Hair Fall Detection and Prevention System

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Final Approval

This is to certify that we have read the report submitted by ***Dilawar Shah, Muhammad Talha Asghar, Noor Ullah Shah (35463, 36673, 35464)***, for the partial fulfillment of the requirements for the degree of the Bachelors of Science in Computer Science (BSSE). It is our judgment that this report is of sufficient standard to warrant its acceptance by Riphah International University, Islamabad for the degree of Bachelors of Science in Computer Science (BSSE).

Committee:

1

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Nadeem Khan
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Declaration

We hereby declare that this document "**Hair Fall Detection and Prevention System**" neither as a whole nor as a part has been copied out from any source. It is further declared that we have done this project with the accompanied report entirely on the basis of our personal efforts, under the proficient guidance of our teachers, especially our supervisor **Sir Nadeem Khan**. If any part of the system is proved to be copied out from any source or found to be reproduction of any project from anywhere else, we shall stand by the consequences.

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Dedication

This project is dedicated to our family, friends and mentors whose constant support make us able to stand here today. To our Teachers, Professors and Supervisor thanks for sharing your knowledge and instilling a passion for learning in our mind.

Finally, we dedicate this project to those who work hard to make a positive impact on society through technology.

Acknowledgement

First of all we are obliged to Allah Almighty the Merciful, the Beneficent and the source of all Knowledge, for granting us the courage and knowledge to complete this Project.

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Abstract

The Hair Loss Detection and Prevention System uses modern machine learning and image processing technology to provide a effective solution for early hair loss diagnosis and proactive hair care. Using Convolutional Neural Network (CNN) the system analyzes scalp photos to detect and categorize various phases of hair loss. Providing users, a personalized insight of their hair health. Integrated data augmentation techniques provide reliable, real-time identification of various scalp diseases, while personalized advice help users maintain and improve hair health. These advices include natural therapies, food guidelines and if necessary dermatological referrals, resulting in a comprehensive eco system for haircare. The system also provides a community-oriented approach by allowing users to share their progress and experience, therefore adding to a supporting network. A built-in dermatology network also recommends nearby specialists for those requiring professional help, increasing accessibility and ensuring that user obtain both preventing and ongoing care. This user-friendly program is intended to provide consumers with early identification and practical tools for managing their hair health over time

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Chapter 1: Introduction

The Hair Loss Detection and Prevention System uses machine learning technology, specifically Convolutional Neural Networks (CNN), to scan scalp images and reliably detect phases of hair loss. This system employs modern image processing and data augmentation techniques to provide dependable real-time results making it an effective solution for early hair loss detection and prevention.

The development of this technology includes not only detection but also personalized advice based on specific hair conditions. By analysing scalp photos, the device can determine the severity and pattern of hair loss and provide consumers with specialized care recommendations. These suggestions may include natural cures, dietary recommendations, and professional referrals, allowing users to make more informed decisions about their hair's health.

The platform also promotes community participation through social sharing, which allows users to share their experiences and progress with others. To provide thorough care, the system also provide location of nearby dermatologists to user, making professional aid available to individuals who require additional evaluation and treatment.

1.1 Goals and Objectives

The major purpose of the Hair Loss Detection and Prevention System is to provide an easy-to use and effective tool for early hair loss detection and preventative management. Objectives include:

- Creating a CNN-based algorithm capable of properly detecting and classifying hair loss phases using scalp photos.
- Implementing a personalized recommendation engine that will present users with practical information based on their individual hair concerns, such as natural therapies, diet, and dermatologist referrals.
- Enabling social sharing tools so that users can share their progress and build a supportive community.
- Creating a dermatologist network to enable professional consultations for users in need of advanced treatment.

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1.2 Scope of the Project

- Analyse scalp images in real time.
- Detect hair fall through image processing.
- Provide recommendation system for personalized hair care.
- Features a user-friendly mobile application UI.
- Allowing users to connect with a network of nearby dermatologist.
- This app is only a supportive tool, not a replacement for medical advice.
- Targeted individual in the early to decrease stages of hair loss who seek for preventive measure and personalized care.

Chapter 2 Literature Review

Chapter 2: Literature Review

2.1 Introduction

The Hair Loss Detection and Prevention System uses machine learning technology, specifically Convolutional Neural Networks (CNN's), to scan scalp images and reliably detect phases of hair loss. This system employs modern image processing and data augmentation techniques to provide dependable real-time results making it an effective solution for early hair loss detection and prevention.

The development of this technology includes not only detection but also personalized advice based on specific hair conditions. By analysing scalp photos, the device can determine the severity and pattern of hair loss and provide consumers with specialized care recommendations. These suggestions may include natural cures, dietary recommendations, and professional referrals, allowing users to make more informed decisions about their hair's health.

The platform also promotes community participation through social sharing, which allows users to share their experiences and progress with others. This feature promotes a supportive environment by allowing users to track their own progress. To provide thorough care, the system also connects users with nearby dermatologists, making professional aid available to individuals who require additional evaluation and treatment.

2.2 Background and Problem Elaboration

Hair loss affects millions of people worldwide, and the causes range from genetics and aging to stress and environmental factors. While hair loss is common, it can have a substantial impact on a person's and mental health. Despite the availability of different therapies and treatments, most individuals are unaware of the initial signs of hair loss and the individualized solutions that are best suited to their particular condition. As a result, there is a need for an accessible, user-friendly system that can detect early signs of hair loss and provide practical advice to consumers. That is what we are creating in this project.

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2.3 Detailed Literature Review

2.3.1 Definitions

The Hair Loss Detection and Prevention System uses machine learning technology, specifically Convolutional Neural Networks (CNNs), to scan scalp images and reliably detect phases of hair loss. This system employs modern image processing and data augmentation techniques to provide dependable real-time results making it an effective solution for early hair loss detection and prevention

2.3.2 Related Research Work 1

The paper (Machine Learning Based KNN Method for Stress Based Hair Fall Detection and Prevention) focuses the use of machine learning approaches, such as the K-Nearest Neighbors (KNN) algorithm, to identify and categorize hair problems. KNN, which depends on features retrieved from scalp images such as texture, shape, and color, has reached a commendable 91.4% accuracy. However, it falls short when it comes to identifying complicated patterns, which is where advanced techniques such as Convolutional Neural Networks (CNNs) shine. Your project's usage of CNNs provides a more sophisticated and accurate solution to this difficulty.

Stress has been defined as a major factor to hair loss, particularly in demanding professions. The article emphasizes the necessity of early detection methods, since untreated hair loss can lead to more serious scalp and hair health problems. Stress has been defined as a major factor to hair loss, particularly in demanding professions. The article emphasizes the necessity of early detection methods, since untreated hair loss can lead to more serious scalp and hair health problems. This is consistent with our project's goal of offering immediate assistance via scalp image analysis and targeted suggestions, ensuring users receive the care they require before conditions get worsen.

The study focuses on several essential factors of dataset usage.

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- Using many data sets to properly train machine learning model.
- To increase the quality of input data, use pre-processing techniques such as noise reduction and picture enhancement.
- KNN classifications are based on similarity measurements like Euclidean distance. These tactics are useful insights for our CNN-based project because they optimize the input data for improved model performance.

The paper provides many areas for further exploration.

- Creating hybrid models that combine the simplicity of KNNs with the advanced capabilities of CNNs to increase prediction accuracy.
- Incorporating user feedback to improve model reliability and usability.
- Expanding datasets that include a more diverse population, ensuring that the system is globally applicable and suitable for a wider range of users.

2.3.3 Related Research Work 2

This study proposes an AI-powered solution to the issues of identifying hair and scalp conditions. Hair loss, which is typically caused by illnesses such as alopecia, psoriasis, and folliculitis, can have a significant impact on a person's confidence and quality of life. Diagnosis is frequently delayed due to the necessity for specialist examination, which leads to deteriorating conditions. Using advances in machine learning and image processing, the scientists created a deep learning-based model that automates disease identification and aids in early intervention. Their research focuses on the use of Convolutional Neural Networks (CNNs) to categorize scalp illnesses based on visual data, addressing a major gap in accessible and efficient diagnostic tools.

Key contribution:

- **Focus:**

  The study aims to detect three primary hair and scalp diseases: alopecia, psoriasis, and folliculitis. These disorders were chosen based on their prevalence and influence on hair quality.

- **Technology Used:**

Two-dimensional convolutional neural networks (CNNs) were used to classify hair disorders. CNNs were chosen because they can extract useful features from raw picture data with little human intervention.

The model had a training accuracy of 96.2% and a validation accuracy of 91.1 percent.

- **Dataset:**

  The dataset used in this study included 150 scalp images divided into three categories: 65 for alopecia, 45 for psoriasis, and 40 for folliculitis. These photographs were obtained from online dermatological platforms such as DermQuest, DermNet and MedicineNet. Furthermore, conversations with medical professionals helped to enrich the dataset, guaranteeing a wide representation of illnesses.

- **System architecture:** To examine nonlinear interactions between input and output variables, the convolutional neural network (CNN) model was constructed with three hidden layers, a softmax output layer, and a ReLU activation function. To avoid overfitting, dropout layers at a 30% rate were added after the pooling layers. To reduce input dimensions, the model used pooling layers with a 2x2 kernel size, and the Adam optimizer was used to improve learning efficiency. Using the processed characteristics, the final model sorted input photos into three unique categories.

- **Challenges Addressed:** The study addressed numerous major issues, including data scarcity, which was addressed by developing a publicly accessible dataset to aid future research. Image quality variability caused by changes in resolution, texture, and color was reduced using advanced preparation techniques. Furthermore, inter-class similarities that could impede accurate classification were addressed by using a strong model architecture and a balanced dataset.

