Hair Disease Prediction

-KHALEELUR RAHMAN M

Abstract

Hair diseases such as dandruff, folliculitis, head lice, psoriasis, and tinea are common conditions affecting millions of people worldwide. This project presents a machine learning-based solution for predicting hair diseases through scalp image analysis. The proposed system utilizes convolutional neural networks (CNNs) to classify images and detect specific hair diseases. By integrating this technology into a mobile application, users can capture scalp images and receive instant predictions, enabling early detection and improved treatment outcomes. This solution is designed to benefit dermatologists, hair care clinics, and individual consumers, providing an accurate and accessible method for diagnosing hair diseases. The project aims to fill the gap in current diagnostic tools, leveraging AI to deliver a reliable and non-invasive hair disease detection system. The project also considers the potential for global scalability, supporting various languages and regions. By automating the disease detection process, this tool reduces diagnostic subjectivity, improving both accuracy and consistency. The proposed solution is also designed to evolve, incorporating new data to continuously improve its predictive capabilities. Moreover, it fosters preventive healthcare by educating users about hair diseases and offering insights into treatment options, contributing to better overall hair and scalp health.

1. Problem Statement

Hair diseases such as dandruff, folliculitis, head lice, psoriasis, and tinea are widespread conditions that affect millions of individuals globally. These ailments not only cause physical discomfort, such as itching, inflammation, and hair loss, but also have a profound impact on mental health and social well-being. Hair loss and visible scalp conditions can lead to embarrassment, reduced self-esteem, and social isolation, making timely diagnosis and treatment crucial. However, the traditional method of diagnosing these diseases largely depends on visual inspection by dermatologists. This process is often time-consuming, subjective, and prone to human error due to variations in expertise and interpretation.

Moreover, access to dermatological care is limited, especially in remote areas, where individuals may have to travel long distances to consult a specialist. This adds to the burden on healthcare systems and leads to delays in diagnosis and treatment. The inconsistency in manual diagnosis also means that similar symptoms may be misdiagnosed, resulting in inappropriate treatments, prolonging the suffering of the patient, and increasing healthcare costs.

There is a growing need for an automated, accurate solution that can provide consistent, reliable diagnoses of hair diseases. A machine learning-based system that analyzes scalp images and predicts common hair conditions offers an opportunity to bridge this gap. Such a system would not only standardize the diagnostic process but also improve early detection, enabling timely and appropriate treatment. The integration of artificial intelligence (AI) could greatly benefit both healthcare providers by reducing workload and individuals by offering a more accessible and efficient method of diagnosis, ultimately improving hair disease management and patient outcomes.

2. Market/Customer/Business Need Assessment

Hair care and dermatology represent multi-billion-dollar global industries, continuously growing due to rising consumer awareness of the importance of hair health. In recent years, there has been a surge in demand for both preventative and therapeutic hair care solutions, driven by increasing incidences of scalp-related issues and hair loss across various demographics. Factors such as pollution, stress, poor diet, and genetic predispositions contribute to the prevalence of hair diseases, making the need for efficient diagnosis and treatment more pressing than ever.

The emergence of telemedicine and advancements in AI-based diagnostics have opened new avenues for integrating machine learning into healthcare, particularly for hair disease prediction. This trend is supported by the growing acceptance of remote healthcare solutions, especially after the COVID-19 pandemic, where people became more reliant on virtual consultations and digital healthcare tools. AI-powered systems that can provide quick and reliable diagnosis remotely align well with this shift towards telemedicine. Additionally, consumers are becoming more proactive about managing their hair health, seeking early diagnosis tools to prevent more severe conditions. This presents a significant opportunity to cater to dermatology clinics, hair care professionals, and individual users through AI-driven scalp analysis and disease prediction systems.

The potential market for an AI-based hair disease prediction tool is vast. Dermatology clinics could use it to streamline diagnosis, allowing them to serve more patients efficiently while improving accuracy. Hair care specialists, including salons and clinics, could incorporate such technology to offer advanced diagnostic services, enhancing their offerings and improving customer satisfaction. Furthermore, individual consumers are increasingly interested in managing their hair health independently. A mobile application that allows them to perform self-checks for hair diseases from the comfort of their homes would cater to this growing demand, enabling users to detect problems early and seek appropriate treatment. Thus, this AI-based solution addresses both a medical need for precise diagnostics and a consumer need for convenience, speed, and accessibility in healthcare services.

3. Target Specifications and Characterization

The target audience for this AI-based hair disease prediction system spans a range of users within the healthcare and personal care industries, each with specific needs:

- **Dermatologists**: Dermatologists are continuously seeking ways to enhance diagnostic accuracy and efficiency. A machine learning tool that analyzes scalp images and predicts diseases can serve as a supportive diagnostic tool, allowing them to validate visual inspections and streamline patient care. The system can also reduce the time spent on each diagnosis, enabling dermatologists to treat more patients without compromising on quality.
- **Hair Care Clinics**: Hair care clinics that specialize in treating scalp-related issues would benefit from integrating advanced diagnostic tools into their offerings. This AI-powered system can provide early detection capabilities, allowing clinics to offer cutting-edge diagnostic services that attract more clients. By incorporating technology into their practice, they can elevate their service quality, providing precise, personalized care to patients.
- **General Consumers**: With the increasing demand for health-tech solutions, general consumers who want to manage their hair health at home are a key demographic. Many individuals are looking for convenient, reliable, and accessible tools that allow them to check for hair diseases without needing to visit a clinic. A mobile application that offers this service will cater to consumers who are proactive about their health, especially in remote or underserved areas where access to specialists is limited. This target audience values ease of use, reliability, and quick results, making an AI-powered solution ideal for their needs.

