefits

The major advantage of such an application is that the Gemini Flash 2.5 Image API can generate a multitude of different hairstyle and hair color visualizations all from the same user's selfie or preferences. If the first result does not meet the user's expectations, they can just click the generate button again, and the machine will produce yet another version with slight tweaks or a completely new style.

Due to the realistic hairstyle options generated, users will be able to compare and view different hairstyles in a more realistic manner. Besides, the photographs coming from the Gemini Flash 2.5 Image API are very lifelike and resemble real hairstyles rather than being artistically or cartoonishly rendered.

Having an actual visualization of both hair color and hair style will help users to easily decide which hair style or hair colour to try first before wearing it in real life, thus making it more of a decision rather than a guess. Moreover, it will be possible to give users a personalized recommendation of the most suitable styles that are based on a combination of the user's look with the face shape analysis and skin color detection features of the Hair Vista AI system.

This is the reason why Hair Vista AI not only brings about diversity and personalization but also provides the user with the feeling of security to experiment with trends and to choose the most flattering hairstyle and color without any risk involved.

3.2.2 Solution Areas

This App, by modifying people's way of picking hairstyles and hair colors, will mainly take away a lot of time and effort of people that they would otherwise spend at salons and in their daily routines. The web will provide the users with a platform through which they can upload their pictures or easily take their selfies to get the right recommendations for hair colors and styles. So, the users are able to very confidently make up their minds about what to do-before they go to the salon.

At the same time, the new software will help not only individuals but also the beauty salons and hairdressers who will be able to offer their clients AI-supported consultations. It can also be utilized in the fashion and entertainment industries where actors, models, and other celebrities could try different looks in a very short time but without going through the hassle of physical changes.

The clients' fears of looking silly with a new hair color or style could be eased by the application of the technology as it will allow them to see the various haircuts and colors on them before deciding.

In the future, the same technology may also be of help to those in the gaming, virtual avatars, and augmented (AR)/digital worlds since the participants will want realistic representations of customizable patterns and textures that resemble hair. Wig companies, along with producers/distributors of beauty products, might also be able to use this software to create a lifelike representation of their products depending on the different types of facial structures and skin tones.

Thus, HairVista AI can be regarded as not only a personal stylist but also a creative tool that can turn various sectors with the beauty and fashion industries as well as entertainment into fully-fledged markets.

3.3 Requirements Specifications

3.3.1 Purpose

The HairVista AI project, through the use of deep learning and computer vision, is intended to be an essential part of the research and development of the AI-based personalized hairstyle and hair coloring recommendation system. The project's main objective is to analyze and characterize a user's facial features (i.e., face shape and skin tone) and produce the most fitting, photorealistic models of the hairstyles and hair colors. Furthermore, HairVista AI will be able to produce stunningly perfect images and ensure that user satisfaction is at the highest level possible.

The development of HairVista AI is a response to the above-mentioned goals and objectives. This tool is designed for those who want to experiment with different looks before finally deciding on one specific hairstyle, and also for beauty salons, hairstylists, and other beauty professionals. Such professionals may opt for the HairVista AI for conducting AI-driven consultations with clients when they need to get expert opinion on their hairstyles.

Apart from the Target Market mentioned, the Fashion and Entertainment Industries are another area where the application would prove beneficial, allowing users to portray themselves in different styles quickly and conveniently. Moreover, a great number of other activities can be envisioned, such as the ones related to the Hair Care, Cosmetics, Hair Salons, Trichology Clinics and Hair Transplant Centres that train their stylists using realistic previews, letting the clients know what to expect before any treatment or styling is done.

Hence, this project will have a broad spectrum of users and will be serving not just people's personal but also different industry-based needs. Developing an Application that offers Users the opportunity to make realistic Life-like Visual Representations of Hair Styles and Hair Colours which can be Customised through Gemini Flash 2.5 Image API's and also being used along with Advanced Face Shape and Skin Tone Detection Capabilities is among the project goals.

This project shall be done in two parts:

- Phase 1: In the initial stage, the face shape classification and skin tone detection models will be trained using the FaceShape dataset by niten19 from Kaggle and the Monk Skin Tone Dataset.
- Phase 2: From the creation and launch of the web application's graphical user interface that employs the trained models to offer individual users personalized hairstyle and hair color suggestions.

The project is built using Python programming language and is dependent on several libraries, thus there is a chance that compatibility issues might arise due to one of the libraries being outdated or getting corrupted. In the developmental stage, accuracy and realism are crucial, as the users might get confused if wrong advice is given or the visualizations are unrealistic.

3.3.2 User Needs

The female market is the main customer segment targeted by the HairVista AI product who want to get the perfect picture of their future look by changing their hairstyle or color, thus, making it very clear what and how they look like. HairVista is the app that practically makes us more beautiful by giving each woman the exact look she wants all the time through personalized virtual hairstyling.

Moreover, hair and beauty salons that have a women-centered service focus can adopt this application for their AI-Based consultations. Women from different areas of work like modelling, being an influencer, content creation and so on can take advantage of the application to get the super fast and lifelike hairstyle transformations that it offers. What is more, this app can even open the way for scalp care clinics to get rid of the guesswork for their female patients by showing them what they will look like after hair restoration and at the end of the treatment.

To be specific, as a female user, the following are my requirements that the application should answer:

- An easy and intuitive interface explicitly created to improve the experience of choosing products among women.
- Selfie sharing easily and with minimum effort, accompanied by proper guidance.
- Identifying female face shapes and skin color, in order to suggest the most appealing hairstyles and shades of color to the hair.
- To be able to allow an individual experiment with a number of patterns by way of different hairstyles and hair colors of the same input.
- Output images that are qualitative, realistic, and depict images that show the appearance in real life and not artificial or computer-animated visuals.
- Fast speed, reactivity: deliver results within seconds.
- Ease of revisiting the previous results to investigate alternate styling recommendations.
- Clear, neat, and convenient design with all functions clearly noticeable.

The fulfillment of these needs ensures Hair Vista AI provides a personalized, interactive, and summary virtual styling experience that is designed especially for the female gender.

3.3.3 Assumptions and Dependencies

3.3.3.1 FaceShape Dataset

In order to perform face shape classification with high precision, we utilize the Face Shape Dataset by niten19 which is available on Kaggle. This collection is made up of 5,000 images of female celebrities taken from different parts of the world. These images are grouped into five categories based on the shape of the face, i.e., Heart, Oblong, Oval, Round, and Square. Each of these groups contains 1,000 images where 800 are for training purpose and the remaining 200 for testing purpose.

The diversity of the images shows the various types of face shapes and angles that can be captured in different lighting conditions and with different backgrounds that will support the model in generalizing better when trying to use it in real-world applications. Besides, the dataset is characterized by precise labels and thus has a balanced distribution between all the classes. So, the dataset can be confidently relied upon for building deep learning face shape recognizer models for the HairVista AI project training.

3.3.3.2 Monk Skin Tone Dataset

The Monk Skin Tone (MST) dataset, which was created by Google together with Dr. Ellis Monk, illustrates a 10-shade scale that relates to the skin tones of humans and that is broader and more inclusive at the same time. The other dataset, Monk Skin Tone Examples (MST-E), contains 1,515 images that were selected to train the annotators and thus, the fairness in the computer vision systems has been improved. The MST dataset, which was created to help models and researchers in the reduction of bias, is the benchmark for skin tone classification that is consistent and also for the development of inclusive AI across various populations.

3.3.3.3 Gender Classification Dataset

In order to guarantee that the application caters specifically to its target audience, we incorporate a Gender Classification Dataset obtained from github. This dataset is made up of a vast number of facial pictures marked as male or female and the system is able to identify the gender of the uploaded image first and then recommend hairstyle and hair color respectively.

The gender classification makes certain that the model uses the female hairstyle options only for the right users. The dataset features photographs taken with different poses, lighting and background settings thereby enhancing the robustness of the model. The Gender Classification dataset is composed of images that are publicly available and intended for academic and research use only.

3.3.3.4 Hardware Resources

HairVista AI is a software application that operates without the use of any hardware components other than those required in the computation infrastructure. For effective development, training, and inference of models in AI applications, the following hardware components are required for general-purpose computation:

- **Processor:** Multi-core processor (e.g., Intel Core i5 or better)
- **RAM:** Minimum 8 GB (16 GB recommended for faster processing)
- **GPU** (Optional but recommended): NVIDIA RTX 3050 GPU with support for CUDA acceleration of deep learning computations
- **Storage:** At least 20 GB of free disk space to store datasets and models
- **System Type:** Desktop or laptop with standard webcam.

3.3.3.5 Environment and Libraries

HairVista AI is developed using the Conda environment and Jupyter (IPython) notebooks. The system depends on a set of Python libraries for deep learning, image processing, and frontend interfacing. The environment setup includes:

- Environment Manager: Conda (Anaconda)
- Development Interface: Jupyter Notebook (IPython)

Key Python Libraries:

- **numpy:** numerical operations
- **opencv-python:** image processing and manipulation
- **dlib / mediapipe:** face detection and facial landmarks extraction
- **matplotlib / seaborn:** data visualization
- **scikit-learn:** for classification tasks like face shape detection
- **tensorflow / pytorch:** deep-learning-based module
- **pillow:** image processing
- **flask or streamlit:** Optional frontend interface (if deploying)
- **joblib or pickle:** model serialization

3.3.3.6 Testing Requirements

The testing will help in ensuring the reliability, accuracy, and usability of the HairVista AI system. The critical requirements for the testing process are:

- **Unit Testing:** Specific modules, for instance, facial shape detection, skin tone extraction, and recommendation engine.
- **Integration Testing:** Test the flow of data from the modules. For instance, data flow from image input to analysis to output.
- **Performance Testing:** Check AI inference time, model latency, and UI responsiveness.
- **Accuracy Testing:** Accuracy testing needs a dataset where face shapes and hair tones are known.
- **User Acceptance Testing (UAT):** Test the functionality of recommendations and usability on real users.
- **Cross-platform Testing:** This involves ensuring the system or application functions on various platforms and browsers if it is a web application.
- **Security Testing:** Validate handling of uploaded images and user information.

3.3.4 Functional Requirements

The functional necessities of HairVista AI, as specified, delineate the primary tasks of the system to be performed in order to satisfy the users. The app should be threefold: firstly, it should permit the uploading of selfies by females, secondly, it should classify the gender of the user to make sure the application is addressed correctly, and lastly, it should ascertain the face shape to the extent of providing the hairstyles that best suit the user's face.

The next step for the system is to analyze the skin tone of the user for the purpose of being very precise and inclusive in the classification. The image processing API that the system utilizes is of high quality and is called Gemini Flash 2.5 Image API, it is also the one that provides the users with the possibility of previewing their hairstyles in different colors. Alternative hairstyles or hair colors will also be offered to users if they are not satisfied with their recommendation or what they saw initially.

Apart from that, the system should provide easy access to the features that users commonly need, such as photo upload, hair and color visualization, regeneration of hair and color, and saving of images for future access. And finally, the system should operate without any limitations and should be highly responsive both on the web and mobile platforms.

3.3.5 Non-Functional Requirements

HairVista AI's non-functional requirements provide the system's quality attributes and performance expectations. The application would have to provide hairstyles and haircolor suggestions based on the uploaded image, classified with a 90% accuracy or higher, while detection of the user's face shape and skin tone. The interface should be designed for women and should be clean and intuitive for easy navigation. The system has to be scalable, supporting multiple users simultaneously, and it must be free of crashes and errors. To ensure privacy and security for users, the application will perform image processing and encrypt all data stored in the program. Besides the above-mentioned features and requirements for the application development, the system will have to be compatible and support any hardware configuration and must also be ethical in AI technology for securing the AI-generated image and protecting the user's privacy.

3.4 Use Cases

Below is the UML use case diagram representing the functional interaction between the core components comprising the HairVista AI framework. It shows the interaction of users in accomplishing personalized hairstyle and hair color recommendations, considering facial features, which is a dynamic collaboration by the user, AI model, and back-end services.

This system flowchart defines system behavior in terms of user requirements, encapsulating major operations like image uploading, face shape identification, AI suggestions for hairstyle, and saving user preferences. It stresses system functions by identifying each system component in providing services for users.

This case diagram represents the purpose of the system and the way in which the external entities interact with the system. It gives a high-level functional description of the program and acts as a guideline both in designing and resolving errors during system implementation.