- **Results:** The algorithm produced high precision and recall scores for all three types of scalp disorders. The precision and recall for alopecia were both 0.895, while psoriasis had values of 0.846. Folliculitis obtained flawless precision and recall ratings of 1.0. These measurements, depicted in a confusion matrix, demonstrate the model's dependability and accuracy for early-stage disease detection.

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- **Applications:** This approach has great potential applications in dermatology, as it benefits both patients and professionals. By automating the classification of scalp problems, the system allows for early detection and treatment of hair and scalp-related diseases, increasing patient outcomes and eliminating diagnostic delays.

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2.4 Literature Review Summary Table

Table 2-1 Literature Review

No.	Name, reference	Inventor	Year	Input	Output	Description
1.	Machine Learning Based KNN Method for Stress Based Hair Fall Detection and Prevention, [Munagala Adi Lakshmi, Radhika, Sadineni Rama Rao, 2024]	Munagala Adi Lakshmi, Radhika, Sadineni Rama Rao	2024	Scalp images, hair texture, shape, and color features	Hair loss classification (healthy hair, alopecia areata, psoriasis, diverticulitis)	The research describes a system that uses the KNearest Neighbors (KNN) algorithm to identify and classify stressinduced hair loss. It analyzes scalp images for texture, shape, and color to provide early detection and individualized care suggestions.

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2.	Hair and Scalp Disease Detection using Machine Learning and Image Processing, [Mrinmoy Roy, Anica Tasnim Protity, European Journal of IT and CS, Vol. 3, Issue 1, January 2023, DOI: 10.24018/ejcompute.2023.3.1.85]	Mrinmoy Roy, Anica Tasnim Protity	2023	Scalp images processed through denoising, CLAHE, and data augmentation	Classification of scalp conditions (alopecia, psoriasis, folliculitis)	This paper uses a 150image dataset to create a CNN-based system for classifying three hair and scalp-related disorders. The system uses pre-processing approaches to improve image quality and achieve consistent classification accuracy.

2.5 Research Gap

Hair loss is a widespread issue affecting millions of people worldwide, with causes ranging from genetic predisposition and hormone imbalances to stress and environmental exposure. Despite its wide influence, there are substantial gaps in current solutions to this problem. Many people have delays in detecting hair loss or related scalp disorders due to a lack of dermatologists and accessible diagnostic instruments. Furthermore, existing diagnostic procedures are frequently reactive, emphasizing treatment after severe hair loss has occurred rather than proactive attempts for early identification and prevention.

Another important gap is the lack of individualized solutions tailored to specific needs. Scalp type, hair texture, lifestyle behaviours, and dietary deficiencies are all important factors in hair health, but they are rarely taken into account by present methods. Furthermore, technology advancements, such as AI-powered picture analysis, have not been fully integrated to give consumers with accurate, real-time insights.

There is also a lack of community support and awareness, leaving individuals without the resources of sharing stories, track progress, or seek comprehensive guidance. Professional consultations, when offered, are sometimes unavailable or expensive, creating hurdles to timely and efficient treatment. These limitations highlight the need for a comprehensive, technology driven system that not only detects hair loss early on but also offers individualized preventative techniques, encourages community engagement, and closes the gap between users and professional treatment.

2.6 Problem Statement

Hair loss is a major condition that affects millions of people worldwide, with causes ranging from hereditary factors and hormonal imbalances to environmental influences and stress. Despite the fact that it occurs, early detection and prevention of hair loss remain significant challenges. Existing treatments primarily manage visible hair loss, which sometimes requires expensive, time-consuming, and inaccessible expert consultations for many people. Furthermore, these systems often lack individualization, failing to take into account individual factors such as scalp type, lifestyle patterns, and nutritional habits.

This study addresses these issues by developing a comprehensive AI-powered system that use Convolutional Neural Networks (CNNs) to predict hair loss stages via scalp picture analysis. It combines detection with practical prevention methods, such as nutritional and lifestyle suggestions, community participation through social sharing, and professional referrals, to provide an accessible, individualized, and comprehensive approach to managing hair loss.

Chapter 3: Requirements and design

Chapter 3: Requirements and Design

Describe all modules of requirements and design in clear English text along with the necessary diagram and figures. Anyone reading your report should be able to reproduce your system/results after reading it.

3.1 Requirements

The Requirements Chapter outlines the important specifications for system development. It is divided into two sections: functional requirements and non-functional requirements.

3.1.1 Functional Requirements

User:

ID	Requirements
FR 1.1	User shall be able to sign up.
FR 1.2	User shall be able to login.
FR 1.3	User should upload images of their scalp for analysis.
FR 1.4	User will be able to take photo directly.
FR 1.5	User will be able to see result of their hair loss analysis.
FR 1.6	User can be received recommendation.
FR 1.7	User can share their experience with others.
FR 1.8	User can check their nearby dermatologist location.

Admin:

ID	Requirements
FR 2.1	Admin shall be able to login to the system.
FR 2.2	Admin can manage user accounts and clinics.
FR 2.3	Admin shall be able to monitor app.

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System:

ID	Requirements
FR 3.1	System classify hair fall stages and provide result.
FR 3.2	System will give recommendation.
FR 3.3	System will store images and other information of users.
FR 3.4	System will provide community support group.
FR 3.5	System will provide location of dermatologist

3.1.3 Hardware and Software Requirements

Hardware Requirements:

- **Smartphone:** Smart Phones that support Android (8.0 or above) and have at least 2GB of RAM and sufficient processing power for handling users' requests.
- **Internet connectivity:** Reliable internet (4G or 5G) or broadband for accessing real-time of application.
- **Storage:** A sufficient storage space to upload images, user profiles and users sharing experience or comments.
- **Display Resolution:** A Smart phone will have minimum 720p screen resolution.

Software Requirements:

- **Operating System:**
  - For development the suitable operating system will be windows (10/11), or Linux (Ubuntu).
- **Programming languages:**

  Following are the languages:

  - Python is used in model training with the following libraries and framework.
  - Machine Learning & Deep Learning:

    - TensorFlow (Keras)
    - Scikit-learn
  - Data processing:
    - NumPy
    - Pandas
    - Matplotlib
    - Seaborn
  - Dart for flutter app frontend.

- **IDE:**
  - Android studio for flutter app development.
  - Google collab for machine learning model training.

- **Database:**
  - In database we will use firebase for storing user data, messages or comment and images.
- **Other tools:**
  - we use GitHub for version control

3.2 Proposed Methodology

The Hair Loss Detection and Prevention System is a smartphone application that helps users identify hair loss phases and provides individualized care recommendations. The system uses AI and machine learning technology to provide real-time detection and recommendations based on individual needs. It is designed to assist those worried about their hair's health by providing accurate information and community-based support.

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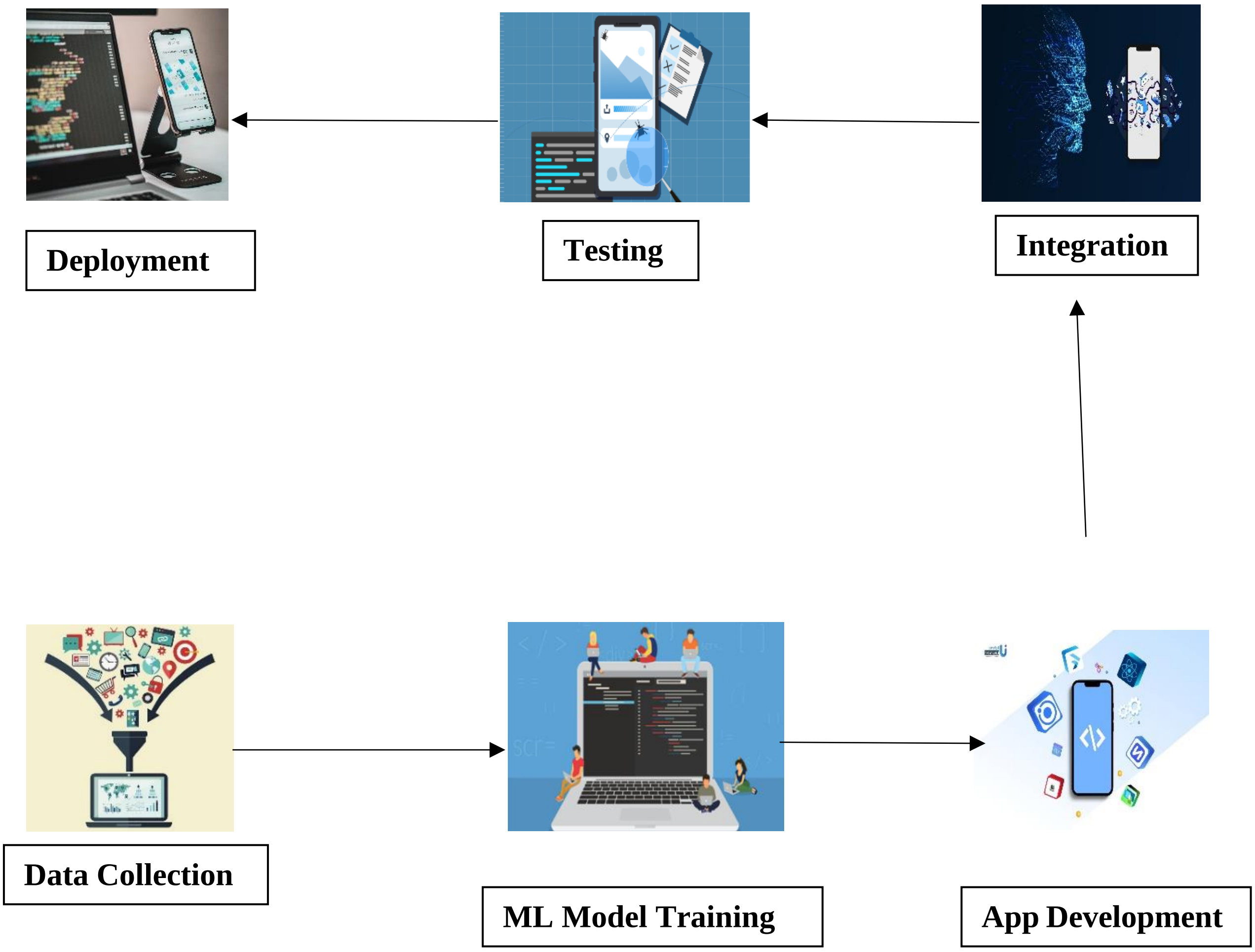
The app allows users to upload scalp images for analysis. It uses CNN models to evaluate these photos and determine different phases of hair loss. Based on the identification, the system offers consumers personalized recommendations such as diet changes, natural cures, and expert referrals. To provide a user-friendly experience, we intend to build the system as a mobile application with real-time capabilities.