This broad target market demonstrates the versatility and potential of the proposed hair disease prediction system in meeting diverse customer needs, from clinical applications to personal health management.

4. External Search

In developing an AI-based hair disease prediction system, a thorough external search is essential to understand the current state of technology, identify knowledge gaps, and gather data sources. The external search process includes reviewing literature from reputable dermatology journals, health-tech websites, and AI healthcare forums. These sources provide insights into the latest trends and advancements in dermatological disease prediction, focusing on the intersection of artificial intelligence and healthcare.

- **Online Dermatology Journals**: Research papers in dermatology offer valuable information on common hair and scalp diseases, diagnostic methods, and emerging technologies in telemedicine. Articles in journals such as the *Journal of the American Academy of Dermatology* or the *British Journal of Dermatology* provide detailed case studies and image datasets that are crucial for training AI models.

- **Health-Tech Websites**: Websites dedicated to healthcare technology, like *HealthTech Magazine* and *MedTech Dive*, provide updates on the integration of AI in diagnostics. These platforms offer case studies and reports on the use of machine learning models in healthcare, including success stories and challenges in implementing AI-powered diagnostic tools. They also discuss relevant frameworks and software that can be leveraged for this project.

- **AI Healthcare Forums**: AI-focused forums and platforms like *AI in Healthcare* and *Healthcare IT News* serve as valuable communities for developers and researchers working on AI-driven healthcare solutions. These forums often share insights on AI models used in disease prediction, best practices for training machine learning algorithms, and resources like publicly available datasets.

- **Relevant Research Papers**: Extensive research has been conducted on disease prediction using machine learning. Papers detailing how convolutional neural networks (CNNs) and other AI models are applied in medical imaging provide a foundation for building the proposed hair disease prediction tool. Furthermore, studies that focus on image-based analysis of skin and scalp conditions offer insights into relevant preprocessing techniques and data augmentation strategies.

- **Public Health Datasets**: Government health organizations, such as the *National Institutes of Health (NIH)* and the *World Health Organization (WHO)*, provide open datasets on dermatological diseases, including hair-related conditions. These datasets serve as training and testing sources for the AI models, improving the system's accuracy and robustness by providing real-world examples of various hair diseases.

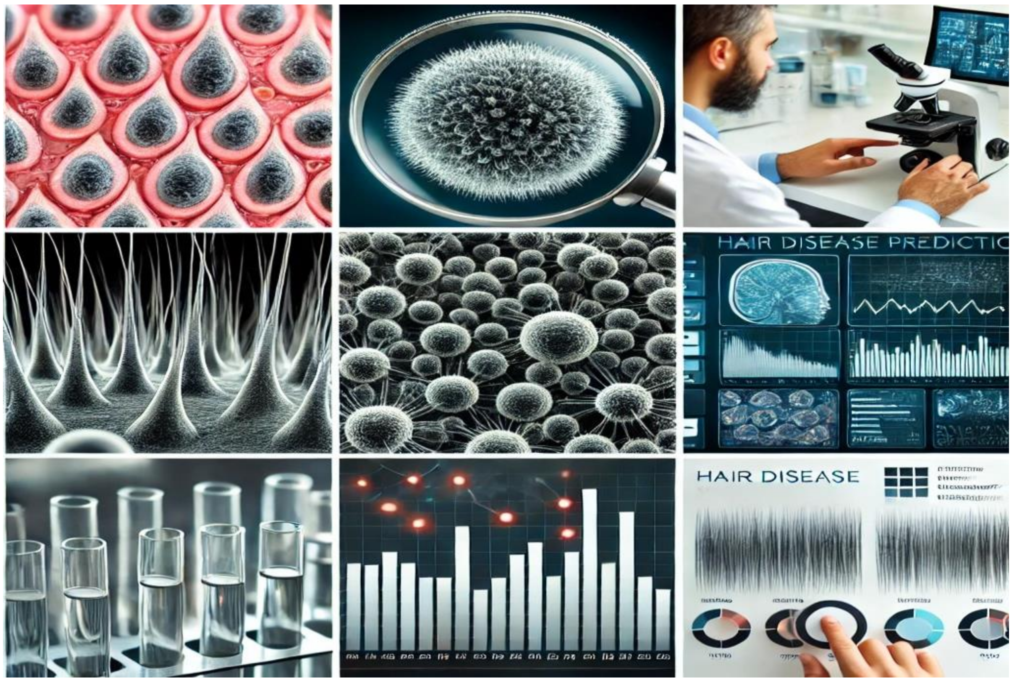
These diverse sources of information and data provide the necessary foundation to build a reliable and accurate AI-powered system for hair disease prediction, ensuring that the solution is backed by scientific research and industry best practices.