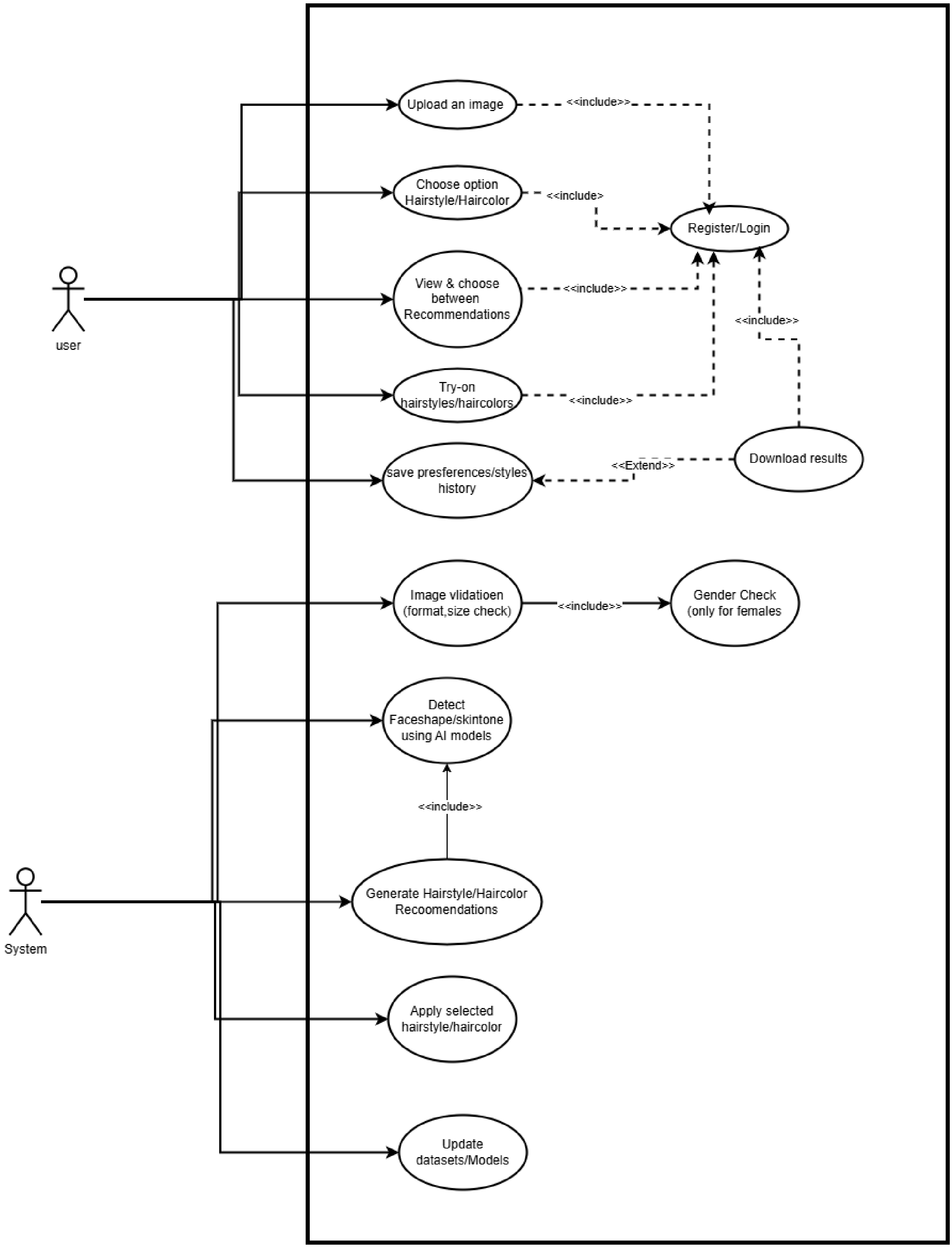

Figure 3.1: Use Case Diagram Illustrating System Functionality

3.4.1 Use case Description

A use case description provides a thorough account of a user's interaction with a system to accomplish a particular goal. Such descriptions of use cases in software development are extremely helpful, as they allow the technical and non-technical audience alike to have a clear picture of what the system is capable of and the way users will be interacting with it. It generally tells us who the user is (actor), what is the desired outcome (goal), and what are the steps to be followed to achieve that (main flow). More specifically, the precondition and postcondition situations, along with the alternative flows, are also presented. In other words, it is a tale that illuminates the user's viewpoint step-by-step.

3.4.2 Use Case 01: Login/Register

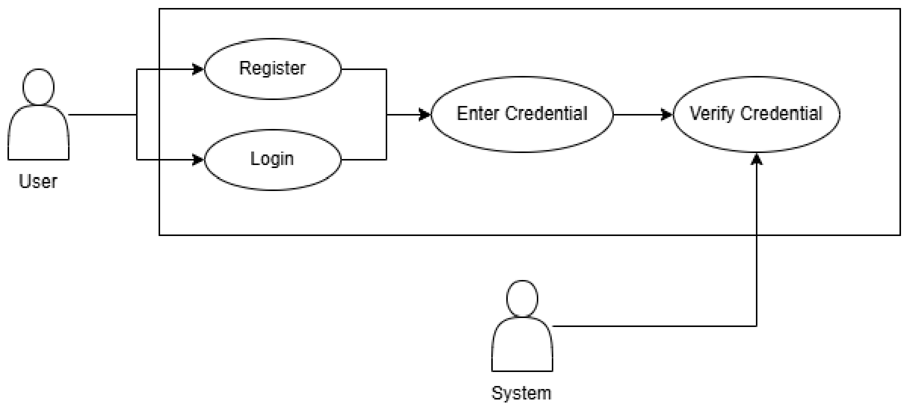

Figure 3.2: Authentication UseCase for HairVista AI

3.4.2.1 Description

Table 3.1: User Registration/Login Use Case Description

Use Case ID	UC1
Use Case Name	Login/Register
Actors	User
Description	Users have the option to sign in or sign up with their own accounts.
Trigger	Click Login/Register Button
Preconditions	User must not be logged in.
Postconditions	User authentication and starting a session.
Normal Flow	
User	**System**
1.User opens login/register form. 2. User enters credentials.	3. System verifies credentials.
Alternative Flows	
1. Wrong credentials entered → Error message is shown.	

3.4.3 Use Case 02: Upload Image

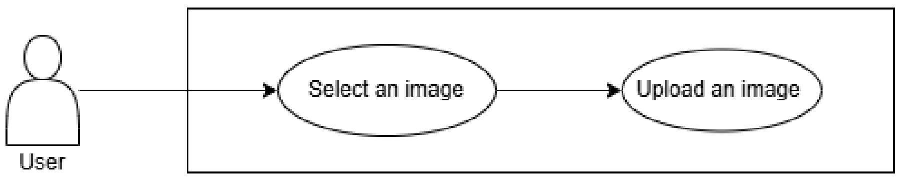

Figure 3.3: Login and Register Use Case of the Proposed System

3.4.3.1 Description

Table 3.2: User Registration/Login Use Case Description

Use Case ID	UC02
Use Case Name	Upload Image
Actors	User
Description	Users can upload an image.
Trigger	Press "Upload Image" Button
Preconditions	User must be logged in.
Postconditions	Image is uploaded and stored for processing.
Normal Flow	
User	**System**
1.User selects an image.	2. System uploads and stores the image for processing.
Alternative Flows	
1. Unsupported format → Error message shown.	

Chapter 4

Design

The next phase outlines the design part of the system which is being developed. All necessary information for the stakeholders and builders is organized and shown in various models and diagrams. To carry out the work in a proper way, it is very important for the team to have an excellent comprehension of the system. Proper design documentation enables the developers to look at a particular part from various angles.

Designing models are a great way to represent the system's complicated nature in a simple way by slicing it into smaller and easier to understand pieces. A design phase that has been planned carefully assures that the system will be designed in such a way that it will cover all the user's needs, it will be easy to use, and it will be technologically viable. The upcoming section introduces the detailed architectural structure of this system using various UML and structured diagrams as the Component Diagram, Sequence Diagram, etc.

4.1 System Architecture

The HairVista system is built upon a layered architectural paradigm where the different layers are User Interface Layer, AI Processing Layer, Output Interaction Layer and Database Layer. A user's picture is taken using the Upload Module. After that, face detection, feature extraction, skin tone and face shape analysis are done on the images. The features that are extracted are then used for recommending hairstyles and hair colors through the engines. The suggestions produced are sent to the Final Output module, which manages user presentation and preference. The system has a dedicated database for each data type that includes user accounts, images, and recommendations. This design ensures that the system behaves persistently and is scalable.

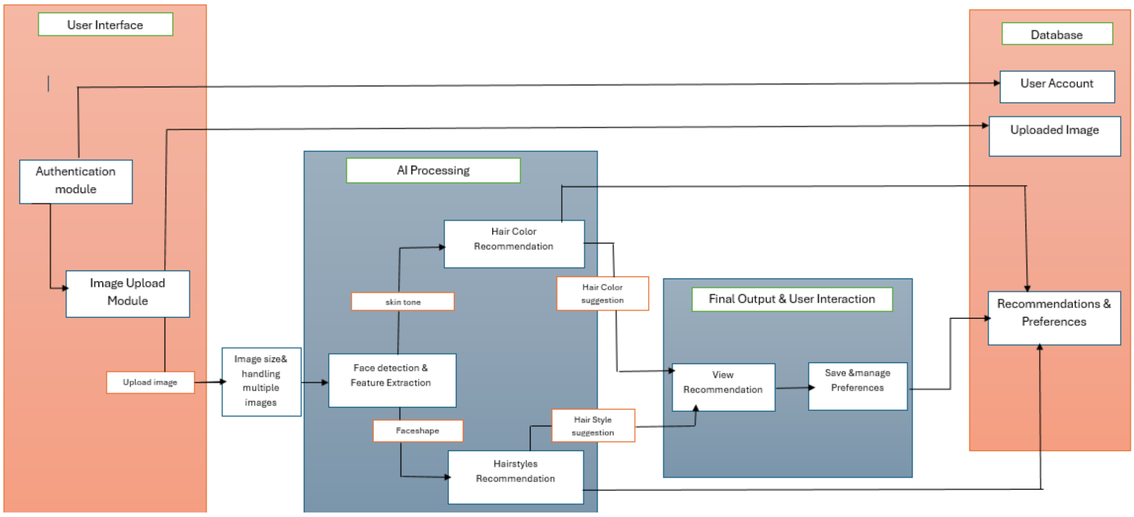

Figure 4.1: System Architecture for HairVista AI

4.2 Design Constraints

Commercially, there were no cost-related problems in terms of design of our system, as there were no financial costs involved in this process. In this way, our design met the time constraints of the project schedule. The design of our system does not specifically focus on any particular hardware platform. It follows standard guidelines concerning usability and has a user-friendly interface.

4.3 Design Methodology

HairVista AI adopts a data-driven modular approach that utilizes deep learning and computer vision techniques. The project is organized into distinct and mutually related modules, which include face detection, face shape categorization, analysis of skin tone, and finally hairstyle and color synthesis.

Each individual module is designed to execute a particular function, ensuring flexibility and scalability in future updates. Since every model is trained individually, they are then merged into one pipeline to process the selfies posted by users.

Gemini-2.5-Flash-Image(Nano-Banana) finds common application in hairstyle and hair-color generation with very natural results. Though not based on the typical deep learning modularity paradigm offered by GANs, its integrated approach and API-friendly workflow make it easy to integrate with web apps.

4.4 High Level Design

4.4.1 Component Diagram

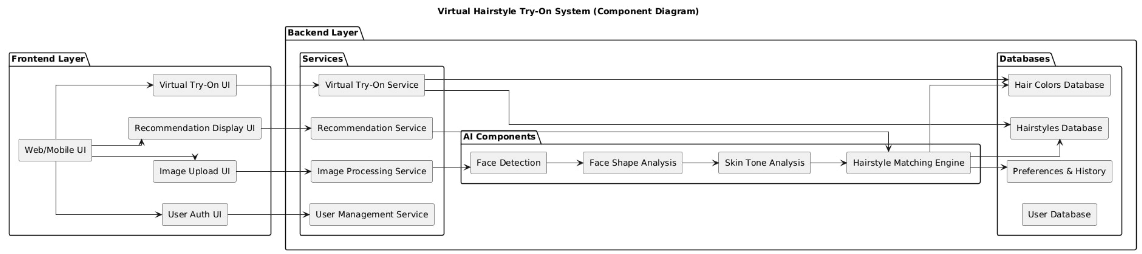

Figure 4.2: A component diagram showing the architecture and data flow of the hairstyle and hair color recommendation system.

In Figure 4.1, The component diagram shows the architectural structure of the proposed hairstyle and hair color recommendation system. The components include face shape and skin tone extraction components that use images uploaded by the user to produce personalized results. The results are processed using NanoBanana hairstyle as well as hair color recommendation engines with the final output presented in an user-friendly manner. The components work together to create an efficient user experience.