We are developing this using machine learning technology. We collect a large set of image data, then apply an augmentation technique to increase dataset diversity and prevent overfitting. Finally, we use Convolutional Neural Networks (CNN), which are well-suited for image classification tasks. on the huge dataset, which provide rather excellent results

To increase user engagement, the app features a social sharing function that allows them to share their progress and connect with others. It also contains a local dermatologist network; the app will refer users to nearby dermatologists if their condition worsens.

Figure 1: Proposed methodology



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3.3 System Architecture

The system architecture of the Hair Loss Detection and Prevention system is intended to give users with a straightforward and effective method for detecting and managing hair loss issues. This architecture utilizes modern machine learning techniques, user-friendly interfaces, and smooth data processing pipelines to enable precise identification and individualized suggestions. The system is made up of multiple modules, such as input, preprocessing, analysis, suggestions, community support, professional integration, and output layers, all of which are designed to work together to deliver a dependable and comprehensive user experience.

3.3.1 Input modules:

This module serves as the system's entry point, allowing users to upload high-resolution scalp pictures from their mobile devices. Camera integration, for example, makes it possible to shoot images seamlessly.

3.3.2 Pre-processing module:

This module analyses the scalp photos in a series of stages to guarantee that the input data is standardized and acceptable for analysis. Denoising filters are used to eliminate unwanted noise while saving vital features. Data augmentation techniques such as rotation, flipping, and cropping are used to diversify the dataset and make the system adaptive to changes in input. Pre-processing activities are performed using Python packages like as OpenCV and TensorFlow.

3.3.3 Analysis module:

The analysis module is at the very core of the system, detecting and classifying different stages of hair loss using a Convolutional Neural Network (CNN). The CNN, which was trained on a broad dataset of scalp photos, recognizes patterns such as early-stage thinning, moderate hair loss, and advanced baldness. This module is based on deep learning frameworks such as TensorFlow or PyTorch, with pretrained models such as Alpha net fine-tuned to specialize in hair loss detection.

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3.3.4 Recommendation Module

Based on the analysis module's results, this module provides personalized advise based on the user's hair condition and additional demographic information. To delay or reverse hair loss, suggestions may include dietary changes, stress management strategies, and natural therapies. The system uses rule-based decision logic to ensure that the recommendations are specific and actionable, providing a more tailored approach to hair care and prevention.

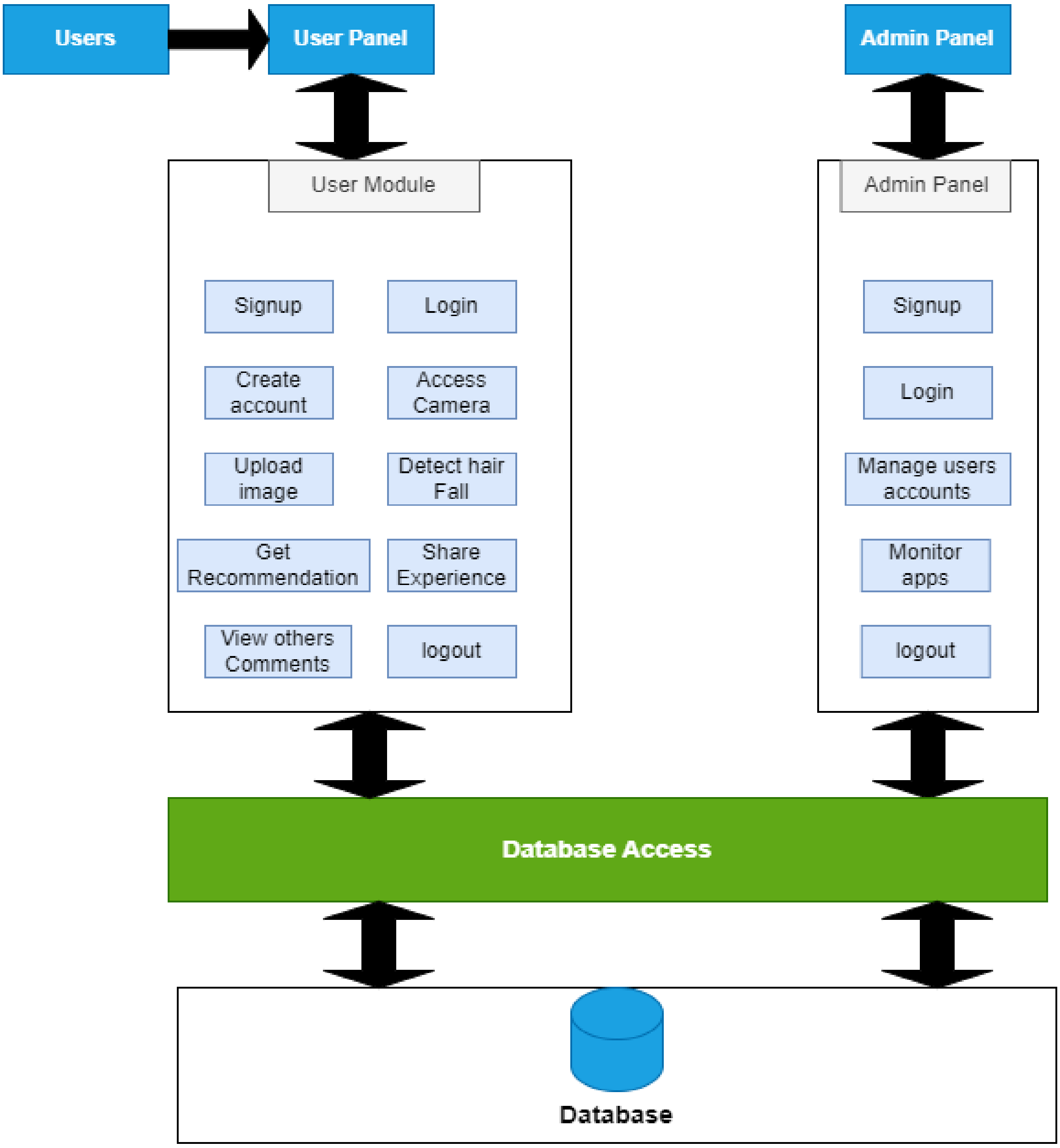
3.3.5 Community and support module

To increase user engagement, this module allows them to track and share their progress via social sharing tools. It also serves as a platform for community interaction, allowing users to share tips, discuss their experiences, and seek assistance from others who share similar issues. Backend frameworks like as Firebase provide real-time interaction, resulting in a user-friendly environment.

3.3.6 Output module

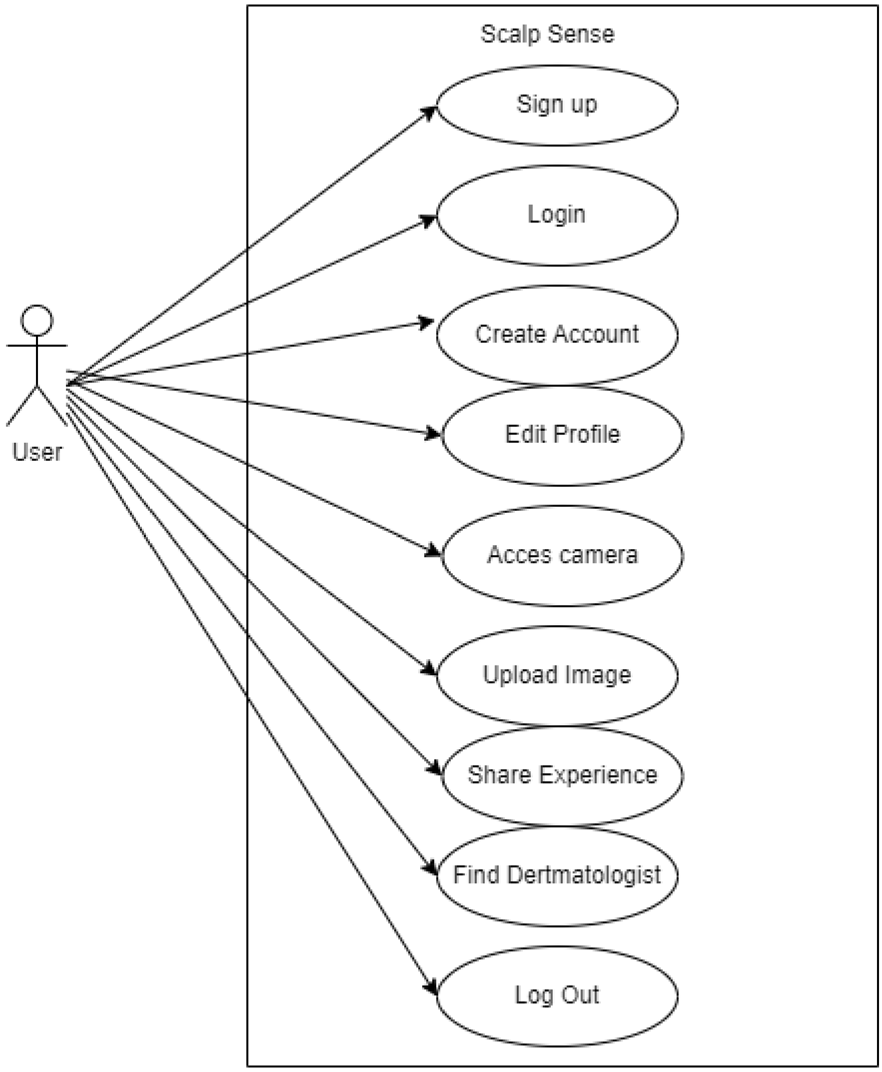
The last module presents the results and recommendations in a user-friendly way. Text-based advice for the next actions. This module guarantees that users can understand and use the system's findings, making hair care management more effective and accessible. The interactive displays are powered by frontend technologies such as React.js and Flutter, which ensure a seamless user experience.

