Design And Development of Hair Strands Detection System Using Image Segmentation

A

MAJOR PROJECT-I REPORT

Submitted in partial fulfillment of the requirements

for the degree of

BACHELOR OF TECHNOLOGY

in

CSE-ARTIFICIAL INTELLIGENCE & DATA SCIENCE

By

GROUP NO. 08

Mohit Sharma	0187AD211025
Nazil Sheikh	0187AD211028
Harsh Singh Rajput	0187AD211017

Under the guidance of

Prof. Ruchi Jain

(ASSISTANT PROFESSOR)

Department of CSE-Artificial Intelligence & Data Science
Sagar Institute of Science & Technology (SISTec) Bhopal (M.P.)

Approved by AICTE, New Delhi & Govt. of M.P.
Affiliated to Rajiv Gandhi Proudyogiki Vishwavidyalaya, Bhopal (M.P.)

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Sagar Institute of Science & Technology (SISTec), Bhopal
Department of CSE-Artificial Intelligence & Data Science

CERTIFICATE

I hereby certify that the work which is being presented in the B.Tech. Major Project-I Report entitled **Design and Development of Hair Strands Detection System using Image segmentation,** in partial fulfillment of the requirements for the award of the degree of ***Bachelor of Technology***, submitted to the Department of *CSE* with *Artificial Intelligence & Data Science*, *Sagar Institute of Science & Technology (SISTec)***,** Bhopal (M.P.) is an authentic record of my own work carried out during the period from July-2024 to Dec-2024 under the supervision of **Prof. Ruchi Jain (Assistant Professor)**.
The content presented in this project has not been submitted by me for the award of any other degree elsewhere.

Signature

Nazil Sheikh	***Mohit Sharma***	***Harsh Singh Rajput***
0187AD211028	***0187AD211025***	***0187AD211017***

This is to certify that the above statement made by the candidate is correct to the best of my knowledge.
Date:

Prof. Ruchi Jain **(Assistant Professor)**	**Dr. Vasima Khan** **HOD, CSE-AI&DS**	**Dr. D.K. Rajoriya** **Principal, SISTec**

ACKNOWLEGMENT

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ABSTRACT

In contemporary society, advancements in image processing and analysis are transforming numerous fields, including forensic science and personal care. To contribute to this progress, this project aims to design and develop a sophisticated Hair Strand Detection System (HSDS) using advanced image segmentation techniques. The proposed system integrates computer vision methodologies to effectively detect and segment individual hair strands from digital images, paving the way for applications in fields like forensic investigations, dermatology, and haircare.

The project's primary objective is to develop a robust and reliable HSDS capable of accurately detecting and segmenting hair strands in various image conditions. Leveraging computer vision and image processing techniques, the system will analyze image features to identify and isolate individual hair strands, addressing challenges such as background noise, overlapping strands, and varying lighting conditions. By utilizing image segmentation algorithms, such as convolutional neural networks (CNNs) and edge detection methods, the system will be trained to recognize and delineate hair strands with precision.

Additionally, the project aims to enhance the usability and practicality of the HSDS by integrating it into existing image analysis platforms. This includes designing an interface that allows users to upload images and receive detailed hair strand segmentation in real-time. The system will also offer options for visualizing and analyzing segmented hair strands, providing users with insights into characteristics such as density, length, and distribution.

The implementation of the HSDS will undergo rigorous testing to evaluate its performance across a range of image conditions and hair types. This will involve both controlled image environments and real-world testing to assess the system's accuracy in detecting hair strands and minimizing segmentation errors. Furthermore, user feedback will be collected to refine the system's functionality and usability, ensuring it meets the needs and expectations of professionals in relevant fields.