4.4.2 Process

4.4.2.1 Sequence Diagram For Hairstyle

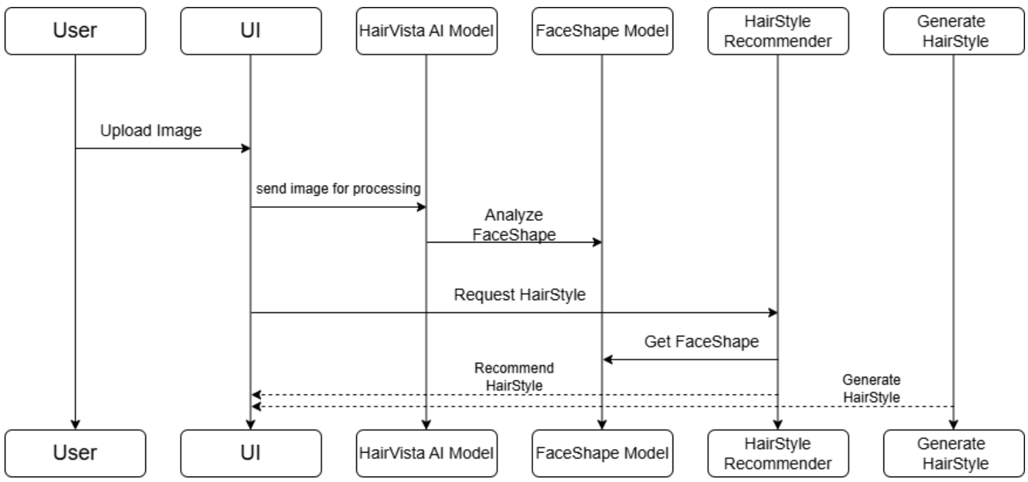

Figure 4.3: Sequence Diagram Illustrating the Hairstyle Recommendation Process in HairVista AI

This sequence diagram shows the process of hairstyle recommendation in HairVista AI. It illustrates how the user uploads an image, which is processed by the HairVista AI model and FaceShape model. The HairStyle Recommender then provides personalized hairstyle suggestions to the user.

4.4.2.2 Sequence Diagram For Haircolor

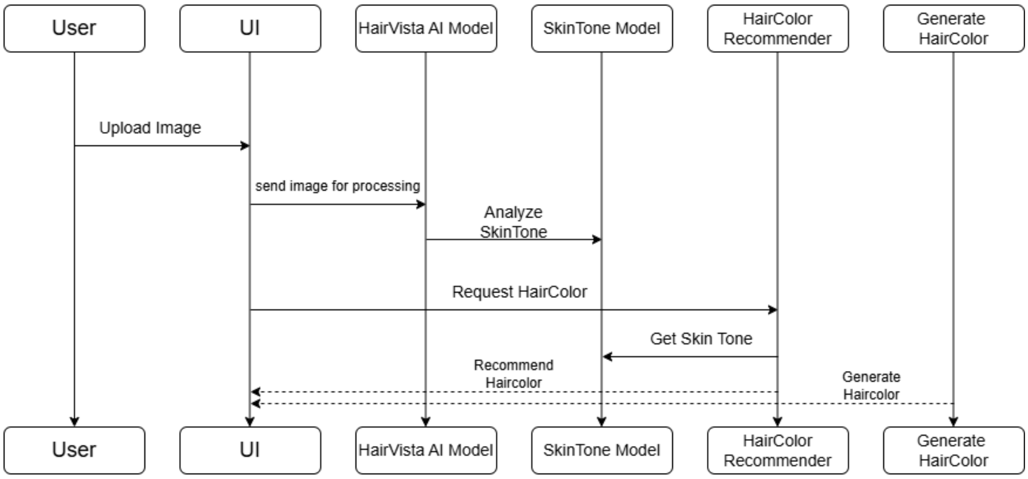

Figure 4.4: Sequence Diagram Illustrating the Haircolor Recommendation Process in HairVista AI

This sequence diagram shows the process of haircolor recommendation in HairVista AI. It illustrates how the user uploads an image, which is processed by the HairVista AI model and Skintone model model. The HairColor Recommender then provides personalized haircolor suggestions to the user.

4.4.3 Physical Diagram

4.4.3.1 Data Flow Diagram

Data Flow Diagram for HairVista AI: The process begins with the upload of images by clients to the HairVista AI system for analysis to provide a recommended hairstyle and color. The results are generated for the client, while the data is stored in a database. The admins have the ability to export data from the system.

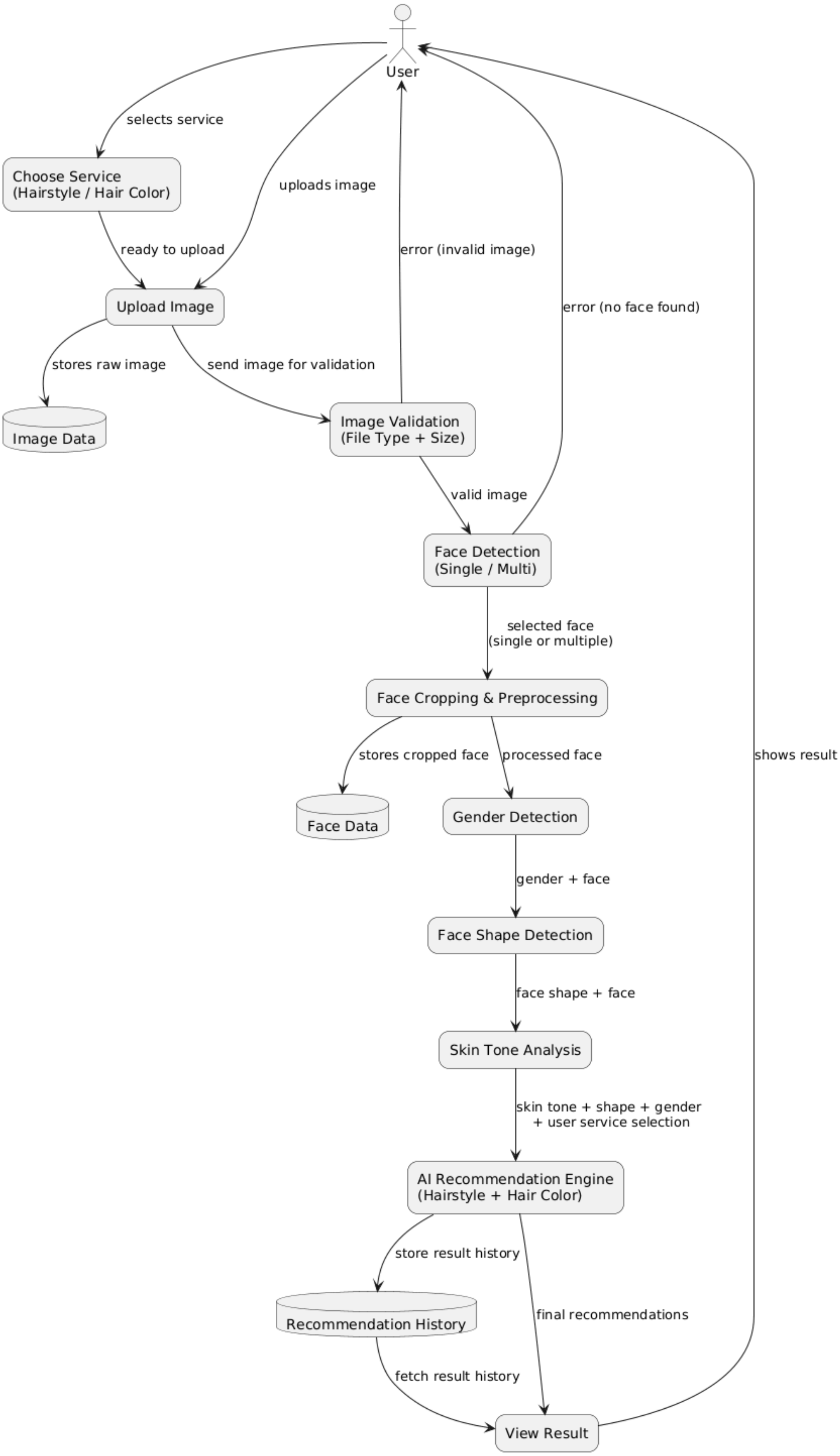

Figure 4.5: Data Flow Diagram of the proposed HairVista AI system

4.5 Low Level Design

4.5.1 Activity Diagram

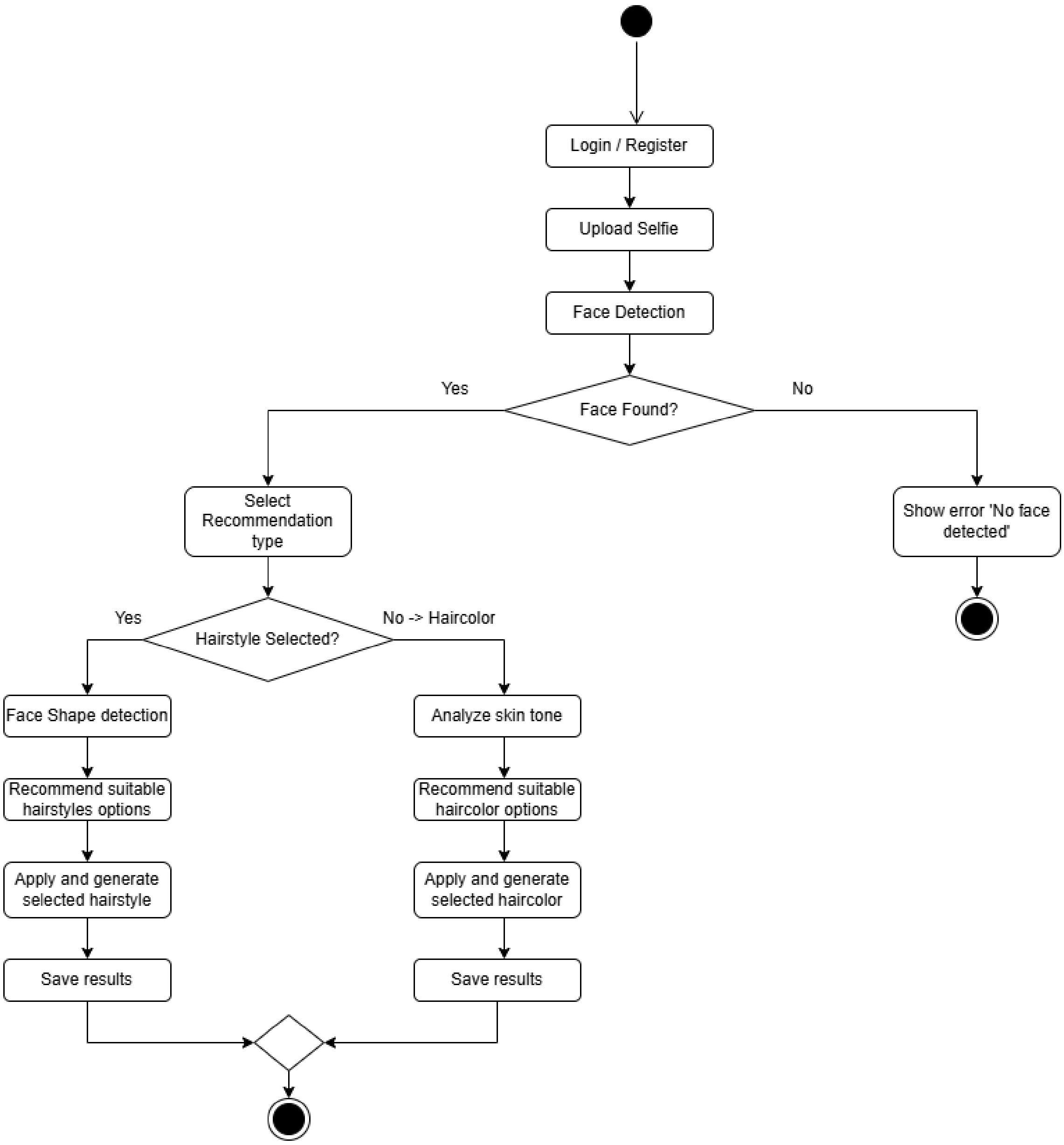

Figure 4.6: Activity Diagram showing the operational flow of the system

The user flow in the HairVista AI system is illustrated in the Activity diagram shown in figure 4.5. User identification and face picture submission are the first steps in the process. The system assesses whether the uploaded face is female; if so, the user has the option to receive hairstyle or hair color suggestions. The system then does an analysis of the facial features according to the option selected and presents suitable hairstyle recommendations.