5. Benchmarking Alternate Products

To effectively position the proposed AI-based hair disease prediction system in the market, it is important to benchmark it against existing products. Most of the available AI-driven diagnostic tools in the market are focused on skin disease detection, specifically conditions like acne, eczema, and moles. These systems use image analysis techniques similar to what is proposed for hair disease detection but lack specificity in identifying hair and scalp-related conditions.

- **Existing Products**: Several mobile applications and online platforms, such as *SkinVision* and *DermaAI*, offer AI-based diagnosis for skin diseases. These tools primarily focus on analyzing images of skin lesions or irregularities to detect diseases like skin cancer, acne, and eczema. While these products have demonstrated the potential of AI in healthcare, they largely ignore the complexities of hair and scalp-related diseases. This gap in the market presents a significant opportunity to develop a specialized tool that caters specifically to hair care.
- **Strengths**: Existing skin disease detection models have shown high accuracy in image-based diagnostics, particularly for conditions like melanoma or acne. These systems use advanced convolutional neural networks (CNNs) and deep learning models to analyze skin images and provide real-time results. The success of these models proves that AI-based image analysis is a viable solution for disease detection, and similar models can be adapted for hair disease prediction.
- **Weaknesses**: Despite their accuracy, these systems are designed primarily for skin conditions and do not account for hair-specific issues like dandruff, head lice, folliculitis, or tinea. The lack of tools focused on hair diseases highlights a critical gap in the market. Moreover, hair diseases often present differently from skin conditions, requiring distinct image preprocessing techniques, feature extraction methods, and disease categorization models. Existing products may not have the necessary algorithms to deal with the complexities of diagnosing hair diseases, such as differentiating between healthy hair, damaged hair, and scalp abnormalities.

By benchmarking against these existing products, the proposed AI-based system for hair disease prediction has the potential to fill an underserved niche in the healthcare market. It will focus on improving diagnostic accuracy for hair-specific conditions, offering a tailored solution that leverages the strengths of existing technology while addressing the shortcomings related to hair and scalp health.



6. Applicable Regulations

Regulatory compliance is a critical aspect of developing and deploying any healthcare-related product, especially one involving sensitive health data and diagnostics. Several regulations must be adhered to in order to ensure the legal and ethical use of AI-driven diagnostic tools.

- **Health Data Regulations**
  Since the proposed hair disease prediction system involves the collection and analysis of personal health information (scalp images), it must comply with stringent data privacy laws, such as the *General Data Protection Regulation (GDPR)* in Europe, and equivalent laws in other regions. GDPR mandates that any system handling personal data must obtain explicit consent from users and provide transparency on how the data will be used, stored, and processed. The system must implement strong data protection measures, including encryption and anonymization of user data, to safeguard against breaches. Additionally, users should have the right to access, modify, or delete their data at any time. Compliance with these regulations is essential to build trust with users and avoid legal penalties.

  In addition, in the United States, compliance with the *Health Insurance Portability and Accountability Act (HIPAA)* is necessary if the system interacts with healthcare providers or stores medical records. HIPAA establishes national standards for protecting sensitive patient health information and requires that proper security measures are in place to prevent unauthorized access.

- **Medical Device Regulations**
  If the hair disease prediction tool is classified as a medical diagnostic device, it must adhere to specific regulatory requirements in different regions. For instance, in the

United States, the *Food and Drug Administration (FDA)* regulates medical devices under the *21 CFR Part 820* guidelines. The FDA's review process ensures that the diagnostic tool is safe, effective, and performs as intended. For AI-based solutions, the FDA has developed a framework for evaluating software as a medical device (SaMD), which assesses the risk levels associated with the technology and its clinical applications.

In Europe, the product must meet the requirements of the *Medical Device Regulation (MDR)* and obtain the *CE Marking*, which indicates that the device complies with European health, safety, and environmental protection standards. This process involves rigorous testing, documentation, and validation to demonstrate the safety and efficacy of the tool for medical use.

These regulations are particularly important if the AI-based system is marketed for professional use in dermatology clinics or hospitals. Proper classification and adherence to medical device regulations ensure that the tool can be deployed in clinical settings and provides a reliable diagnostic service.

- **Other Regional Regulations**
  Depending on the markets targeted, the tool must also comply with local regulations in other regions, such as *Health Canada* regulations for medical devices or *TGA (Therapeutic Goods Administration)* guidelines in Australia. Each regulatory body has its own standards for the approval and certification of medical diagnostic tools, which must be followed to ensure the product can be used globally.

By adhering to these applicable regulations, the AI-based hair disease prediction system can ensure that it is not only legally compliant but also trusted by consumers and professionals alike. This fosters confidence in the tool's accuracy, safety, and privacy measures, contributing to its success in the market.

7. Applicable Constraints

When developing an AI-driven hair disease prediction system, several constraints must be considered to ensure the project is feasible and successful. These constraints encompass budgetary limits, expertise requirements, and hardware needs.