Figure 2: System architecture

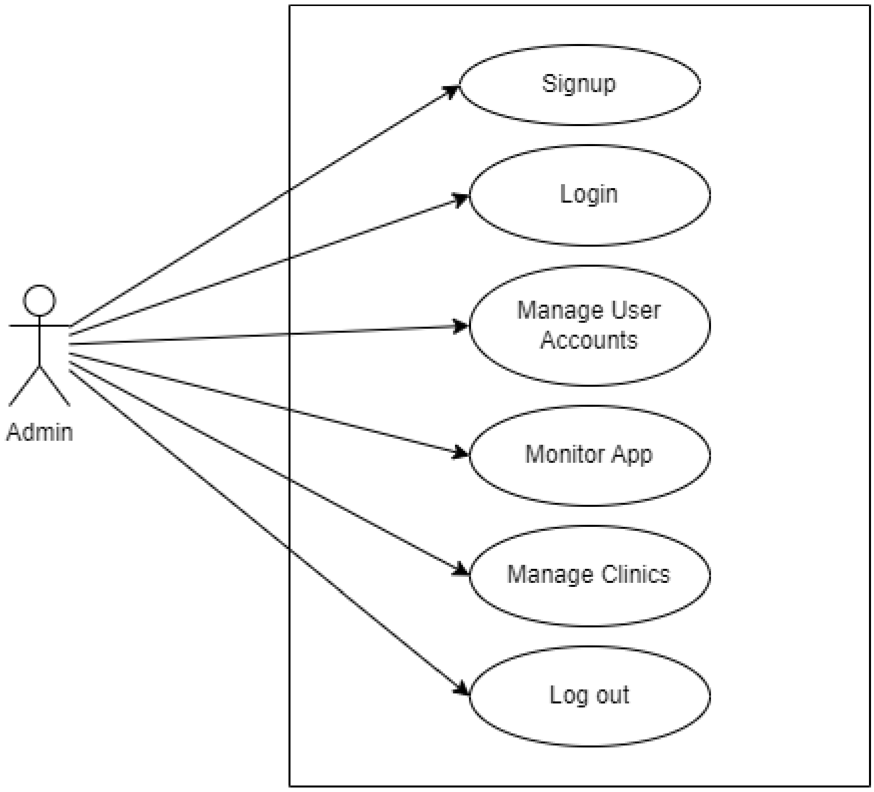


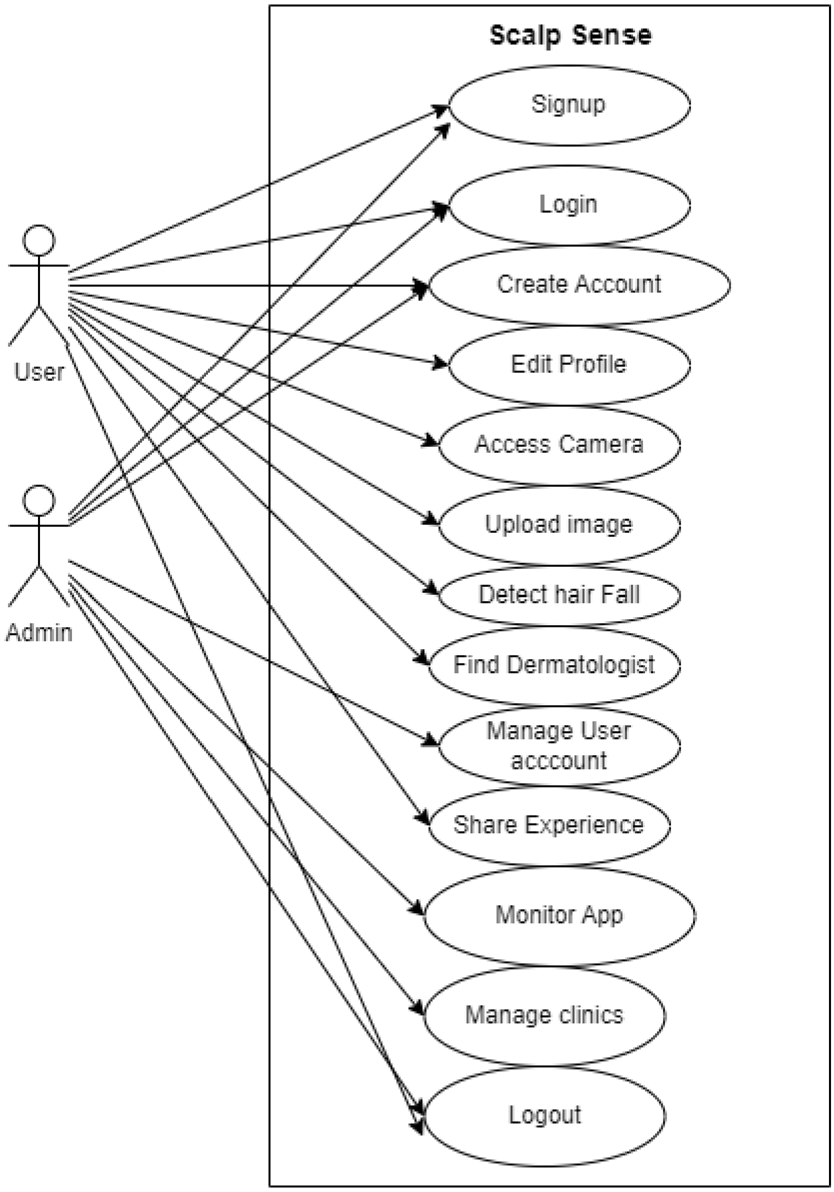
3.4 Use Cases

User:



Admin:


Signup
Login
Manage User Accounts
Monitor App
Manage Clinics
Log out
Admin


Scalp Sense
User
Admin
Signup
Login
Create Account
Edit Profile
Access Camera
Upload image
Detect hair Fall
Find Dermatologist
Manage User acccount
Share Experience
Monitor App
Manage clinics
Logout

3.4.1 Sample Use Case Name Here

Fully Dressed Use cases:

Signup:

<table>
<tr><td>Name</td><td colspan="4">Sign Up</td></tr>
<tr><td>Actors</td><td colspan="4">User.</td></tr>
<tr><td>Summary</td><td colspan="4">The system allows users to create new account by providing new information.</td></tr>
<tr><td>Pre-Conditions</td><td colspan="4">None.</td></tr>
<tr><td>Post-Conditions</td><td colspan="4">A new account will be created and users can log in to the system.</td></tr>
<tr><td>Special Requirements</td><td colspan="4">None.</td></tr>
<tr><td colspan="5">Basic Flow</td></tr>
<tr><td colspan="2">Actor Action</td><td colspan="3">System Response</td></tr>
<tr><td>1</td><td>The user opens the app.</td><td>2</td><td colspan="2">The signup page is displayed asking for email and password.</td></tr>
<tr><td>3</td><td>The user enters email and password.</td><td>4</td><td colspan="2">The system create account and show message “Account is created”.</td></tr>
<tr><td colspan="5">Alternative Flow</td></tr>
<tr><td>3</td><td>If the user enters incomplete information.</td><td>4-A</td><td colspan="2">The system responds with an error message indicating “incomplete or invalid credential”.</td></tr>
</table>

Login:

Name	Login		
Actors	Admin, User.		
Summary	The users (Admin, user) should enter their email and password in the login form and after successful verification user will be get access to the home page.		
Pre-Conditions	User must have account before login.		
Post-Conditions	After login user will be redirected to the home page of the app.		
Special Requirements	None		
Basic Flow			
Actor Action		**System Response**	
1	The user opens the login page.	2	The login page is displayed asking for email and password.
3	The user enters valid email and password.	4	The system verifies the email and password, establishes a session for the user and redirects the user to the home page.
Alternative Flow			
3	The user enters invalid email or password.	4-A	The system responds with an error message: *Incorrect email or password entered.*

Upload Image:

Name	Upload image
Actors	User.
Summary	The user will upload image from their gallery through the home page of app.

Pre-Conditions	User must be login and have access to home page.		
Post-Conditions	Picture will be uploaded for processing.		
Special Requirements	Image of Scalp.		
Basic Flow			
Actor Action		**System Response**	
1	The user opens the home page. And click on the "Select image" button	2	The pop-up appears and will ask for image source.
3	The user clicks on gallery and select the image and click on add button	4	The image is uploaded now the system will process it.
Alternative Flow			
3	The user clicks on the "Select Button" and then click cancel.	4-A	

Take picture:

Name	Take Picture		
Actors	User.		
Summary	The user will upload image to the system using their mobile phone camera.		
Pre-Conditions	User must be login and have access to home page.		
Post-Conditions	Picture will be uploaded for processing.		
Special Requirements	Image must be of Scalp.		
Basic Flow			
Actor Action		**System Response**	

1	The user opens the home page. And click on the “Select image” button	2	The pop-up appears and will ask for image source.
3	The user clicks on “Camera” and take picture to upload.	4	The image is uploaded now the system will process it.
Alternative Flow			
3	The user clicks on the “Select Button” and then click cancel.	4	

Hair Fall Detection:

Name	Hair Fall Detection		
Actors	User.		
Summary	The user will upload an image of their scalp, and the system will identify it according to the stage the user's hair is in.		
Pre-Conditions	User must be login and have access to home page.		
Post-Conditions	Result will come out.		
Special Requirements	Image of Scalp.		
Basic Flow			
Actor Action		**System Response**	
1	The user upload image of the scalp.	2	The system display “Show detected result” Button.
3	The user clicks on the “Show detected result” Button.	4	The system displays the result of the user scalp.
Alternative Flow			
3	The user upload image other than scalp.	4-A	The system shows error message “Invalid input”.