If the face is not female, the user will have to upload another face that fits the criterion.

4.6 GUI

4.6.1 GUI Prototype

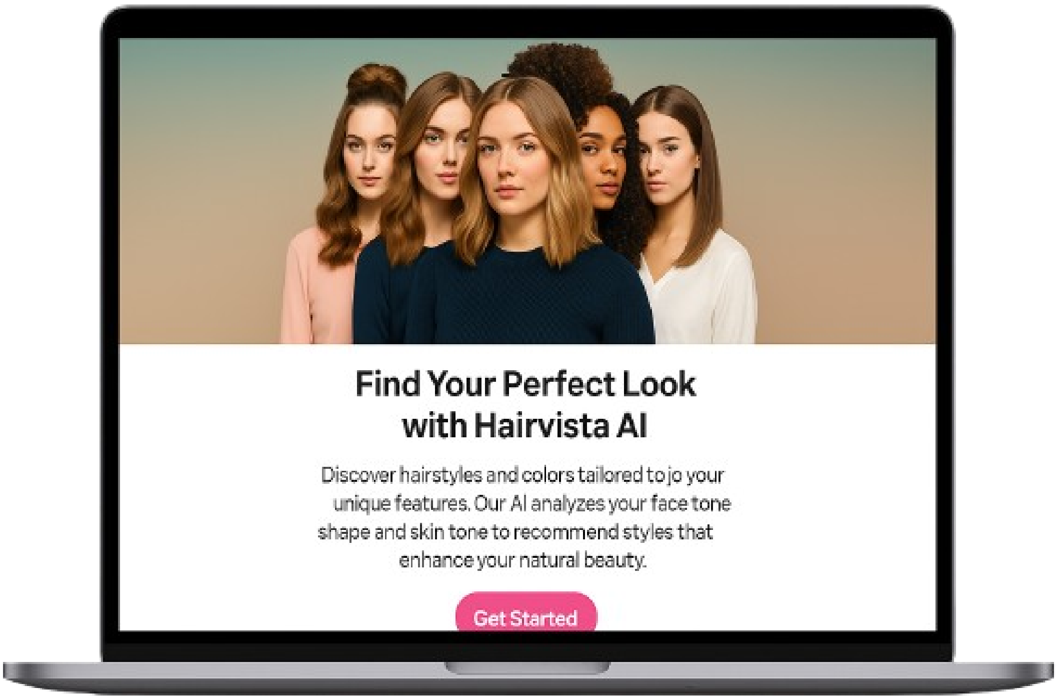

Figure 4.7: Initial User Interface splash screen of the application

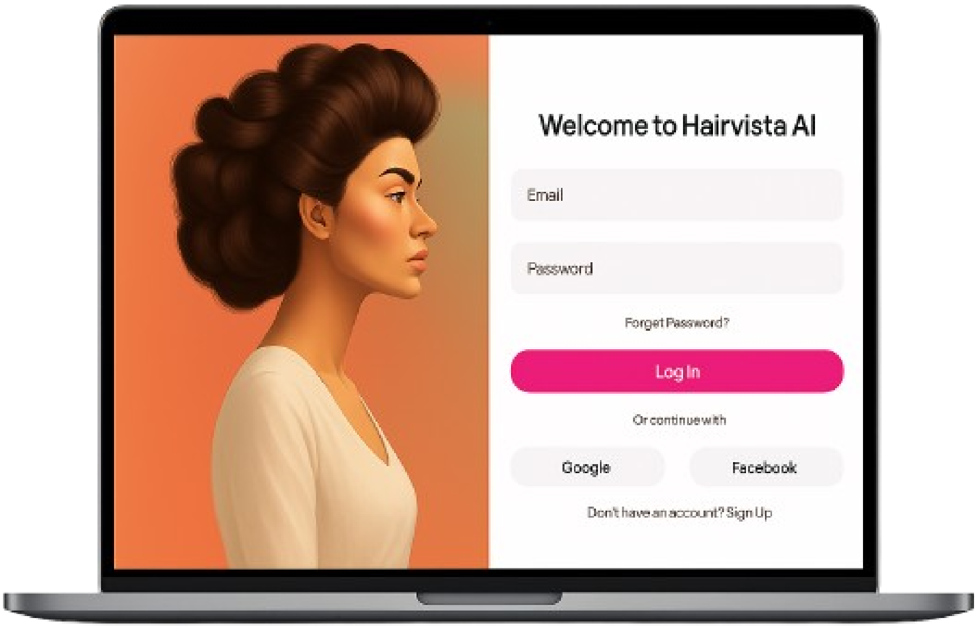

Figure 4.8: Login/Signup screen of the HairVista AI Application

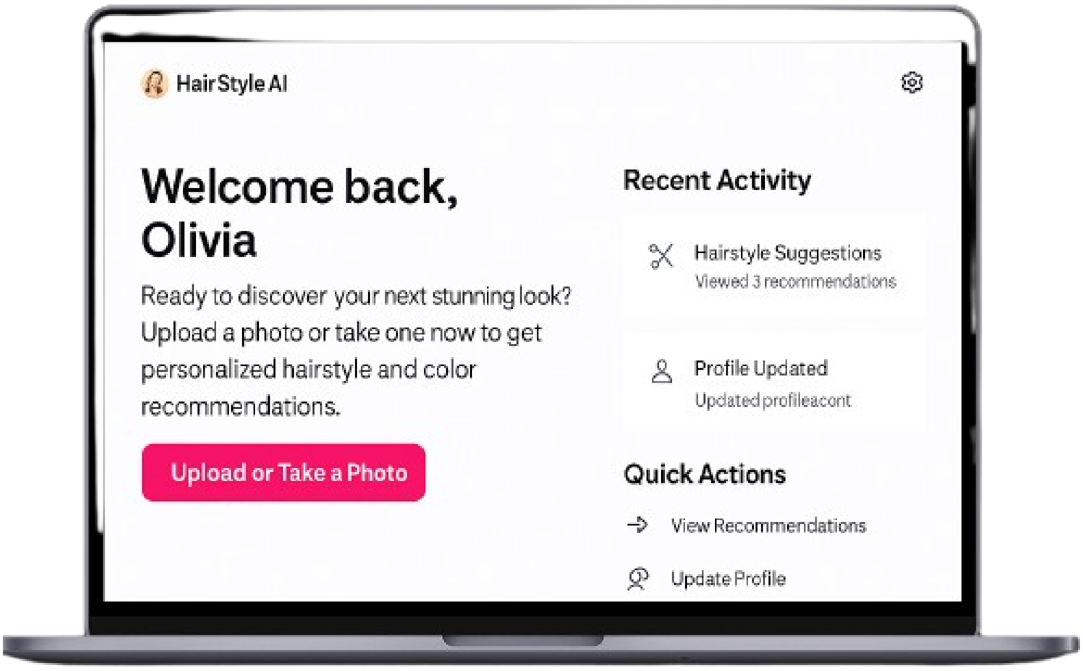

Figure 4.9: User Recent activity Interface in HairVista AI

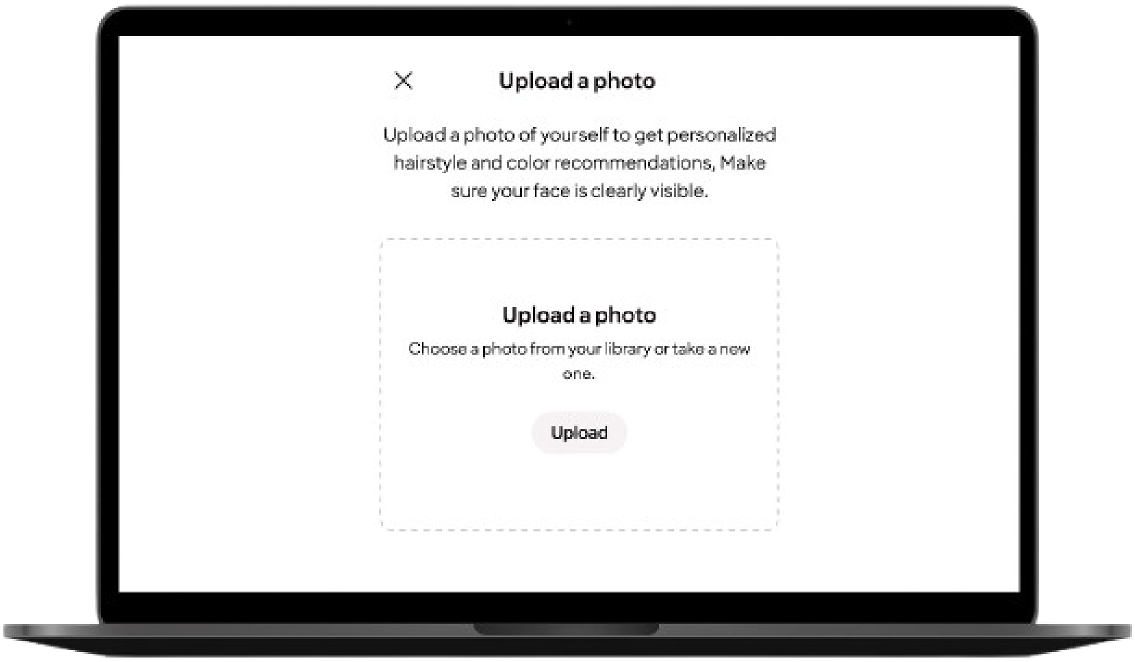

Figure 4.10: Upload Image

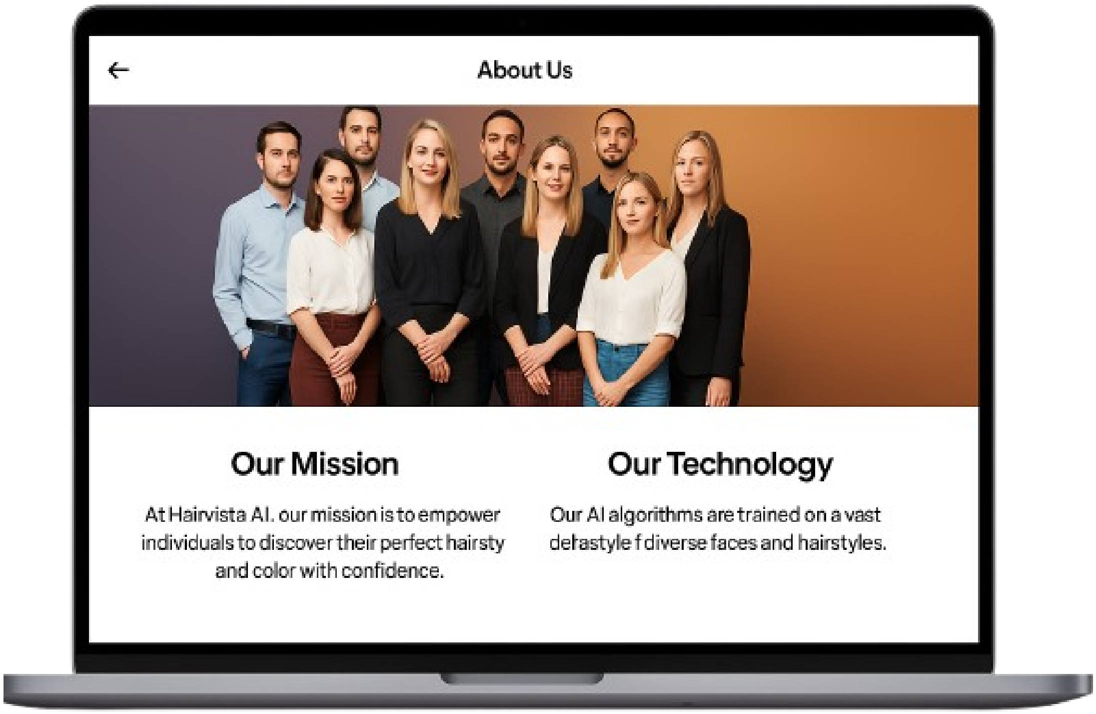

Figure 4.11: About Us Page view

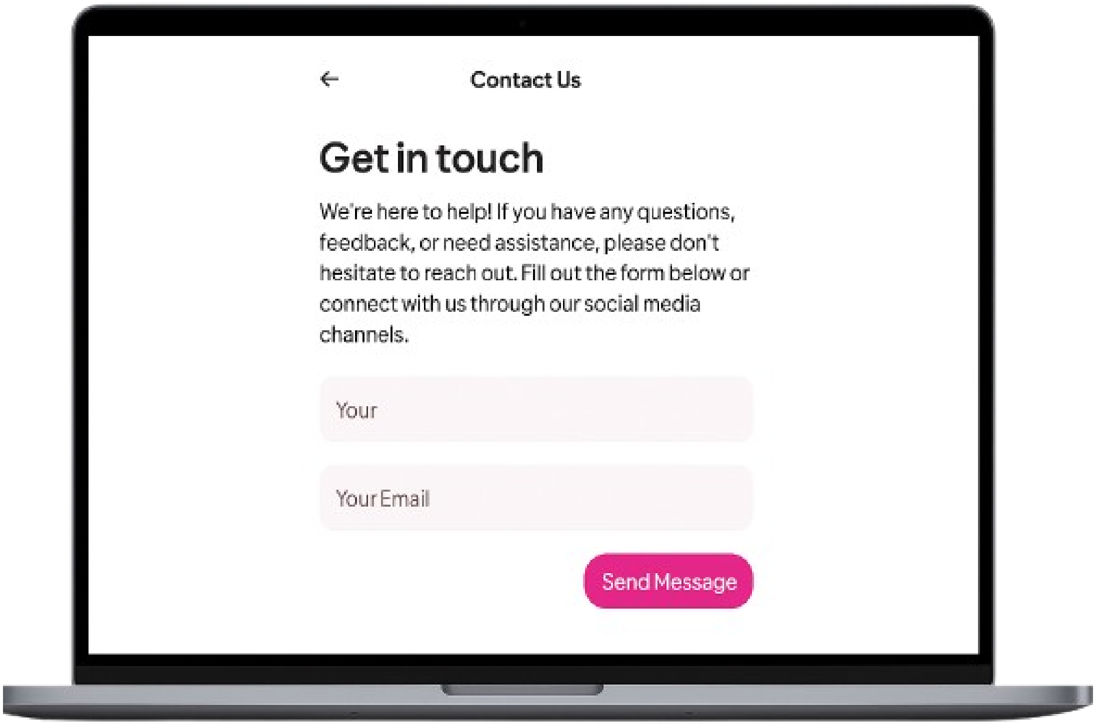

Figure 4.12: Contact us Page view

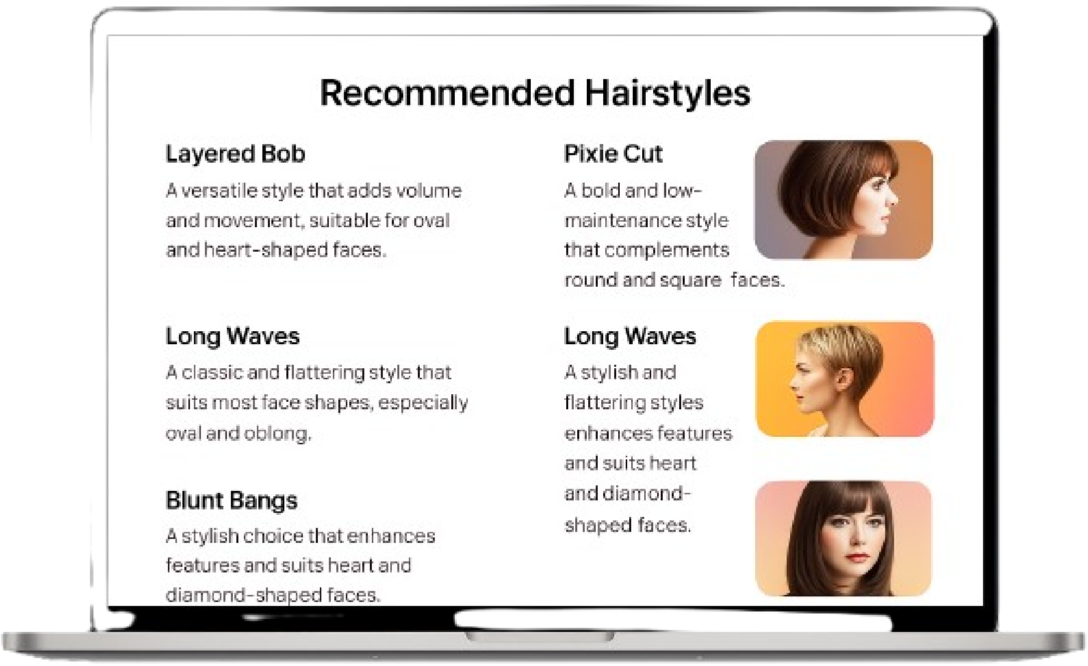

Figure 4.13: Recommended Hairstyles Page view

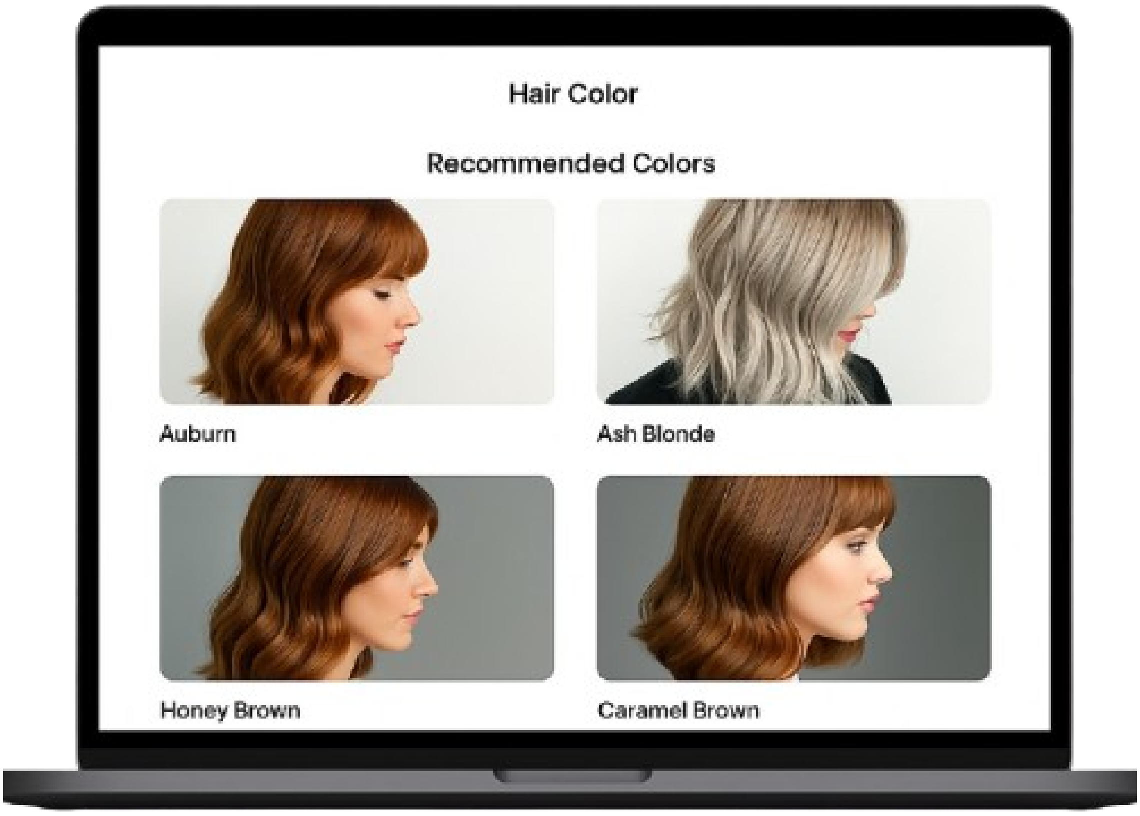

Figure 4.14: Recommended Haircolor Page view

Chapter 5

System Implementation

In this chapter, the component diagram is used to present the HairVista AI system architecture and to explain the implementation phase that illustrates the system's design and development. Moreover, it intends to give a detailed view of the project's operation, revealing the role of face shape detection in hairstyle recommendations and skin tone analysis in hair color suggestions.

5.1 System Architecture

5.1.1 System Internal Components

The HairVista AI system consists of 6 critical internal modules that handle the entire process of uploading the image, analyzing and making suggestions based on it, API-based changes, and user interaction via the web interface.

1. **Input & Preprocessing:** This layer is used for uploading the image, resizing, normalizing, and detecting gender.
2. **Face Analysis:** The feature detects the shape of the face, skin tone, and automatically handles multiple faces in group photos.
3. **Recommendation Engine:** This generates personalized hairstyle and hair color recommendations.
4. **Gemini 2.5 Flash Image Transformation:** Applies hairstyle and hair color changes in Gemini 2.5 Flash Image with a combination of more realistic appearance and accurate blending and identity preservation outcomes.
5. **User Interaction & Storage:** Presents the user with filtered images, allows the user to select and save into the user profile.

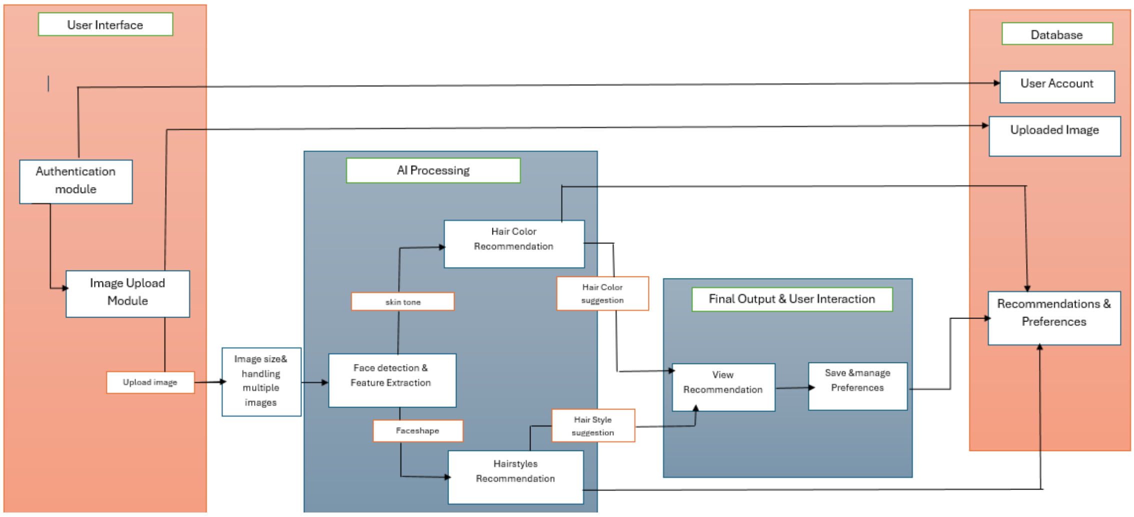