- **Budget**: Developing machine learning models for image analysis and implementing cloud-based services for real-time processing can be costly. Initial costs include expenses for data acquisition, model training, and infrastructure setup, including servers and databases. Ongoing costs will also arise from maintaining the system, including cloud service fees, data storage, and scaling resources to handle user demand. Additionally, budget allocations for marketing, user support, and continuous updates to the system will be essential to attract and retain customers. Securing adequate funding through investors, grants, or partnerships will be critical to overcoming these financial constraints and ensuring long-term sustainability.
- **Expertise**: Building a sophisticated AI-driven diagnostic tool requires a multidisciplinary team with diverse expertise. Dermatologists are essential for providing insights into hair diseases, ensuring that the AI models are trained on

relevant data, and validating the diagnostic accuracy. Data scientists with experience in machine learning and image processing are needed to develop and optimize the algorithms that power the diagnostic tool. Software developers are crucial for creating the user interface, backend infrastructure, and ensuring seamless integration with existing telemedicine platforms. The complexity of this project necessitates a collaborative approach, which may pose challenges in terms of coordinating schedules, aligning goals, and managing communication among team members with different expertise.

- **Hardware**: The success of the AI-based diagnostic tool relies on high-quality images for accurate disease detection. Therefore, users will need access to high-resolution cameras or smartphones capable of capturing clear images of their scalps. The variability in camera quality among different devices may affect the system's performance, making it essential to define minimum hardware specifications to ensure reliable image capture. Additionally, the system may need to incorporate features that assist users in achieving optimal image quality, such as guides for proper lighting, angle, and distance during image capture. Consideration must also be given to the potential need for partnerships with smartphone manufacturers or camera companies to enhance accessibility and ensure high standards.

8. Business Model

To create a sustainable revenue stream for the hair disease prediction system, a well-defined business model is essential. The following components outline the proposed approach:

- **Subscription-Based Service**: The primary revenue model will target dermatology clinics and hair care specialists, offering subscription plans that provide access to advanced diagnostic tools and resources. Clinics can subscribe on a monthly or annual basis, allowing them to utilize the AI system for patient diagnosis and management. This model not only generates steady revenue but also fosters long-term relationships with healthcare providers, who can benefit from ongoing support and software updates. Tiered subscription levels can be established, offering different features based on the clinic's size and patient load, ensuring scalability and adaptability.
- **Mobile App**: A freemium model will be implemented for individual consumers, allowing users to download the mobile application for free with limited access to basic diagnostic features. Users can perform initial assessments of their scalp conditions and receive general information about hair health. For more detailed diagnostics, users will have the option to purchase premium features, such as personalized treatment recommendations, historical tracking of scalp health, and advanced analytics based on their captured images. This model encourages users to engage with the app and explore the benefits of the paid features, driving potential revenue growth.
- **API Licenses**: An additional revenue stream can be generated by offering API licenses to telemedicine platforms and healthcare applications. These APIs would allow integration of the hair disease prediction tool into existing healthcare software, enabling providers to offer comprehensive care solutions. By partnering with telemedicine services, the tool can reach a broader audience and be incorporated into virtual consultations, making it easier for users to access hair health diagnostics as

part of their overall healthcare management. Licensing fees for API access can provide a continuous source of income while expanding the system's reach.

By diversifying the revenue model through subscriptions, a freemium mobile app, and API licenses, the project can establish a sustainable business framework that meets the needs of healthcare providers and individual consumers alike.

9. Concept Generation

The concept for the AI-driven hair disease prediction system was born out of the increasing demand for innovative diagnostic tools in healthcare, particularly in the realm of dermatology. The growing awareness of hair health issues, combined with the limitations of existing diagnostic methods, highlighted the need for a more efficient solution. Traditional diagnosis relies heavily on visual inspection by healthcare professionals, which can be subjective and prone to errors.

Recognizing these challenges, the idea to integrate machine learning with scalp image analysis emerged as a promising solution. By leveraging AI algorithms, the proposed system can provide real-time, non-invasive diagnoses, allowing users to capture images of their scalps and receive instant feedback regarding potential hair diseases. This approach not only streamlines the diagnostic process but also empowers individuals to take proactive measures in managing their hair health.

The initial concept also involves creating an accessible platform for both healthcare providers and consumers, ensuring that high-quality diagnostic tools are within reach for a wide audience. By focusing on user experience and data-driven insights, the system aims to enhance the understanding of hair diseases and promote early intervention strategies. Ultimately, this innovative approach aligns with the broader trend of utilizing artificial intelligence to improve healthcare outcomes, making it a timely and relevant solution in today’s market.

10. Concept Development

The objective of this project is to develop a machine learning-based application specifically designed for analyzing scalp images to predict various hair diseases. The application will leverage advanced techniques in artificial intelligence, particularly convolutional neural networks (CNNs), which have proven highly effective in image classification tasks.

To achieve this, the app will be trained on a comprehensive dataset composed of annotated images of scalp diseases, ensuring that the machine learning model has a diverse range of examples to learn from. The dataset will include images representing different conditions such as dandruff, folliculitis, head lice, psoriasis, and tinea, with labels indicating the specific disease present. This variety is crucial for enhancing the model's ability to generalize and accurately classify unseen images. The training process will involve preprocessing the images to enhance quality, normalize sizes, and augment the dataset through techniques like rotation, flipping, and cropping to ensure the model's robustness against real-world variations.