Share Experience:

Name	Share experience		
Actors	User.		
Summary	The user can share their experience with the app in community support group		
Pre-Conditions	User must be login and have access to home page.		
Post-Conditions	Other member can get the idea about the app		
Special Requirements	None		
Basic Flow			
Actor Action		**System Response**	
1	The user login to the home page and clicks on the community support group icon from bottom navigation bar	2	The system displays the group where user can share the experience.
3	The user writes their experience and clicks on send button icon.	4	The message is sent and other members can see it.

Reset password

Name	Reset password
Actors	User.
Summary	If the user forget his password he can reset it and can change the password easily.
Pre-Conditions	User email must be registered before trying to login.
Post-Conditions	User password will be changed to new one.

Special Requirements	None		
Basic Flow			
Actor Action		**System Response**	
1	The user will tap on "forgot password"	2	The system will send an reset password email to the user email.
3	User will click on the link in the email	4	A new interface will be appear for new password
5	User will write his new password and click on "save" button.	6	Password will be updated successfully

Get recommendation:

Name	Get recommendation		
Actors	User.		
Summary	The user will upload an image of their scalp, and the system will identify his hair fall stage and will provide recommendation according to their hair conditions.		
Pre-Conditions	User must upload image of their scalp.		
Post-Conditions	User can see the recommendation given by system.		
Special Requirements	Image of Scalp.		
Basic Flow			
Actor Action		**System Response**	
1	The user upload image of the scalp.	2	The system display "Show detected result" Button.
3	The user clicks on the "Show detected result" Button.	4	The system displays the result of the user scalp and provide recommendation.

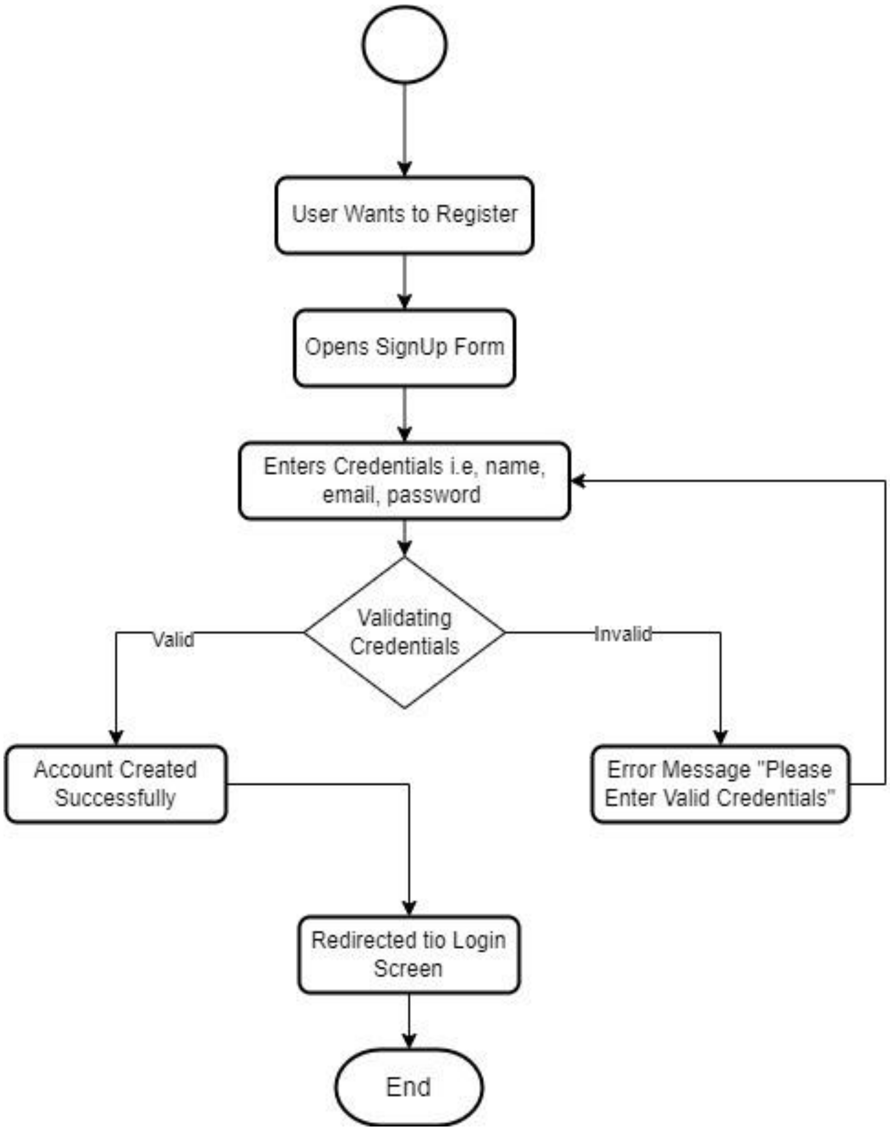
5	User can see recommendation given by system.		
Alternative Flow			
3	The user upload image other than scalp.	4-A	The system shows error message “Invalid input”.

Logout:

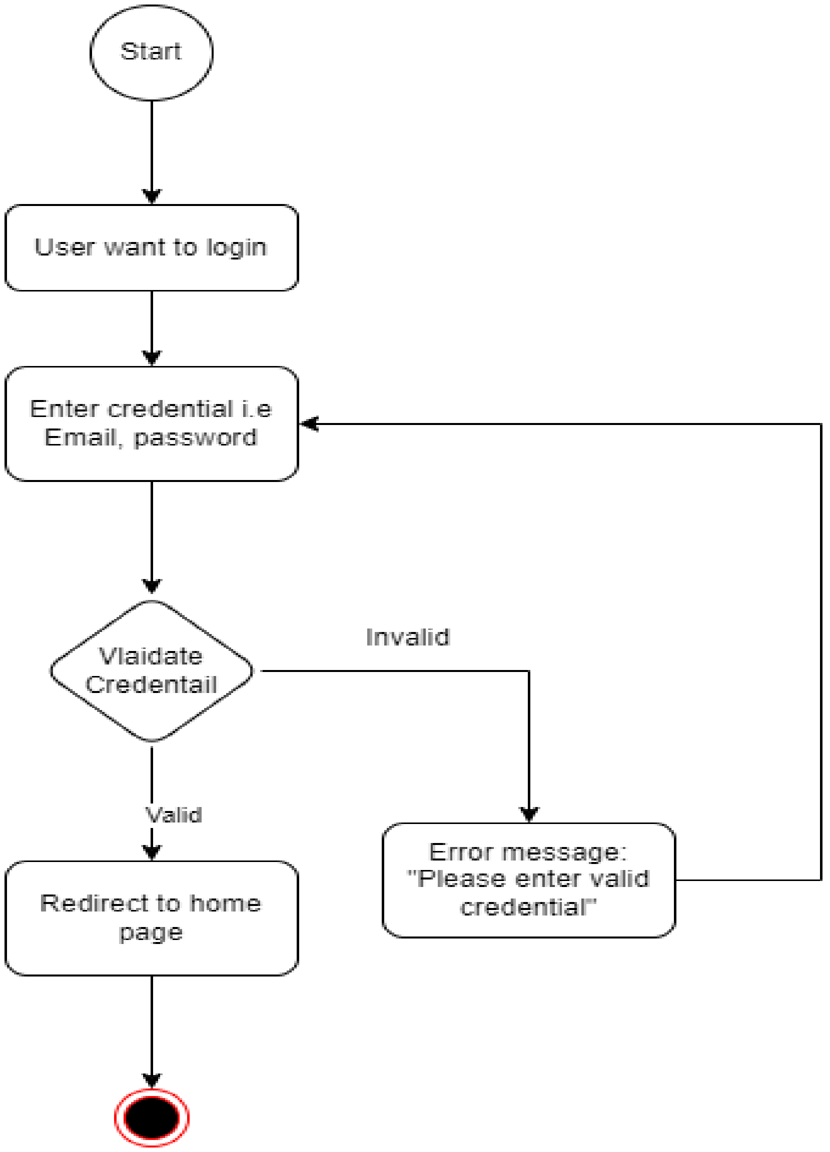
Name	logout		
Actors	Admin, User.		
Summary	The users (Admin, user) can logout from the system if they want.		
Pre-Conditions	User must be login to the system.		
Post-Conditions	Users will be logout and will have no access to homepage..		
Special Requirements	None		
Basic Flow			
Actor Action		**System Response**	
1	The users click on the menu in bottom navigation bar.	2	The system displays a pop up.
3	The user clicks on logout.	4	The system logout the user and navigate him to sigh in screen.