Figure 5.1: Layered Architecture of the AI-Driven Hairstyle and Haircolor Recommendation System

5.2 Functionality of Components

1. **Input & Preprocessing:** In this part of the system, the user uploads an image which is then subjected to initial processing. The image is treated to some basic preprocessing methods that change its size, normalize its values, and convert it to a specific format that is suitable for the analysis. Moreover, the gender detection step is executed using the Xception model that has been trained on a gender dataset and is thus capable of detecting the gender of the user. In this way, only females are allowed to further go through the workflow.

2. **Face Analysis:** Once the preprocessing of the image is complete, the face shape and the skin color of the user are detected by means of the ViT models in this module. Also, this module can consider many faces in the group image and choose the most prominent face for the subsequent procedures. It is crucial to detect face shapes and skin colors to ensure that the recommendations made are highly personalized.

3. **Recommendation Engine:** The Flan-T5 model is utilized in this component to create customized recommendations for both hairdos and hair dyes. The system, taking into account the identified face shape and skin tone, presents three attractive hairdos and three appealing hair color choices exclusively for the user. These recommendations are guaranteed to be in line with the user's facial features and skin color thus providing a realistic and beautiful result.

4. **Gemini 2.5 Flash Image Transformation:** After the user is presented with a number of suggestions, the alterations the user prefers regarding the hairstyle and color are

applied to the photo with the help of Gemini 2.5 Flash Image. This process renders the image result very lifelike and sophisticated since it precisely integrates the selected style or color on the user's face in a way that is naturally fitting, not overpowering, and very realistic.

5. **User Interaction & Storage:** The transformed images are presented to the user for selection. The user will be able to select their preferred hairstyle and color combination, while the system will allow the user to store the preferences in their account. The component will thus ensure an interactive user experience while considering the user preferences.