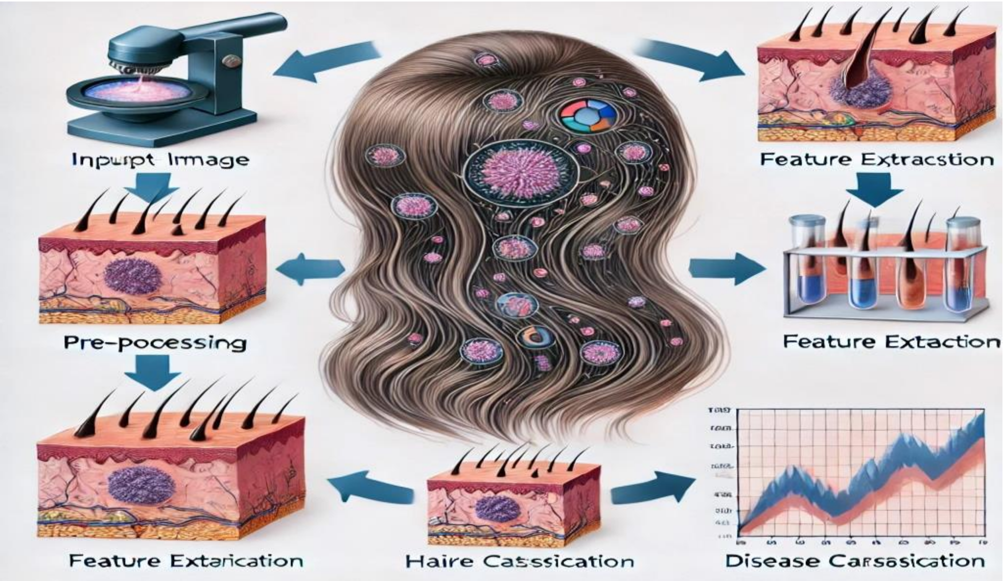
Throughout the development process, iterative testing and validation will be conducted to assess the model's accuracy and improve its performance. The application will also incorporate user-friendly features that guide users in capturing high-quality images of their scalps, enhancing the input data quality for accurate disease prediction.

Ultimately, this concept aims to create a powerful tool that empowers users to proactively manage their hair health, providing timely insights and recommendations for treatment based on accurate disease predictions derived from advanced machine learning techniques.

11. Final Product Prototype (Abstract)

The final product will take the form of a mobile application designed to empower users with the ability to monitor and diagnose their hair health easily. This application will be capable of capturing clear images of the user's scalp using a smartphone camera. Upon capturing the image, the app will process it through a trained convolutional neural network (CNN) model specifically developed for identifying common hair diseases such as dandruff, folliculitis, head lice, and more.

Once the image is analyzed, the application will output predictions regarding the presence of specific hair diseases, along with suggestions for possible treatments or next steps, such as consulting a dermatologist. By providing immediate feedback, the app aims to facilitate early detection and intervention, ultimately promoting better hair health outcomes.



Schematic Diagram

The system flow diagram for the application will illustrate the following components:

- **Image Input**: Users capture an image of their scalp, which is then uploaded to the app.

- **Pre-Processing**: The image undergoes various preprocessing steps to enhance its quality for analysis.
- **Feature Extraction**: The CNN model extracts relevant features from the image, focusing on patterns indicative of specific hair diseases.
- **Disease Classification**: The model classifies the image based on the extracted features, determining the presence of hair diseases.
- **Prediction Output**: Finally, the app presents the user with the diagnosis, suggested treatments, and guidance for further actions.

12. Product Details

How Does it Work?

1. **Image Capture**: Users will initiate the process by capturing a clear image of their scalp using their smartphone. The app will include guidelines on optimal conditions for image capture, such as lighting, angle, and distance, to ensure high-quality input.
2. **Data Processing**: Once an image is captured, it will be processed to remove noise and enhance relevant features. This step includes resizing the image to a standardized format, adjusting brightness and contrast, and normalizing color profiles to ensure consistency across the dataset.
3. **Prediction**: The trained CNN model will analyze the processed image to predict the presence of specific hair diseases. The app will return a diagnosis, offering potential treatment options based on the identified condition and guiding users on the next steps, whether it be self-care measures or recommendations to consult a dermatologist.

Data Sources

The development of this application will utilize a dataset comprised of annotated images of various scalp conditions. This dataset will be sourced from reputable dermatology departments and public health organizations, ensuring a diverse and representative collection of images. The inclusion of images from various demographics and environmental contexts will enhance the model's ability to generalize effectively.

Algorithms, Frameworks, Software

- **Algorithms**: The primary algorithm employed will be convolutional neural networks (CNNs), known for their effectiveness in image classification tasks. Techniques such as transfer learning will be utilized to improve accuracy by leveraging pre-trained models that have already learned features from vast image datasets.
- **Frameworks**: The application will be built using popular machine learning frameworks such as TensorFlow and Keras, providing a robust environment for developing and training the CNN model.
- **Team Required**: A multidisciplinary team will be essential for the successful development of the application. This team will include dermatologists for expert labeling and validation of the dataset, data scientists to focus on model development and optimization, and software engineers responsible for the app's development, ensuring a user-friendly interface and smooth functionality.