3.4.2 Activity diagram

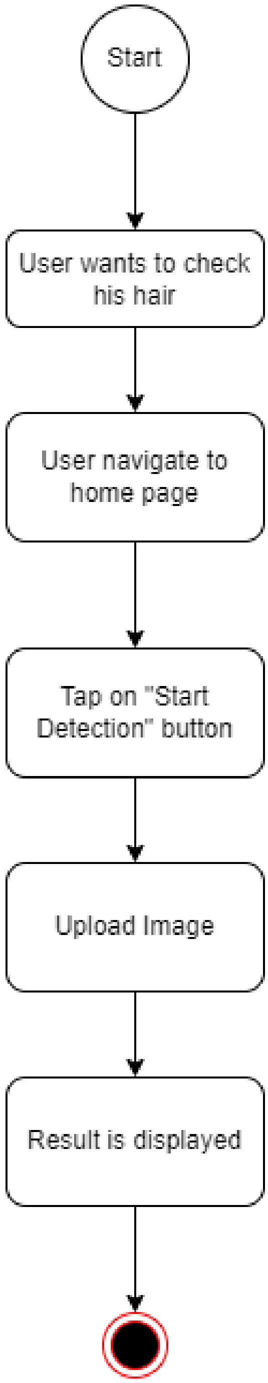
3.4.2.1 Registration



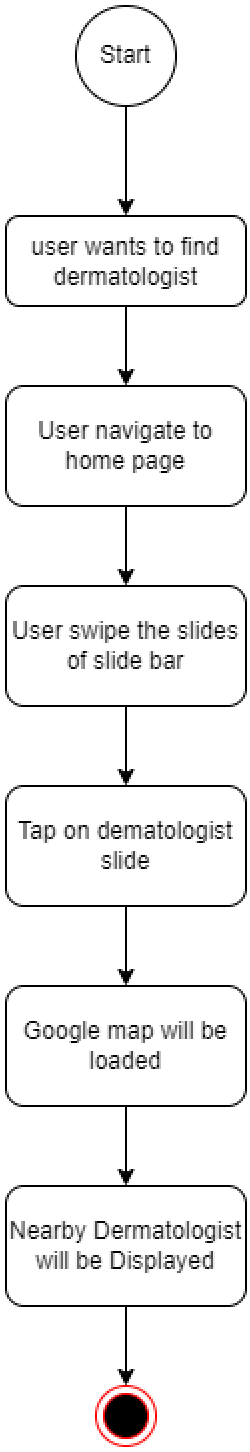
3.4.2.2 Login


Start
User want to login
Enter credential i.e
Email, password
Vlaidate
Credentail
Invalid
Valid
Redirect to home
page
Error message:
"Please enter valid
credential"

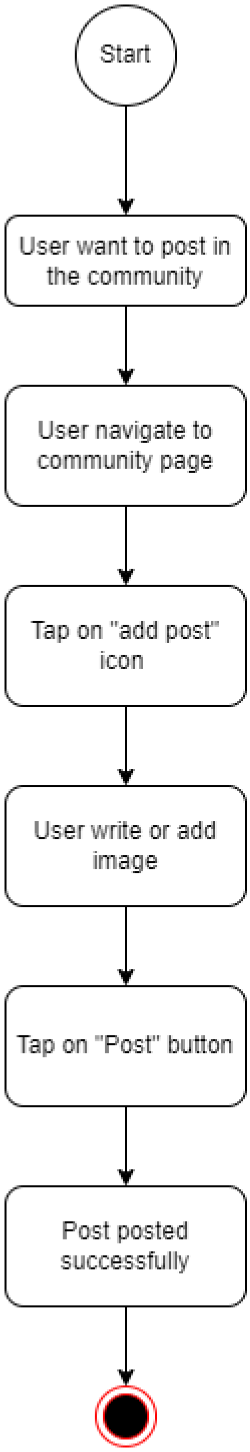
3.4.2.3 Start detection



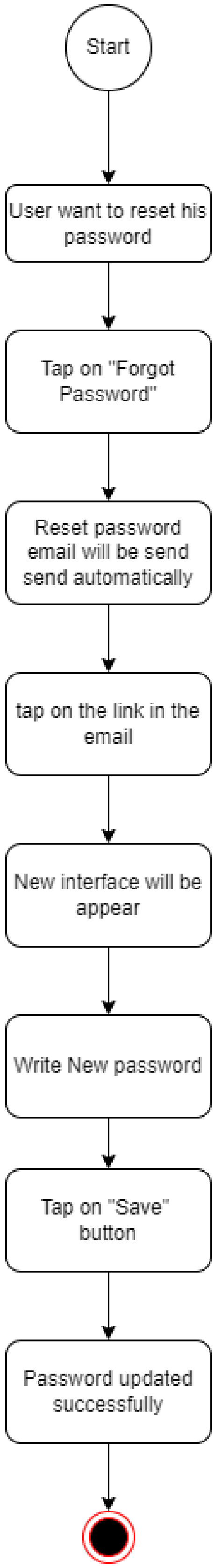
3.4.2.4 Find Dermatologist



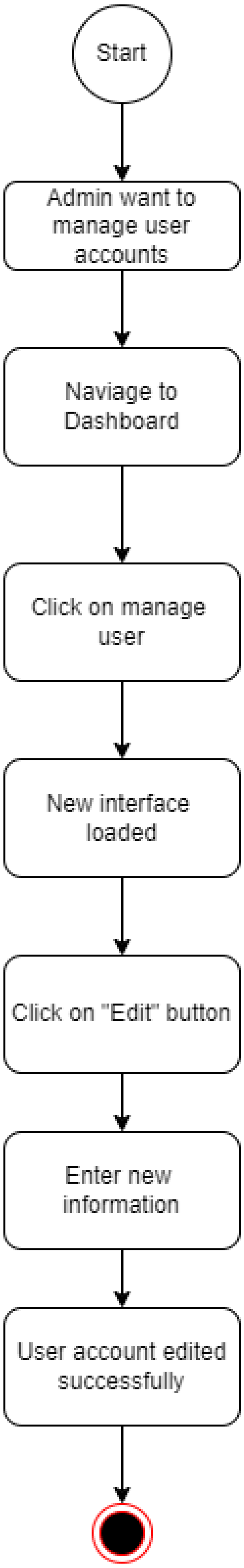
3.4.2.5 Share Experience



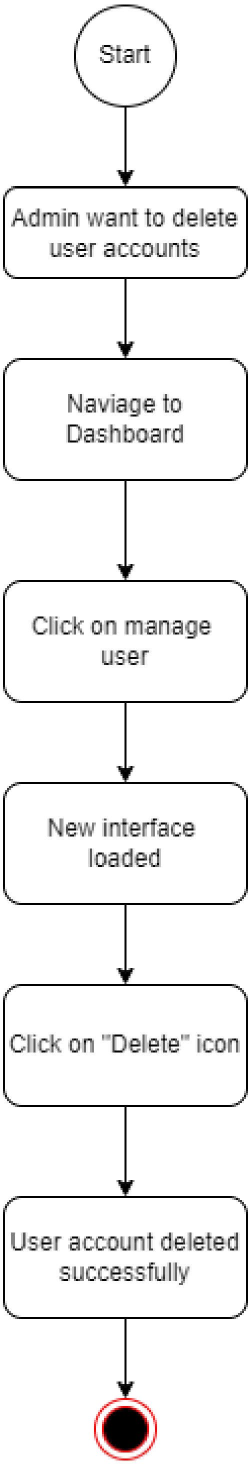
3.2.4.6 Reset password



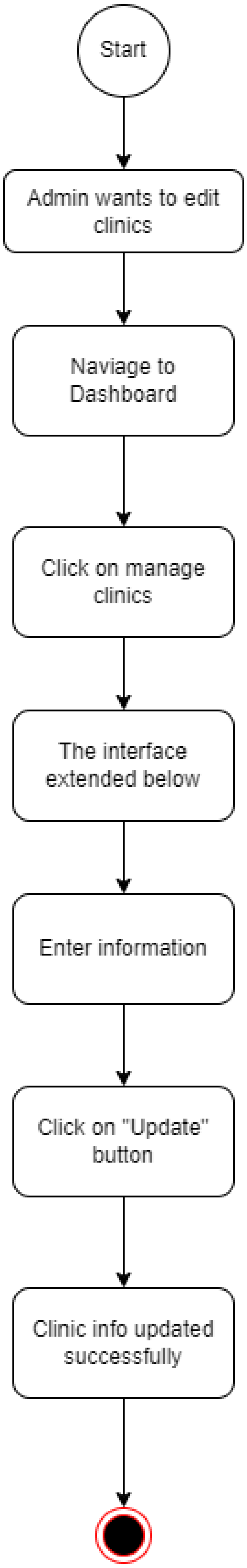
3.4.2.7 Edit user profile



3.4.2.8 Delete user account



3.4.2.9 Edit Clinic information



Chapter 4: Implementation and Test Cases

Chapter 4: Implementation and Test Cases

4.1 Implementation

4.1.1 Implementation of First Component/Algorithm

Dataset Management:

The code begins with dataset management, which involves integrating Google Drive to retrieve and store essential files and outputs. The dataset, which is stored as a compressed zip file, is extracted to a specified directory. Once extracted, the implementation collects all picture file paths and labels, which are derived from the names of the subdirectories where the images are located. Following that, the dataset is divided into two subsets: training (80%) and testing (20%), with labels stratified. The split data is next organized into directories for training and testing, with subfolders created for each label category.

Data Augmentation:

To improve the model's generalization capabilities, data augmentation techniques are used on the training dataset. These methods include rescaling pixel values to normalize image data, as well as transformations like rotation, width and height shifts, shear, zoom, and horizontal flips. These augmentations imitate changes in the dataset, allowing the algorithm to acquire more robust characteristics for detecting hair loss.

Model Design:

The implementation leverages both pretrained deep learning models and custom convolutional neural networks (CNNs) for feature extraction and classification. Pretrained models such as ResNet50V2 and DenseNet169, are used as base feature extractors, and their outputs are connected to fully connected layers for fine-tuning the models on the specific dataset. In addition to pretrained models, a custom CNN is built from scratch with convolutional layers for feature extraction, pooling layers to reduce spatial dimensions, and fully connected layers to perform classification. These architectures are designed to efficiently process scalp images and predict different stages of hair loss.