5.3 System Implementation

5.3.1 Dataset

In HairVista AI, three customized datasets serve as fuel for successive levels of functionality in this AI-driven application. The Gender Dataset, available on GitHub, serves as a training dataset for Xception and involves a collection of pre-tagged pictures for male and female faces and thus helps identify female users in a precise manner. The Face Shape Dataset, contributed by niten19 on Kaggle, consists of 5,000 images of female celebrities and is divided into five face shapes: Heart, Oblong, Oval, Round, and Square. For detecting skin tone, a 10-shade skin tone classifier, known as the Monk Skin Tone (MST) dataset, is available and represents a diverse range of skin tones produced by a collaborative effort between Google and Dr. Ellis Monk for a much broader applicability and application context for this dataset on human skin tones for a specified 10-shade MST. This 10-shade MST dataset is further split into five broader skin tones: Fair, Light, Medium, Dark, and Brown for a precise and categorized classification of skin tone for this personalized hairstyle and color recommendations technology, a fundamental part of HairVista AI.

5.3.2 Training Deep Learning Model

The aim of this module is to train the Deep Learning models which will then be used in HairVista AI software for gender recognition tasks, classification of face shape and skin tones, and style and color transformations. Below are the sub-modules of this module.

1. EDA (Exploratory Data Analysis)
2. Data Cleaning
3. Data Preprocessing
4. Train Deep Learning Models

5.3.2.1 EDA (Exploratory Data Analysis)

The practice of employing visualizations and analyses in the exploration of data to discern it better is known as EDA. In this undertaking, EDA was applied to look into the datasets' anatomy, their distribution, and also their quality being utilized in gender detection, face shape classification, and skin tone estimation. Using python visualization libraries like Matplotlib, different plots have been produced to analyze class distribution, patterns, and unbalanced data points in the dataset. Data visualization helps to understand relationships among different variables of a dataset, points out inconsistencies or biased values, and helps in preprocessing, resulting in improved performance of a machine learning model.

5.3.2.2 Data Cleaning

Data cleansing entails the verification of the integrity of all the images contained in the dataset. Downstream is the removal of images that appear to be corrupt or duplicated. More images need to be verified to ensure that they have all the required attributes or classes, including gender, face shapes, and skin tones. For the face shapes and skin tones categories, the checking ends with the confirmation that all images in the dataset pertain to female user images. Where images fall into the wrong categories, they need to be corrected.

5.3.2.3 Data Preprocessing

Data preprocessing plays a critical part in the development of a high-performing model. All the images undergo processing with the MTCNN to detect and crop the faces appropriately, thus allowing the model to work on only the required facial part. In gender classification tasks, the images undergo resizing and ImageDataGenerator processing to increase variability. In the classification of skin tones, a custom-defined class called 'SkinToneDataset' with lighting and color augmentations addresses challenges posed by lighting and increases robustness in the model. In the case of face shape classification, the preprocessed steps involved image resizing, crop processing to extract the faces, and various techniques of image augmentations to build predictive models capable of performing efficiently in various facial shapes.

5.3.2.4 Train Deep Learning Models

The deep learning models are then trained on their respective preprocessed datasets to effectively perform each of their respective tasks. Gender detection, face shape, and skin tone classification are accomplished through the use of Xception models as they are quite efficient for image recognition, whereas face shape and skin tone classification are accomplished through the use of ViT models for the same reason of high efficiency for image recognition. However, to create personalized recommendations for hairstyles and hair colors, the Flan-T5 model is utilized as they are quite skilled at interpreting the results of attribute detection and provide recommendations based on those results. However, to apply the selected styles to the images, Gemini 2.5 flash image is utilized to apply selected hairstyles and hair color changes to images to provide realistic results.

5.4 Front-end Development

The HairVista AI front end is developed using React JS and is designed using Tailwind CSS, providing a highly responsive and interactive user interface. By using this web application, one is able to upload an image and identify their facial skin type and skin color, which is then used for getting hairstyle and hair color suggestions.

Finally, after the detection process is finished, the system gives the user options to choose a hairstyle and hair color from. The user selects the desired option and clicks the Generate Hairstyle or Generate Hair Color button, which will implement the transformation using the Gemini 2.5 Flash image transformation technique. The resulting images are immediately displayed to the user on the interface.

In addition, users are also able to save their favorite hair styles or colors into their accounts, and all their choices are safely archived in a MongoDB database. This process provides an intuitive and personalized user experience allowing them to try and change their looks easily.

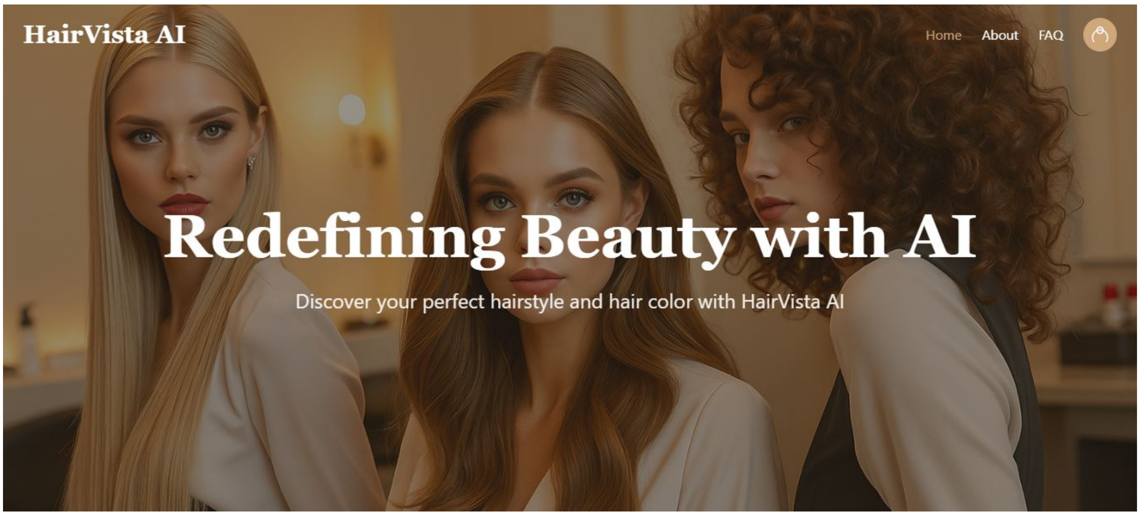

Figure 5.2: Main Home Screen of the HairVista AI System

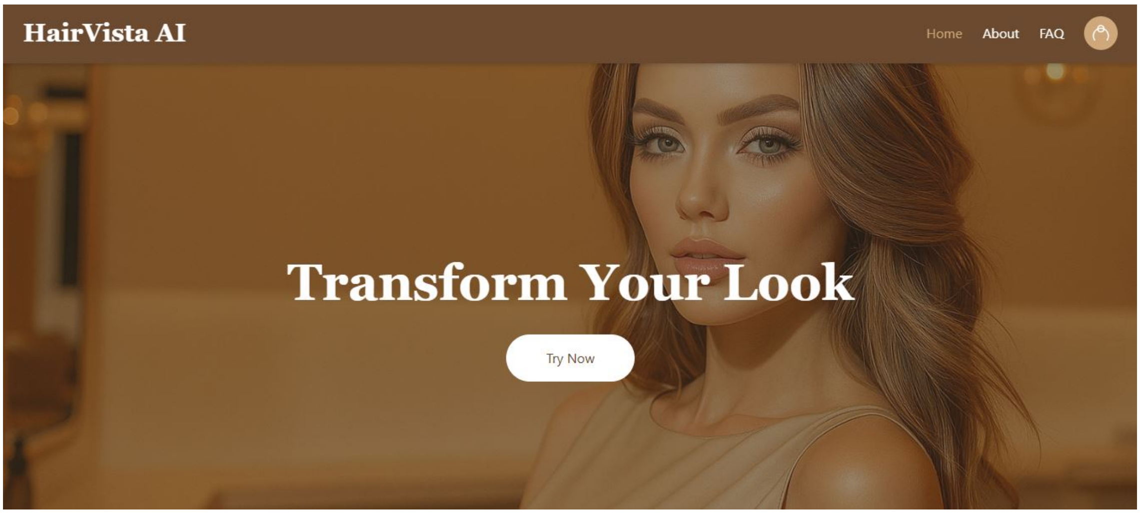

Figure 5.3: Home Page Button for initiating HairStyle and HairColor Recommendation in HairVista AI