13.Code Implementation:

Training Steps:

1. Dataset Preparation:

Base Directory: The dataset is organized with a train and validation folder, each containing subdirectories for classes.

base_dir specifies the dataset's root directory.

train_dir and validation_dir are paths to training and validation sets.

2. Data Augmentation:

ImageDataGenerator is used to augment and normalize the images:

train_datagen: Augments training images with operations like rescaling, shearing, zooming, and flipping to prevent overfitting.

validation_datagen: Only rescales validation images without augmentation.

3. Image Generators:

flow_from_directory: Creates batches of images from the directories for training and validation.

Images are resized to (150, 150).

class_mode='categorical' ensures labels are one-hot encoded (suitable for multi-class classification).

4. Model Definition:

A sequential model is created:

Input Layer: Accepts images of size (150, 150, 3) (RGB).

Conv2D Layers: Extract features using 32 and 64 filters of size (3, 3) with ReLU activation.

MaxPooling2D: Reduces spatial dimensions, focusing on prominent features.

Flatten: Converts the feature map into a 1D vector.

Dense Layers: Fully connected layers with 512 neurons for feature learning and 6 neurons for classification (6 scalp disease classes).

Softmax Activation: Outputs probabilities for each class.

5. Compilation and Training:

optimizer='adam': Adaptive optimizer for efficient training.

loss='categorical_crossentropy': Loss function for multi-class classification.

metrics=['accuracy']: Tracks accuracy during training.

model.fit: Trains the model for 10 epochs using the training and validation generators.

6. Model Saving:

The trained model is saved as scalp_disease_model.keras.

Training Code:

```
import os

import tensorflow as tf

from tensorflow.keras.preprocessing.image import ImageDataGenerator

from tensorflow.keras.models import Sequential

from tensorflow.keras.layers import Conv2D, MaxPooling2D, Flatten, Dense


# Define the base directory for the dataset

base_dir = r'C:\Users\Admin\PycharmProjects\scalp_disease_detection\Scalp disease'

train_dir = os.path.join(base_dir, 'train')

validation_dir = os.path.join(base_dir, 'validation')


# Data augmentation and normalization for training

train_datagen = ImageDataGenerator(

    rescale=1./255,

    shear_range=0.2,

    zoom_range=0.2,

    horizontal_flip=True
```

```
)

# Normalization for validation
validation_datagen = ImageDataGenerator(rescale=1./255)
# Flow training images in batches of 20 using train_datagen generator
train_gen = train_datagen.flow_from_directory(
    train_dir,
    target_size=(150, 150),
    batch_size=20,
    class_mode='categorical'
)

# Flow validation images in batches of 20 using validation_datagen generator
val_gen = validation_datagen.flow_from_directory(
    validation_dir,
    target_size=(150, 150),
    batch_size=20,
    class_mode='categorical'
)

# Model definition
model = Sequential([
    tf.keras.layers.InputLayer(input_shape=(150, 150, 3)),
    Conv2D(32, (3, 3), activation='relu'),
    MaxPooling2D(2, 2),
```

```
    Conv2D(64, (3, 3), activation='relu'),
    MaxPooling2D(2, 2),
    Flatten(),
    Dense(512, activation='relu'),
    Dense(6, activation='softmax')  # Assuming you have 5 classes
])
model.compile(optimizer='adam', loss='categorical_crossentropy', metrics=['accuracy'])
# Train the model
model.fit(train_gen, epochs=10, validation_data=val_gen)


# Save the model
model.save('scalp_disease_model.keras')
```

Testing Steps:

1. Loading the Model:

The saved model is loaded using tf.keras.models.load_model.

2. Class Mapping:

class_names maps the indices of the model's output to descriptive disease names.

3. Image Preprocessing:

Function: preprocess_image ensures test images are resized to (150, 150), normalized, and reshaped for prediction.

4. Camera Setup:

OpenCV is used to access the webcam (cv2.VideoCapture(0)).

5. Main Loop:

Continuously captures frames from the webcam.

Displays the live feed using cv2.imshow.

6. Key Press Actions:

Capture (c key):

Preprocesses the captured frame.

Predicts the disease using the model.

Displays the class ID and description on the frame using cv2.putText.

Quit (q key):

Releases the camera and closes all OpenCV windows.

Output:

During testing:

Pressing c captures the current frame, predicts the scalp disease, and overlays the result on the frame.

Pressing q exits the application.

This implementation provides an end-to-end solution for training a model on a custom scalp disease dataset and testing it in real-time using a webcam.