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Model training:

The Adam optimizer is used in the training process, which dynamically adapts the learning rate, as well as categorical crossentropy loss for multi-class classification. Training metrics, such as accuracy and loss, are monitored across epochs for both training and validation data. To improve the training process, callbacks such as early stopping and learning rate reduction on the validation loss plateau are used. Early stopping reduces overfitting by interrupting training when validation loss no longer improves, whereas learning rate reduction adjusts the learning rate in order to boost convergence when the model approaches a plateau.

Performance evaluation:

The model's performance is measured using a range of metrics, including precision, recall, F1-score, and accuracy. These metrics are calculated on the validation and test datasets, providing insight into how effectively the model generalizes to new data. A classification report is generated, and the results are represented using confusion matrices, which provide a thorough perspective of the model's predictions for each class. Additional visualizations include plotting training and validation accuracy and loss over epochs, which can help in analysing model improvements and detecting potential overfitting or underfitting concerns.

Model Saving:

To save the trained model for future use, the implementation saves its weights and parameters to Google Drive. This ensures that the trained model may be easily reloaded for further testing, evaluation, or deployment without requiring retraining.

Testing:

Finally, the trained model is tested on unseen data to validate its real-world performance. The evaluation metrics and results are documented, and detailed visualizations such as plots and confusion matrices are generated to provide a comprehensive analysis of the model's capabilities. These reports help in fine-tuning the model and understanding its strengths and areas for improvement.

4.2 Test case Design and description

This section defines the structure for creating and defining test cases for the Hair Loss Detection and Prevention System. Test cases ensure that all system components, from image upload to personalized recommendations generation, work as expected.

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Common Attributes of Taste Cases

- **Input Constraints:** All tests assume legitimate image inputs (e.g., JPEG/PNG files), valid location data for the dermatologist locator, and authorized user sessions.
- **Environmental Needs:** A reliable mobile internet connection to access ML models, social sharing features, and a dermatologist locator.
- **Special procedural Requirements:** App access must be authenticated, and users must have the necessary permissions (e.g., admin access).
- **Shared case dependencies:** The successful execution of one test case may be dependent on the completion of another (for example, successful picture upload is necessary before image analysis).

4.2.1 Test case No 1

User Registration			
Hair Loss Detection and Prevention System			
Test Case ID:	*TC 01*	**Test Date:**	*4/24/2025*
Test case Version:	*V 1.1*	**Use Case Reference(s):**	*UC-1*
Revision History:	*No*		
Objective	*To check user can successfully register or not*		
Product/Ver/Module:	*Hair Loss Detection and Prevention System / v1.0 / User Management Module.*		
Environment:	*Smart Phone (Android 10+)*		
Assumptions:	*Assumee that server and database are operational and provide valid email*		
Pre-Requisite:	*Registration page is accessible and user must not have an existing account with the same email and number.*		

Step No.	**Execution description**	**Procedure result**
	Navigate to registration page	*Page loaded successfully.*
	Enter valid information (Name, Email, Number, Password)	*System send verification email to the provided email.*

	Click on the verification link	*Successfully registered and navigate to login page*
Comments: In additional test, we also submit incomplete or wrong forms, and it indicates error.		
☑*Passed* ☐*Failed* ☐*Not Executed*		

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4.2.2 Test Case No 2

User Login			
Hair Loss Detection and Prevention System			
Test Case ID:	*TC 02*	**Test Date:**	*4/27/2025*
Test case Version:	*V 1.2*	**Use Case Reference(s):**	*UC-2*
Revision History:	*No*		
Objective	*The objective of this test case is to check the functionality of login component.*		
Product/Ver/Module:	*Hair Loss Detection and Prevention System / v1.0 / User Management Module.*		
Environment:	*Smart Phone (Android 10+)*		
Assumptions:	*We can assume that user is registered and is logging in through his credential.*		
Pre-Requisite:	*User must have an active registered account and connected to internet.*		

Step No.	Execution description	Procedure result
	Navigate to Login page	*Page loaded successfully.*
	Enter valid Email and Password.	*Login Successfully and navigated to homepage*
Comments: we also test unregistered user cannot login		
☑ *Passed* ☐ *Failed* ☐ *Not Executed*		

4.2.3Test case No 3

Upload Image

Hair Fall Detection and Prevention System.

Hair Loss Detection and Prevention System			
Test Case ID:	*TC 02*	**Test Date:**	*4/24/2028*
Test case Version:	*V 1.3*	**Use Case Reference(s):**	*UC-4*
Revision History:	*No*		
Objective	*The objective of this test is to check the functionality of image uploading.*		
Product/Ver/Module:	*Hair Loss Detection and Prevention System / v1.0 / image processing Module*		
Environment:	*Smart Phone (Android 10+)*		
Assumptions:	*Assume that user is already logged into the system.*		
Pre-Requisite:	*App must have permission to access the camera and gallery.*		
Step No.	**Execution description**	**Procedure result**	
	Navigate to home page and scroll down	*Page loaded successfully.*	
	Tap on "Start detection" button	*User is presented option to capture photo using camera or select image from gallery.*	
	Select or capture a clear picture of scalp	*Image uploaded successfully.*	
Comments: After uploading the image. The system will display the results.			
☑ *Passed* ☐ *Failed* ☐ *Not Executed*			

4.2.4 Test case No 4

Share Experience			
Hair Loss Detection and Prevention System			
Test Case ID:	*TC 04*	**Test Date:**	*4/24/2025*
Test case Version:	*V 1.4*	**Use Case Reference(s):**	*UC-6*

<table>
<tr><td colspan="2">Revision History:</td><td>No</td></tr>
<tr><td colspan="2">Objective</td><td>To verify the user can successfully write their experience and can share it with others in the app.</td></tr>
<tr><td colspan="2">Product/Ver/Module:</td><td>Hair Loss Detection and Prevention System / v1.4 / Community Module</td></tr>
<tr><td colspan="2">Environment:</td><td>Smart Phone (Android 10+)</td></tr>
<tr><td colspan="2">Assumptions:</td><td>Assumee that user is already logged in and community sharing feature is operational</td></tr>
<tr><td colspan="2">Pre-Requisite:</td><td>User is authenticated and app has access to community interface.</td></tr>
<tr><td>Step No.</td><td>Execution description</td><td>Procedure result</td></tr>
<tr><td></td><td>Tap on ‘community’ icon</td><td>Page loaded successfully.</td></tr>
<tr><td></td><td>Write or add image to the post and tap on the ‘Post’ button.</td><td>Post successfully posted</td></tr>
<tr><td colspan="3">Comments: In community group user can share any article, past experience, can post image and also user can like posts of other.</td></tr>
<tr><td colspan="3">☑Passed ☐Failed ☐Not Executed</td></tr>
</table>

4.2.5 Test case No 5

Dermatologist Locator module			
Hair Loss Detection and Prevention System			
Test Case ID:	*TC 05*	**Test Date:**	*4/24/2025*
Test case Version:	*V 1.5*	**Use Case Reference(s):**	*UC-7*
Revision History:	*No*		
Objective	*To verify the user can successfully find any nearby dermatologist.*		
Product/Ver/Module:	*Hair Loss Detection and Prevention System / v1.5 / Dermatologist locator*		
Environment:	*Smart Phone (Android 10+)*		
Assumptions:	*Assumee that that GPS is turned on in the device*		
Pre-Requisite:	*Slider is active and responsive and location service are enabled on the device.*		

Step No.	**Execution description**	**Procedure result**
	Open the home page of the app	*Page loaded successfully.*
	Swipe the slide bar left or write to view the dermatologist slide and tap on the dermatologist slide	*App triggered the google map service with current location*
	The app send a request to google map API to fetch the nearby dermatologist.	*Maps interface loads and show nearby dermatologist.*
Comments: Remember that the app can only locate dermatologists within a 20-kilometer radius.		
☑ *Passed* ☐ *Failed* ☐ *Not Executed*		

4.2 Sample test case matric

Metric:	**Purpose**
Number of Test Cases:	5
Number of Test Cases Passed:	5
Number of Test Cases Failed:	0
Test Case Defect Density:	0
Test Case Effectiveness:	0
Traceability Matrix:	Traceability is the ability to determine that each feature has a source in requirements and each requirement has a corresponding implemented feature.

Chapter 5:

Experimental Results and Analysis

Hair Fall Detection and Prevention System.

Hair Fall Detection and Prevention System.

5.1 Experimental results and analysis:

This chapter dives into the experimental results and analysis of the Hair Loss Detection and Prevention System, with a particular emphasis on how well the Convolutional Neural Network (CNN) model performs in classifying different stages of hair loss and various scalp conditions. We take a close look at evaluation metrics like precision, recall, F1-score, and accuracy to gauge the model's effectiveness. To help visualize the findings, we include tools like confusion matrices and accuracy/loss plots, which shed light on the model's performance. The results clearly show that the system can accurately identify hair loss stages and offer trustworthy recommendations, while also pointing out strengths and areas where there's room for improvement.

5.2 Classification Performance:

The CNN model was put to the test using a dataset filled with scalp images, which were sorted into two categories: Alopecia Areata, Androgenetic Alopecia, Telogen Effluvium, and Invalid (which includes non-scalp images). The classification report, neatly summarized in Table 1, provides a breakdown of the precision, recall, and F1-score for each category, as well as the overall accuracy.

5.3 Scalp Disease Classification Model:

The very first CNN model was designed to identify two scalp conditions: Alopecia Areata and Psoriasis. It was tested using a dataset filled with scalp images. You can find a summary of the classification performance in Table 1.1.

Table 5.1 Classification Report for Scalp disease detection

	Precision	**Recall**	**F1-Score**	**Support**
Alopecia Areata	0.99	0.99	0.99	295
Androgenetic Alopecia	0.96	0.96	0.96	53
Macro Average	0.98	0.98	0.98	348
Weight average	0.99	0.99	0.99	348
Accuracy			0.99	348

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This model boasted an impressive overall accuracy of 99%, showing strong precision and recall for both conditions. Interestingly, Alopecia Areata performed just a bit better, probably because its visual patterns are more distinct compared to Psoriasis, which sometimes shares similar features.