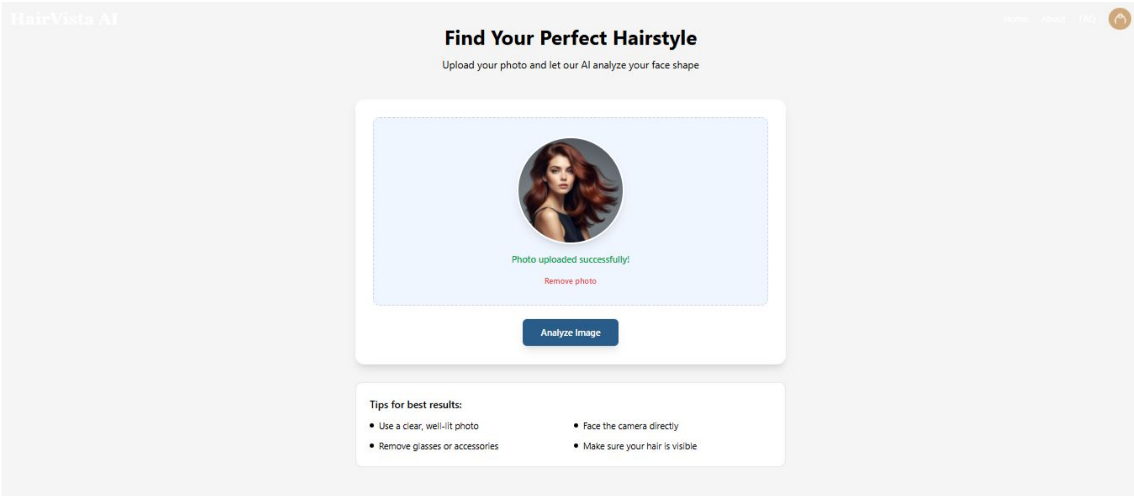

Figure 5.4: Graphical User Interface for Uploading Image for Analysis

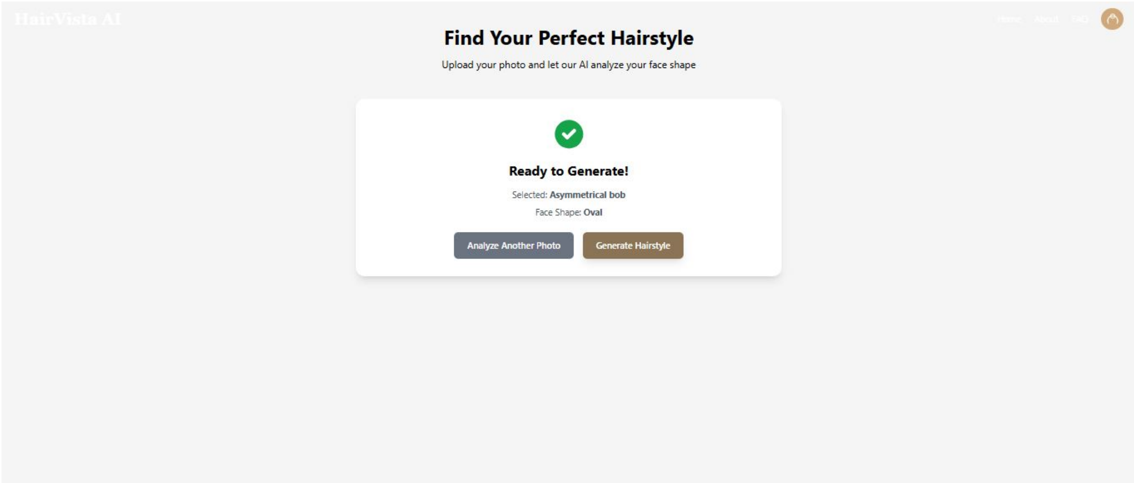

Figure 5.5: HairVista AI Screen Highlighting the Hairstyle generation function

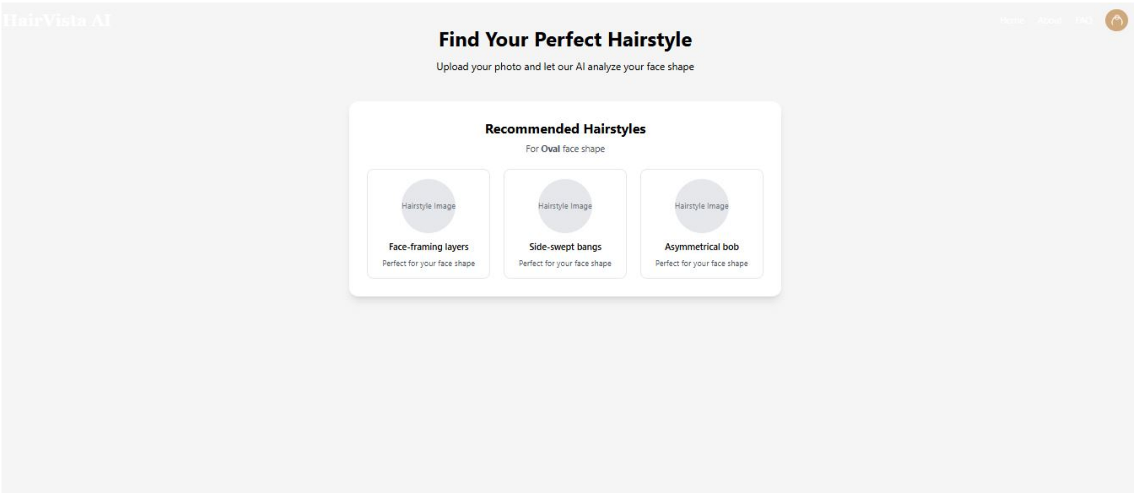

Figure 5.6: Displaying suitable hairstyle options for users

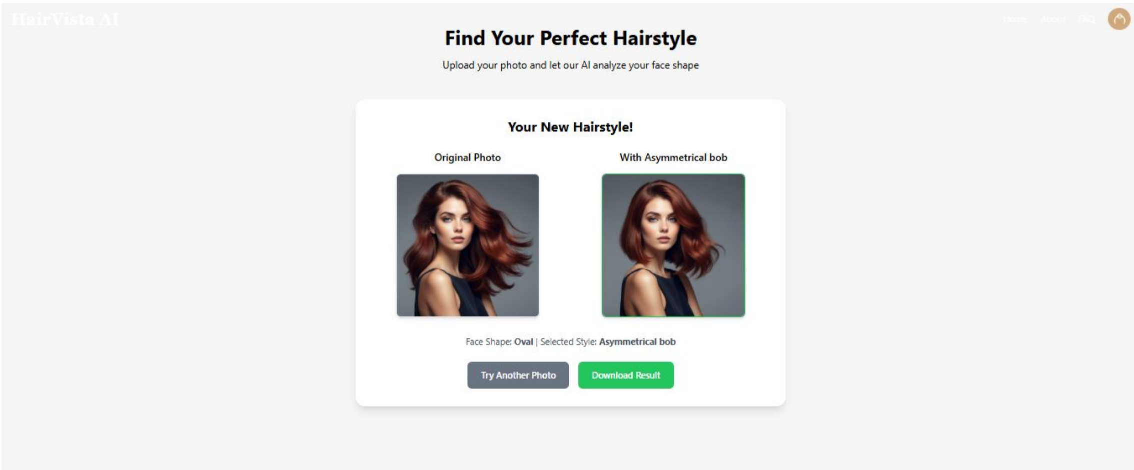

Figure 5.7: HairVista AI screen displaying the generated hairstyle with save feature

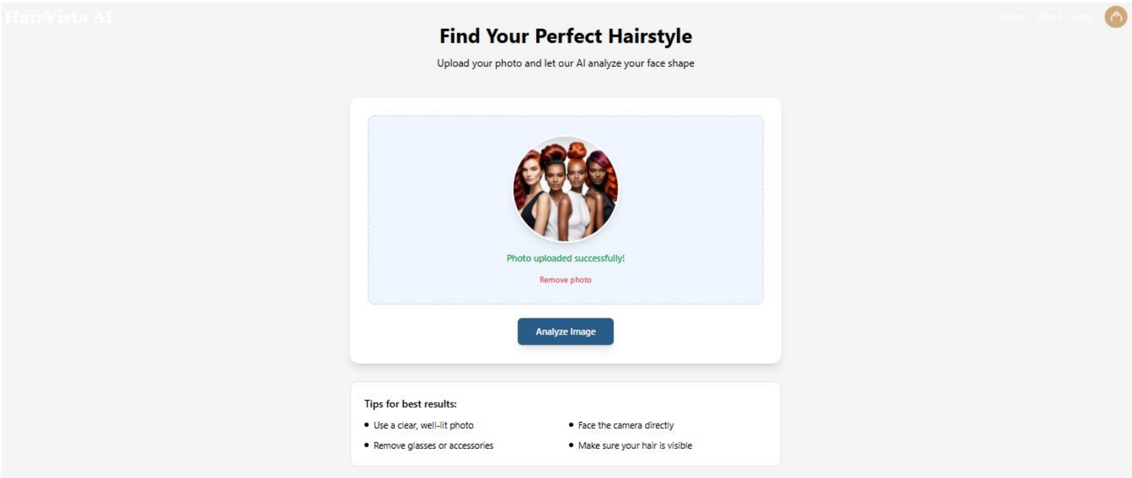

Figure 5.8: Graphical User Interface for Multi-person photo upload in the proposed system

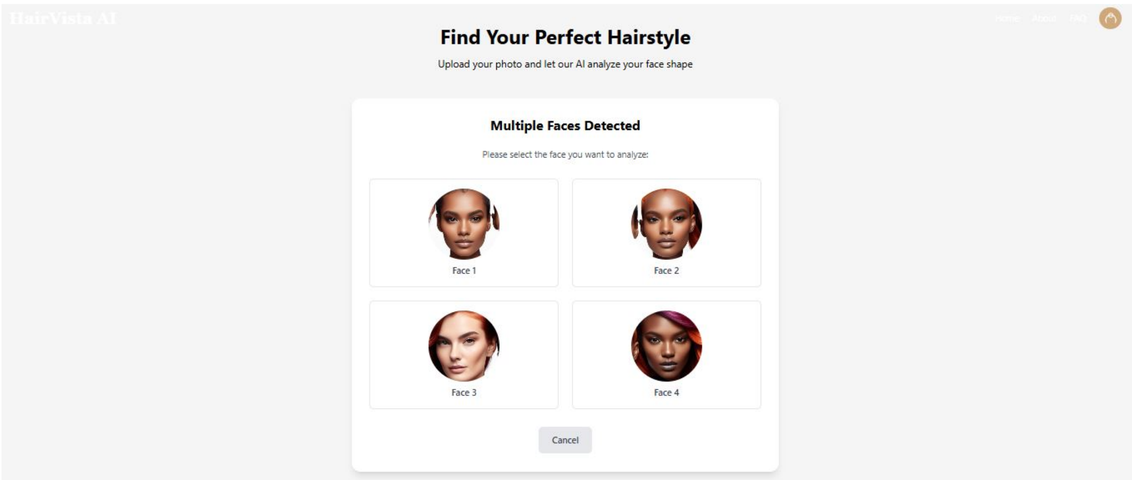

Figure 5.9: GUI handling Multiple face image uploads for analysis

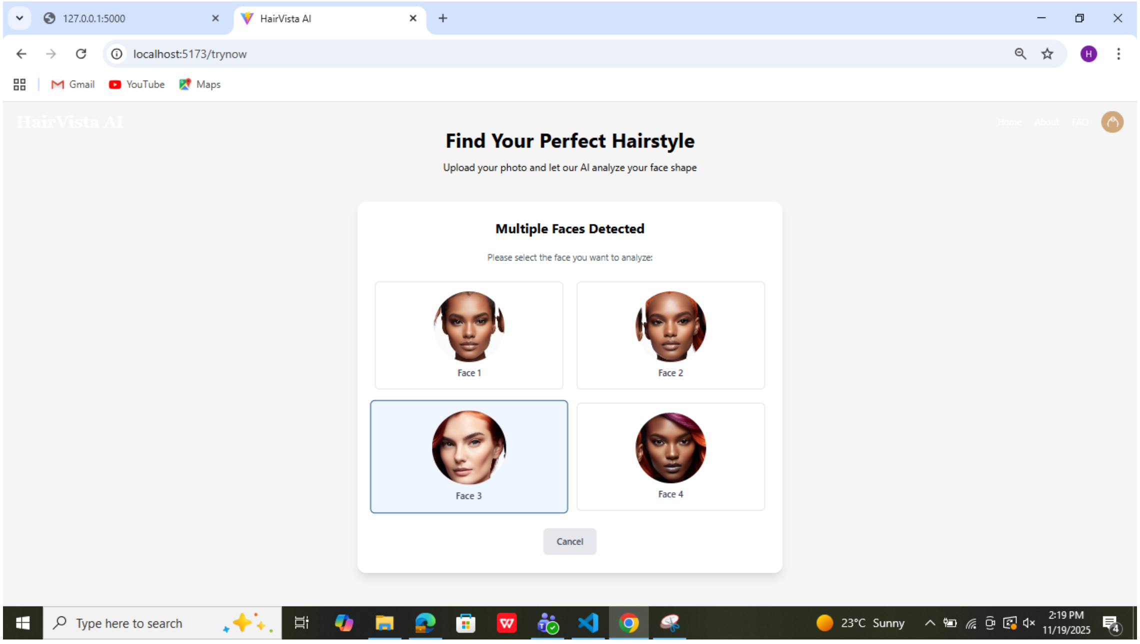

Figure 5.10: User Interface showing face selection from uploaded images

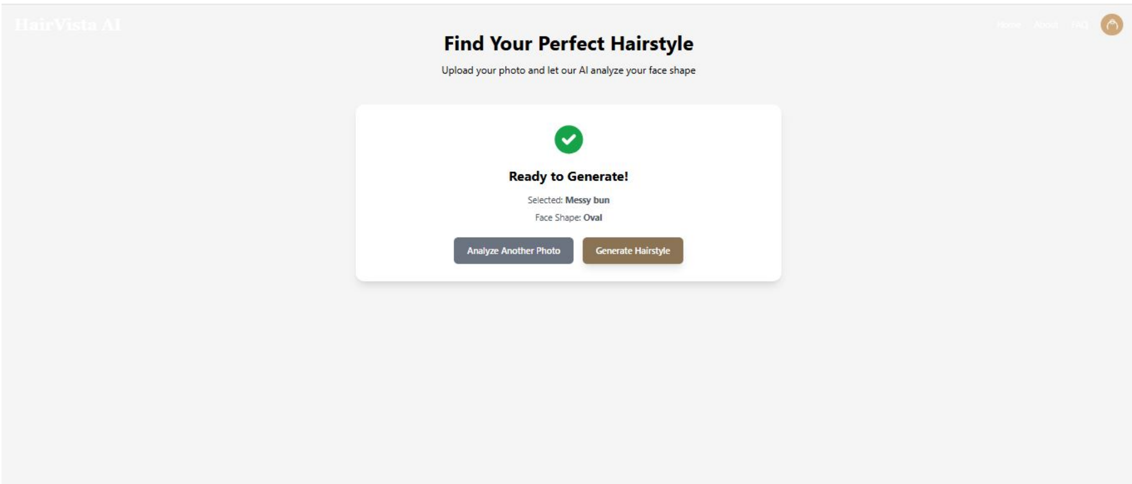

Figure 5.11: User Interface showing hairstyle generation for the selected face

5.4.1 Deployment Diagram

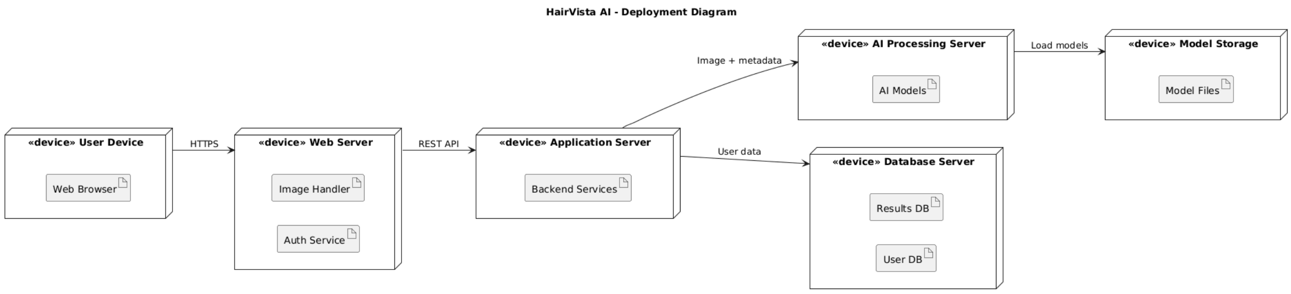

Figure 5.12: Hairvista AI architecture with user devices, app server, AI models, and database deployment diagram for hairstyle recommendations.

In Figure 5.12, the deployment diagram details the runtime architecture for a hairstyle and hair color recommendation system using AI as proposed in this work. In this diagram, it can be seen that the user device communicates with the online Hairvista AI app using HTTPS requests securely. The application server is used for user authentication, analysis requests, and controlling recommendations, where it interacts with the AI model server and database server simultaneously. In the AI model server, it contains modules such as the face shape classifier, skin tone extractor, and NanoBanana recommendation engine for users to produce their own personal results. The database server stores hairstyles, hair colors, and user details for easy retrieval by users.