Testing Code:

```
import tensorflow as tf

import cv2

import numpy as np



# Load the saved model

model = tf.keras.models.load_model('scalp_disease_model.keras')



# Create a dictionary to map class indices to disease descriptions

class_names = ['dandruff-Hair', 'Folliculitis', 'Head Lice', 'No disease', 'Psoriasis', 'Tinea']
```

```python
# Function to preprocess the image
def preprocess_image(image):
    image = cv2.resize(image, (150, 150))
    image = image.astype('float32') / 255.0
    image = np.expand_dims(image, axis=0)
    return image


# Initialize the camera
cap = cv2.VideoCapture(0)

while True:
    ret, frame = cap.read()
    if not ret:
        break

    # Display the frame
    cv2.imshow('Scalp Disease Detection', frame)

    # Check for key press
    key = cv2.waitKey(1) & 0xFF
    if key == ord('c'):  # Capture image on 'c' key press
        # Preprocess the frame
        processed_frame = preprocess_image(frame)
```

```
        # Make prediction
        prediction = model.predict(processed_frame)
        class_id = np.argmax(prediction, axis=1)[0]

        # Get the disease description
        description = class_names[class_id]
        # Display the prediction and description on the captured frame
        cv2.putText(frame, f'Class: {class_id}', (10, 30), cv2.FONT_HERSHEY_SIMPLEX, 1,
(0, 255, 0), 2, cv2.LINE_AA)
        cv2.putText(frame, f'Description: {description}', (10, 70),
cv2.FONT_HERSHEY_SIMPLEX, 0.5, (0, 255, 0), 1,
                    cv2.LINE_AA)
        cv2.imshow('Captured Image - Prediction', frame)

    if key == ord('q'):  # Quit on 'q' key press
        break
cap.release()
cv2.destroyAllWindows()
```

14.Output:

<u>Key Components of the Output</u>

Class Identification:

The system classifies the input into predefined categories, such as:

Dandruff-Hair: Flaky scalp condition.

Folliculitis: Inflammation or infection of hair follicles.

Head Lice: Infestation caused by lice.

No Disease: Normal and healthy scalp.

Psoriasis: Chronic skin condition causing flaky, crusty patches.

Tinea: Fungal infection on the scalp (ringworm).

Predicted Class:

Displays the most probable class for the input image or captured frame. For example:

Class: 1 (Folliculitis).

Confidence Score/Probability:

The prediction comes with a probability for each class. For example:

Yaml

Dandruff-Hair: 0.10

Folliculitis: 0.05

Head Lice: 0.75

No Disease: 0.05

Psoriasis: 0.03

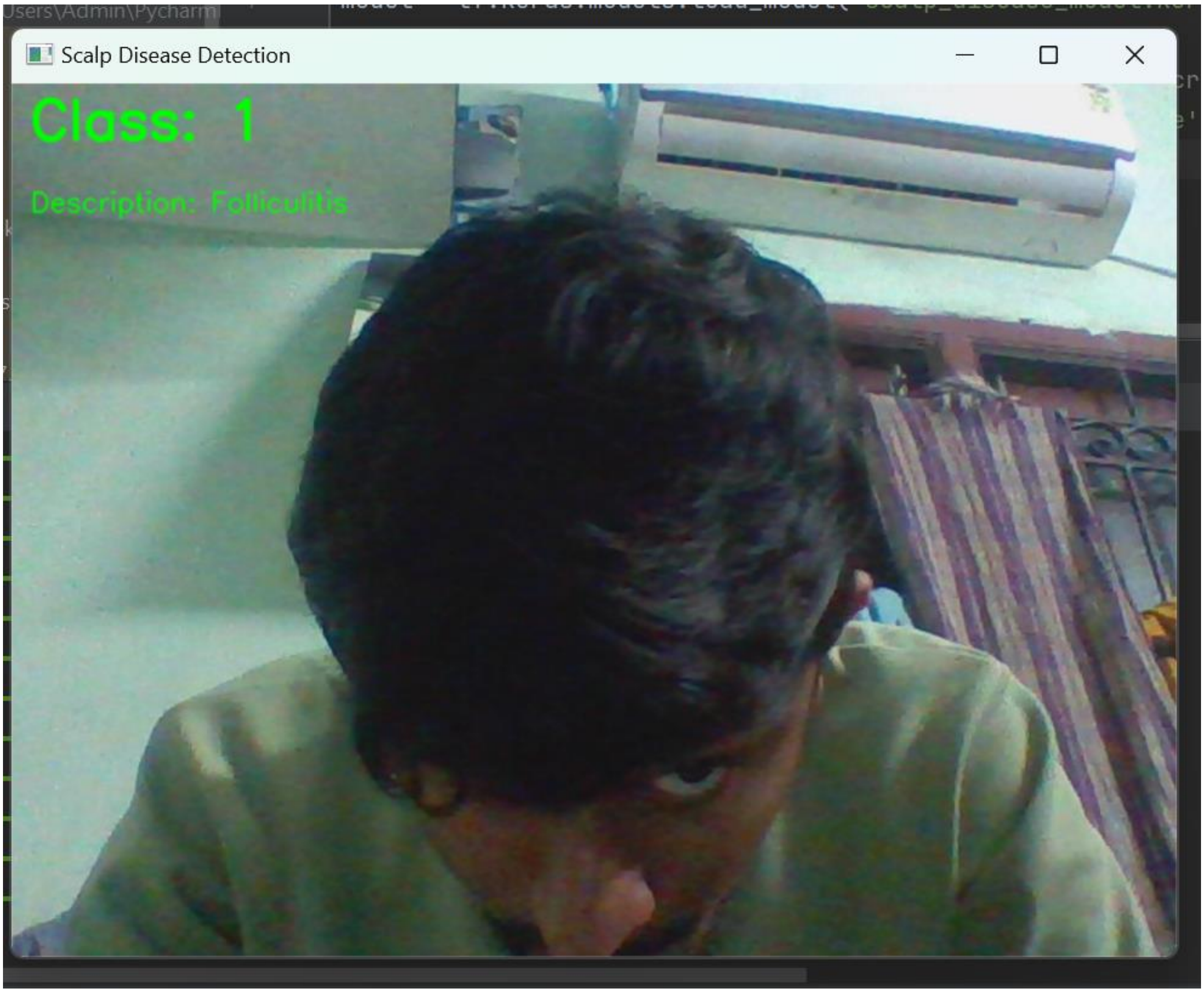
Tinea: 0.02

The class with the highest probability (e.g., 0.75 for Head Lice) is considered the predicted disease.

Description:

Accompanies the class ID with a brief description of the condition for better understanding. For example:

"Head Lice: Parasitic insects causing itching and irritation on the scalp."



Visualization on the Image:

Overlayed Information: The frame or image includes text annotations showing:

Class ID

Predicted Condition Name

<u>Use Cases of the Output</u>

Healthcare Support:

Helps dermatologists or trichologists screen patients for common scalp conditions.

Personal Use:

Assists individuals in identifying potential scalp issues for preventive care.

Research and Training:

Improves diagnostic tools for better understanding of hair and scalp diseases.

Limitations

Accuracy Depends on Dataset: The model's reliability depends on the quality and diversity of the training dataset.

Lighting and Camera Quality: Poor image quality can lead to incorrect predictions.

Scope: The model predicts only the trained diseases; unrecognized conditions will not be detected.

Business Modeling

For the scalp disease detection service, adopting a Freemium Subscription-Based Model is recommended.

Initial Free Features: To build trust and attract users, core features like basic disease detection and general scalp health tips will be provided for free.

Premium Subscription: Advanced features, such as detailed disease reports, personalized treatment suggestions, and dermatologist consultations, will be locked under a paid subscription model.

In a subscription model:

Users pay a fixed fee periodically (monthly or annually) to access the premium features.

The challenge lies in user conversion: effectively transitioning free users into paying customers through persuasive marketing and consistent service quality.

Strategies to boost conversion:

Free trials for premium features.

Discounts for long-term subscriptions.

Gamification to increase user engagement.

This model ensures steady cash flow and creates opportunities for customer retention, loyalty, and data-driven service improvements.

Financial Modeling

To assess financial viability, the service can be launched directly into the retail market with a competitive pricing strategy.

Key Assumptions:

Initial Product Price: ₹250 per subscription.

Target Market Size: 10,000 users in the first year.

Conversion Rate: 10% of free users opt for a premium subscription.

Equations for Revenue Estimation:

$R=250\times1000=$₹$250{,}000$.

Operational Costs:

Fixed Costs (e.g., servers, maintenance): ₹50,000

Variable Costs (e.g., marketing): ₹100 per user

$\text{Profit}=R-(\text{Fixed Costs}+(\text{Variable Cost/User}\times N))$.

The **Freemium Subscription-Based Model** is an effective approach for the scalp disease detection service, ensuring an engaging entry point for users through free features and driving long-term revenue via premium subscriptions. By addressing the challenge of converting free users to paid ones through strategic marketing efforts, the model can achieve scalability and sustainability. The recurring revenue stream from subscriptions also offers financial predictability and opportunities for reinvestment in improving the service.

The financial viability of the service is supported by competitive pricing and a scalable revenue model. With an initial subscription price of ₹250, even a modest conversion rate of 10% can yield significant revenue. By managing fixed and variable costs efficiently, the business can achieve profitability while maintaining affordability for the target audience. This model provides a strong foundation for long-term growth and expansion into larger markets.

13. Conclusion

This project proposes the development of a machine learning-based mobile application aimed at predicting hair diseases through advanced image analysis techniques. The integration of artificial intelligence into healthcare represents a significant shift in how we approach diagnosis and treatment, particularly in the domain of dermatology and hair health. By leveraging convolutional neural networks (CNNs) to analyze scalp images, the application provides users with an innovative tool for early detection of common hair diseases such as dandruff, folliculitis, head lice, and psoriasis.

As the demand for AI-driven healthcare solutions continues to rise, this application addresses an urgent need in the market for accessible and reliable diagnostic tools tailored specifically for hair health. By offering users the ability to capture and analyze their scalp images from the comfort of their homes, the application significantly reduces the necessity for frequent visits to dermatologists for initial assessments. This not only alleviates the burden on healthcare professionals but also fosters a more proactive approach to personal health management among users.

In summary, the proposed machine learning-based mobile application has the potential to revolutionize hair disease management by providing a user-friendly, efficient, and accurate diagnostic tool. Through this innovation, the project aims not only to enhance the accuracy of hair disease detection but also to promote overall hair health awareness, ultimately contributing to improved well-being and confidence for users. As technology continues to advance, solutions like this will play a critical role in shaping the future of healthcare, making it more accessible and effective for everyone.