5.4 Hair Loss Stages Classification:

The second CNN model was designed to identify three stages of hair loss: Early Thinning, Moderate Hair Loss, and Advanced Baldness, along with a category for Invalid images that don't show the scalp. You can find the classification results in Table 2. The model boasted an impressive overall accuracy of 98%, with the Invalid category achieving perfect precision and recall, which means it effectively filtered out non-scalp images. While the model performed well in classifying the hair loss stages, there were a few minor mix-ups between Early Thinning and Moderate Hair Loss, likely due to the subtle visual differences.

Table 5.2 Classification Report for hair loss stages detection

	Precision	**Recall**	**F1-Score**	**Support**
Invalid	1.00	0.99	1.00	174
Normal	0.93	1.00	0.96	27
Stage 1	1.00	0.96	0.98	80
Stage 2	0.89	1.00	0.94	24
Stage 3	1.00	0.99	0.99	73
Macro Average	0.96	0..99	0.98	378
Weight average	0.99	0.99	0.99	378
Accuracy			0..99	378

5.5 Sample Prediction analysis

In Figure 1, you can see a sample scalp image that the scalp disease model processed. It was accurately classified as Androgenetic alopecia, and the model was highly confident about this, scoring 0.99.

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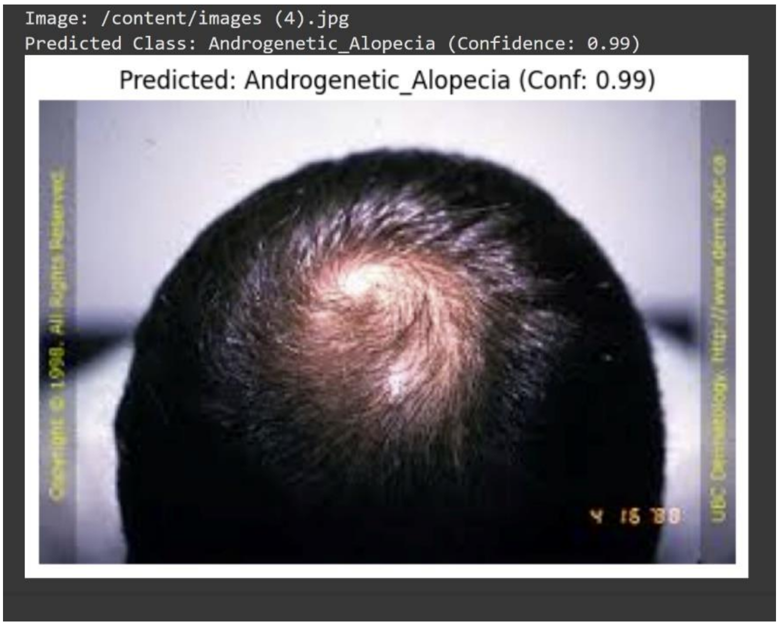
Figure 5.1 Sample Scalp image prediction.

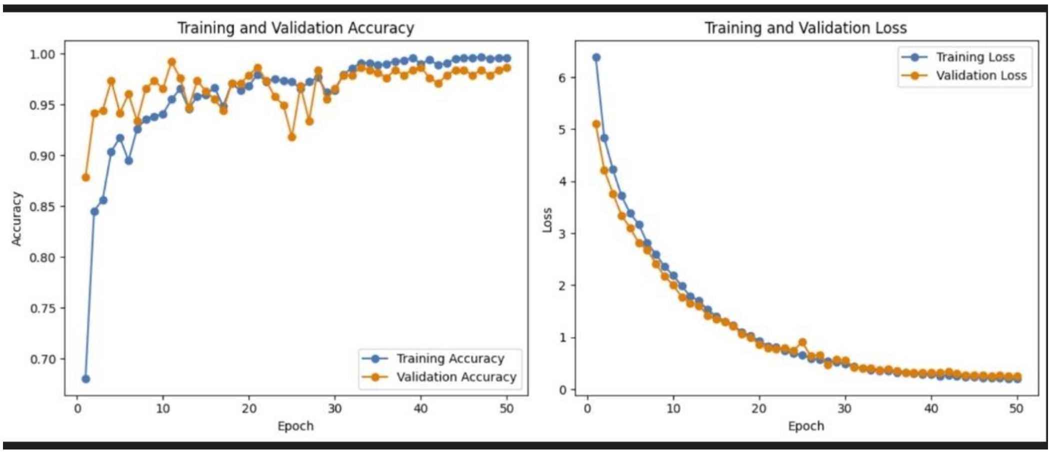


This high confidence score really showcases the model's knack for accurately identifying hair loss stages, thanks to solid preprocessing and data augmentation techniques that boost feature extraction.

5.6 Training and Validation Performance

Both models were trained on datasets divided into 80% for training and 20% for testing, with data augmentation used to enhance generalization. Figure 2 shows the training and validation accuracy and loss for the hair loss stages model, and similar trends were noted for the disease model.

Figure 5.2: Training and Validating Accuracy (Hair Loss Stages Model)



The hair loss stages model reached an impressive accuracy of about 99% after 40 epochs, with the validation loss closely mirroring the training loss, which suggests there was hardly any overfitting.

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Similarly, the disease classification model also showed strong performance, achieving 99% accuracy and maintaining stability throughout the epochs.

5.7 Confusion Matrix Analysis:

Figures 3 display the confusion matrices for hair loss stages model, which provide detailed insights into classification performance.

Table 3: Confusion Matrix for Hair Loss Stages Detection

173	0	0	1	0
0	27	0	0	0
0	2	77	1	0
0	0	0	24	0
0	0	0	1	72

In the hair loss model, most of the mistakes happened between Early Thinning (stage 1) and Moderate Hair Loss (stage 2), which makes sense given their similar appearances. On a positive note, the Invalid class was always identified correctly, which really shows how strong the model is at filtering out irrelevant inputs.

5.8 Discussion

The experimental results highlight how effective both CNN models are in their specific tasks. The model for classifying scalp diseases achieved an impressive 99% accuracy, particularly excelling at telling apart Alopecia Areata from Androgenetic alopecia. However, there’s room for improvement to reduce misclassifications that arise from visual similarities. On the other hand, the hair loss stages model boasted a 99% accuracy, successfully identifying different stages of hair loss and non-scalp images. This success is largely thanks to the use of pretrained architectures like ResNet50V2 and DenseNet169, along with strong data augmentation techniques.

There are some challenges, though, including minor misclassifications in both models, especially among visually similar categories. To tackle these issues, expanding the datasets to include a wider variety of samples and using advanced image enhancement techniques could be beneficial. Plus, ensuring the models can handle low-quality images is crucial for their real-world application.

5.9 Conclusion

The Hair Loss Detection and Prevention System effectively utilizes two CNN models to classify scalp diseases and hair loss stages, achieving accuracies of 99% and 99%, respectively. By integrating preprocessing, data augmentation, and fine-tuned pretrained models, the system delivers reliable performance. Its ability to filter out non-scalp images and offer personalized recommendations makes it a valuable tool for proactive hair care. Looking ahead, enhancements like larger, more diverse datasets and better handling of low-quality images will further boost the system's capabilities, positioning it as a comprehensive solution for managing hair health.

Chapter 6:
Conclusion and Future Directions

Hair Fall Detection and Prevention System.

6.1 Conclusion

The Hair Loss Detection and Prevention System highlights the power of integrating machine learning and image processing to solve one of the most frequent and emotionally significant health issues: hair loss. The technology uses Convolutional Neural Networks (CNNs) to analyze scalp photos and accurately identify the severity and stage of hair loss. It goes beyond diagnosis, including personalized recommendations such as natural remedies, nutritional guidance, and dermatological referrals, resulting in a comprehensive ecosystem for preventive and continuing hair care.

Furthermore, the platform emphasize user involvement through community factors, which allow individuals to share their perspectives and experiences, hence increasing emotional support among users. The addition of a dermatologist locator bridges the gap between AI-powered tests and professional medical intervention, ensuring comprehensive care. The mobile-friendly interface and real-time analytic functions improve accessibility and user experience, making it an efficient support tool for hair health management.

In short, this system is a proactive, user-focused solution that enables people to use current technology to manage their hair health. It delivers its major goals of early detection, prevention, and user education.

6.2 Future Directions:

To improve the capabilities and reach of the Hair Loss Detection and Prevention System, the following future advancements are suggested:

6.3 Progress Monitoring and Timeline Tracking

Add a timeline feature that tracks users' scalp photos over time to show the evolution or improvement of their hair condition.

Use change-detection algorithms to provide quantitative input on hair regrowth and loss.

6.4 Integration of Wearable Technology

Enable integration with scalp analysis devices or smart combs to collect real-time physiological data (for example, scalp temperature and follicle health).

Use Bluetooth-enabled scalp cameras for more accurate picture capture and detection.

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6.5 Global Dermatologist and Pharmacy Network

Expand the dermatologist referral system by working with verified clinics around the world, enabling in-app appointment booking.
Collaborate with pharmacies or e-commerce platforms to give customers direct access to recommended hair care items.

6.6 Deep Learning-Based Model Enhancement

Train the model on larger and more diverse datasets to better detection of different hair kinds, ethnicities, lighting circumstances, and image qualities.

6.7 Voice-based and Augmented Reality Support

Add voice input support, allowing users to describe symptoms and receive spoken recommendations.
Using Augmented Reality (AR), the user can mimic the effects of various hair treatments or styles on their present scalp condition.

Future approaches aim to make the system more *accurate, **inclusive, and **integrated* with the larger healthcare ecosystem—transforming it from a diagnostic app to a *complete digital medical assistant* for hair care and scalp wellbeing.

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