Chapter 6

System Testing and Evaluation

6.1 System Testing

The HairVista AI platform was subjected to system testing on the fully integrated web-based architecture with the purpose of ensuring that all the modules constituting it worked in perfect harmony according to the agreed functional requirements. Since the system was built upon a set of interdependent components such as facial detection and recognition of facial shape and skin tone, as well as hairstyle and hair color suggestions and Gemini 2.5 Flash-based hairstyle and hair color makeover, it was important to ensure a smooth transition of the workflow from end to end.

The main aim of this testing phase was to demonstrate the functional capabilities of the isolated parts but also to thoroughly check the system performance in terms of usability, accuracy, and reliability. In academic research, merely deploying an application is not adequate but a rigorous evaluation that feeds into the identification of the system's strengths and weaknesses, which ultimately signals technical maturity and academic diversification, is required.

6.2 User Experience and System Working After Testing

This part delineates the user experience and the operational characteristics of the HairVista AI web application after the testing phase has been concluded. The primary intention was to ensure that the application had offered its users an interaction that was intuitive, smooth and totally free of errors. The system is organized in such a way that the users are able to upload an image, recognize facial features, receive hairstyle and hair color recommendations, and see the change of those elements, so even tiny flaws or delays can cause usability issues. Therefore, vigorous testing was performed to prove that every single step of the process, starting from the uploading of the image to the final rendering of the hairstyle or hair color, was carried out in a consistent and precise manner. The interaction between the user and the system, the interface's clarity, the system's response time, and the user's overall satisfaction were all evaluated and given special consideration. The results indicated that it was indeed possible for real users to interact with the interface without any difficulties and to reap the benefits that were intended from the system.

6.3 Testing Environment

Also, the testing of the HairVista AI was done on the general browsers of the computing machines for better compatibility and results in general usage. The software was tested on Google Chrome (Version 96.0.4664.45, 64-bit) as well as Microsoft Edge (Version 90.0.818.62, 64-bit). Why these browsers? They are widely used, stable, and thus provided an ideal background for testing. Testing activities covered overall scenarios like testing of images with varied quality, image format, facial features, skin tone identification, generation of recommendations, hairstyles, haircolor, transition, as well as navigation elements.

6.4 Types of Testing Considered

Through the application of several different testing modalities HairVista AI was subjected to a thorough testing process. Functional testing took place to confirm that the uploading of the image, face detection, face classification, hairstyle and hair color conversion features worked according to the intended design, and also provided the right outputs. The emphasis of non-functional testing was on system usability, interaction flow, response time, visual consistency and reliability, under various use conditions. Other methodological approaches included quantitative analysis to measure the processing accuracy and speed, alongside qualitative evaluation to investigate the realism of the generated hairstyles and hair colors and the overall user experience. The combination of these different testing strategies enabled a comprehensive understanding of system behavior and its alignment with user expectations.

6.5 Strengths and Limitations Evaluation

An objective and thorough appraisal of HairVista AI showed its various strengths and limitations that were very visible. Facial shape and skin tone detection were the main features where the system was strong enough, and the same could be said for the visually convincing transformation of hairstyles and hair color for increased user engagement. The web interface was made to be very user-friendly so that it would not only be easy to navigate but also to interact with it. However, a number of limitations were observed: the quality of the transformations of hairstyles and hair color was highly dependent on the resolution of the uploaded images to the point that low-resolution images or images taken in poorly lit conditions did not give satisfactory results; moreover, the processing time varied with respect to the load of the browser and the system resources, which impacted the overall user experience. These limitations should not be seen as a drawback for HairVista AI but as an indication of the areas where more optimizations and improvements can be done in the future. To admit both the strengths and the weaknesses is part of a comprehensive, thorough, and academic evaluation of the system.

6.6 Functionality Testing

6.6.1 Upload Image

Test ID	HairVista-TC-01
Functional Requirement Tested	HairVista-FR01
Test Case Description	Image Upload Verification.
Use Case Name	Image Upload
Precondition	User is on the upload screen.
Post-condition	Image is displayed on screen.
Steps to be Executed	Click "Upload Image".
Test Environment	Web application, Windows 10, Chrome browser
Expected Result	Loaded Image and Displayed.
Actual Result	Image uploaded successfully.
Result	`Positive Pass`

Table 6.1: Test Case for Image Upload Functionality

6.6.2 Hairstyle or Haircolor Recommendations

Test ID	HairVista-TC-02
Functional Requirement Tested	HairVista-FR01
Test Case Description	User can select hairstyle or haircolor
Use Case Name	Create Hairstyle Suggestions
Precondition	Face shape or skin tone detected based on selection.
Post-condition	It shows 3 new hairstyles.
Steps to be Executed	User clicks "Hairstyle" or "haircolor" button.
Test Environment	Web Application, Windows 10, Google Chrome Browser
Expected Result	The system shows 3 recommendations.
Actual Result	Recommendations displayed
Result	Pass

Table 6.2: Test Case for Generating Hairstyle Recommendations

6.6.3 User Selects a Style

Test ID	HairVista-TC-03
Functional Requirement Tested	HairVista-FR01
Test Case Description	The user has many choices between style and color.
Use Case Name	User Chooses Style
Precondition	Recommendations shown.
Post-condition	Picked style for generation saved.
Steps to be Executed	Click on a hairstyle/hair color and confirm selection.
Test Environment	Web UI selection interface.
Expected Result	Value selected, option highlighted and stored.
Actual Result	The selected option will be shown to the user.
Result	Pass

Table 6.3: Test Case for User Style Selection (HairVista-TC-03)

6.6.4 System Generates Hairstyle / Hair Color Output

Test ID	HairVista-TC-04
Functional Requirement Tested	HairVista-FR01
Test Case Description	System applies the selected choice
Use Case Name	Generate Hairstyle / Color Output
Precondition	A style was chosen by the user.
Post-condition	An image generated.
Steps to be Executed	System displays final output.
Test Environment	Web application
Expected Result	Generating the output image successfully.
Actual Result	Final image is displayed
Result	Pass

Table 6.4: Test Case for Generating Final Output ((HairVista-TC-04)

6.6.5 Save / Download Result

Test ID	HairVista-TC-05
Functional Requirement Tested	HairVista-FR01
Test Case Description	User must be able to save or download the result.
Use Case Name	Save / Download Result
Precondition	Output generated.
Post-condition	File saved on user's device.
Steps to be Executed	1. Click "Download"
Test Environment	Web browser download system.
Expected Result	Image downloads successfully.
Actual Result	Image saved in user profile
Result	Pass

Table 6.5: Test Case for Saving / Downloading Result (TC-05)

6.7 Ensuring System Testing in HairVista AI

6.7.1 Usability Testing

The usability concept in HairVista AI is achieved through a continual examination of the user interface and the user interaction flow. The actual users were asked to upload their photos, guess their face shape and skin tone, and then play with the hairstyle and hair color options. It was monitored how they interacted with each other in order to find the moments of confusion or delays. The user interface, button positions, and instructions were all improved using the feedback so that the system was made easier and more friendly to the users. The goal was to make it possible for users to navigate through the platform with no hassles, carry out all the main tasks without any help, and count on the hairstyle and color change feature.

6.7.2 Software Performance Testing

The measuring of response time and processing efficiency of core modules encompassing face detection, feature extraction, hairstyle recommendation and hair transformation guaranteed the performance of HairVista AI. The deep learning models for each of these operations are computationally intensive so performance testing comprised checking that the system was processing images within the limit of time set. Stress tests included simultaneous upload of images and generation of hairstyles on demands to check the speed and reliability of the system. There were several optimization strategies such as model quantization and preprocessing that were applied to achieve this goal.

6.7.3 Compatibility Testing

In HairVista AI, compatibility tests were carried out by testing it on various browsers and devices. This was done on Google Chrome, Mozilla Firefox, Microsoft Edge, and Safari browsers to ensure that all aspects of the system, including upload sub-systems and recommendation and preview pages, load correctly. Resolution tests included all types of resolution, including mobile and desktop resolutions. Through this process, all aspects of the system were perfected to ensure all system users have an equally similar experience when using the system.

6.7.4 Exception Handling

The verification of user input and the handling of unexpected behavior were very effective in ensuring that the exception-handling aspect was taken care of at HairVista AI. This is because anytime the user attempted to upload files with the wrong formats, failed images, and poor-quality images, the system is able to detect this and notifies the user about it using error messages. Another aspect that is offered by the backend services is the use of try-catch in model prediction to ensure that errors from the model do not propagate to the user interface.

6.7.5 Load Testing

Load testing on the HairVista AI system was conducted by simulating the process of several users accessing the system at the same time. Tests involving frequent image uploading to the system, quick Hairstyle generation request submission, and multiple simultaneous accesses to the system's recommendation services were carried out. This allowed issues related to bottlenecks on the server and modeling inferencing process to be identified and addressed by properly configuring the server and modeling inferencing process to enable the system to work under heavy loads.

6.7.6 Security Testing

To provide security testing in HairVista AI, the protection of user images, personal data, and internal model endpoints was primarily relied upon. The situation of secure upload management was come up with to prevent the injection attack or illegal access to files. All communications between the frontend and backend were authenticated to ensure that no sensitive endpoints were opened without any authentication. Moreover, users' uploaded photos were not retained indefinitely and only were temporarily processed, which safeguarded users' privacy. These security concerns contributed to the system's unexposed state to unauthorized access and possible data breach.

6.7.7 Installation Testing

The installation testing was also executed by deploying HairVista AI to different environments, such as local machine, development servers, and production hosting. The setup was thought to consist of dependency installation, machine learning models loading, and backend services setting up. Each and every step was thoroughly tested to confirm that the system was implemented without any bugs and all the modules, like face shape detection, hair color suggestion, and Gemini-API-based transformation usage, were functioning correctly post-deployment. The installation testing across the varied setups also led to the conclusion that HairVista AI could be installed and successfully run in different deployment configurations.

Chapter 7

Conclusion

This project concludes in the form of a fully functional web-based application, HairVista AI, designed to assist users in selecting suitable hairstyles and hair colors based on their facial features. The tool utilizes advanced artificial intelligence and machine learning methodologies that assist in automating the currently existing manual and subjective procedure. This tool can, on the basis of a user-uploaded image, assist a user in taking informed decisions regarding hairstyles through accurate recommendations provided by HairVista AI. The main aim of developing HairVista AI involved less dependence on human labor due to trial-and-error techniques usually adopted by beauty parlors during beauty consultation services. The application involves the integration of various models of deep learning techniques, such as the use of Xception model for gender identification and face shape and skin tone models based on ViTs for appropriate detection of prominent characteristics that determine hairstyles to be adopted. In this case, there is the application of Flan-T5 recommendation models to provide relevant hairstyle and color suggestions based on the characteristics identified.

For improving the experience of the users, the software has been designed with an elegant and interactive UI using React JS and Tailwind CSS, which will provide easy navigation and interaction to the users. After completing the analysis process, the users will have access to the recommended choices and will be able to check out some different hairstyle and color suggestions and select the one they like the most as per their desired preferences and will result in increased applicability and usefulness of the platform.

The final product was also tested rigorously. The alpha test was performed internally. This verified each module of the system, such as image uploading, feature identification, or recommendation generation. All the test scenarios were run and validated for uniformity, reliability, and accuracy within the application.

Therefore, HairVista AI was developed and tested within a high-performance system environment, leveraging an i7 9th-generation CPU with 32GB DDR4 RAM and an RTX-2070 GPU.

In the end, it is without doubt that HairVista AI has achieved its ultimate goal of providing an intelligent, user-friendly, and practical solution for hairstyle and hair color recommendations. By combining powerful machine learning models with a modern web interface, the system demonstrates the potential of AI in enhancing everyday decision-making in the beauty and styling domain.

7.1 Further Advancements

The project introduces a personalized hairstyle and hair color recommendation system that is still in its early stages and operates on the basis of facial analysis. Right now, the system is only available to women, but more users will be added in the future making the tool even more adaptable and useful.

We will also be automating the entire process, so there will be almost no manual input required from the time the images are uploaded to the time the final hairstyle is previewed. Besides the face shape and the skin color, future enhancements will use hair texture, hair length, and eye color to give even more personalized and accurate recommendations. It also paves the way for real-time AR try-on, stylist matching, and more sophisticated personalization features.

Such innovations will not only improve the content and variety of the recommendations but also their authenticity. Consequently, the system will find its application in digital salons, personal styling applications, and websites or platforms dedicated to beauty and fashion, along with the option of customizing avatar appearance in a virtual world.

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