LIST OF ABBREVIATIONS

ACRONYM	FULL FORM
SDLC	Software Development Life Cycle
SQL	Structured Query Language
HTML	Hyper Text Markup Language
UML	Unified Modeling Language

LIST OF FIGURES

Chapter 1
Introduction

CHAPTER-1
INTRODUCTION

1.1 ABOUT PROJECT

The project arises from the recognition of increasing complexity in image processing, particularly in areas where precise object identification and analysis are essential. Image segmentation techniques offer a methodology to address this complexity by focusing on accurately identifying and isolating objects within an image. Concurrently, the growth of Data Science has expanded the possibilities for deriving insights and enhancing processes through data-driven analysis.

This project endeavors to bridge the gap between these two domains, aiming to create a symbiotic relationship between image segmentation techniques and data-driven insights. By combining segmentation principles with the analytical power of Data Science, the project seeks to improve the accuracy and relevance of hair strand detection within images, which has practical applications in fields like forensics, cosmetology, and digital imaging.

1.2 PROJECT OBJECTIVES

Domain Understanding: Conduct comprehensive research to gain a deep understanding of the field of hair strand detection, including its applications, challenges, and the stakeholders involved in using image segmentation for accurate hair detection.

Modeling Domain Concepts: Develop image segmentation models that effectively capture the essential features, structures, and patterns associated with hair strands in diverse image contexts.

Data Collection and Analysis: Gather relevant image datasets and apply data analysis techniques to uncover patterns, trends, and insights that can enhance segmentation accuracy and improve the performance of detection algorithms.

Integration of Domain and Data: Integrate image segmentation techniques and data insights into the detection system, ensuring that the resulting solution is both segmentation-driven and data-informed.

Validation and Feedback: Validate the effectiveness of the hair strand detection model through testing, user feedback, and iterative refinement to ensure accuracy and reliability in varied image contexts.

Documentation and Knowledge Sharing: Document the project findings, methodologies, and outcomes to facilitate knowledge sharing and future research at the intersection of image segmentation and Data Science.

Evaluation of Impact: Evaluate the impact of adopting segmentation and Data Science techniques on detection accuracy, system quality, and user satisfaction.

Through these objectives, the project aims to demonstrate the feasibility and benefits of combining Data Science practices with image segmentation techniques. It seeks to provide researchers and practitioners with methodologies to develop more robust, adaptable, and accurate hair detection models.

The complexity in image processing is a result of diverse image qualities, varying lighting conditions, and the intricacies of real-world scenes. Traditional approaches to object detection have often struggled to accurately capture fine details such as hair strands, leading to solutions that fall short of precision or adaptability.

Image segmentation offers a paradigm shift by advocating for an in-depth understanding of image structure, facilitating more precise identification of target elements. By focusing on the unique characteristics and patterns of hair strands, image segmentation enables the development of models that more accurately reflect the target detection domain.

Simultaneously, the rise of Data Science has transformed the way image data is analyzed to optimize and enhance detection performance. Techniques such as machine learning, statistical analysis, and predictive modeling have become crucial for achieving high accuracy in detection systems and for adapting solutions to diverse image conditions.

Recognizing the complementary nature of image segmentation and Data Science, this project seeks to leverage the strengths of both domains to address the challenges of modern Gimagebased detection. By integrating segmentation-driven techniques with data-driven insights, the project aims to create detection models that are not only technically robust but also aligned with the practical needs and complexities of the hair detection domain.

Moreover, this project is driven by a commitment to empirical validation and continuous improvement. Through rigorous testing, user feedback, and iterative refinement, we seek to ensure that the resulting detection models meet the highest standards of quality, usability, and accuracy.

In documenting our findings, methodologies, and outcomes, we aim to contribute to the expanding body of knowledge at the intersection of image segmentation and Data Science. By sharing our experiences and insights, we hope to inspire further research and innovation in this promising area.

Ultimately, the success of this project will be measured not only by the tangible outcomes achieved but also by the impact it has on the broader field of image processing. By demonstrating the feasibility and benefits of incorporating Data Science into segmentation-driven detection, we aim to equip researchers and practitioners with tools and methodologies to tackle the challenges of modern image detection tasks with precision and confidence.

Chapter 2
Software & Hardware Requirements

CHAPTER-2
SOFTWARE AND HARDWARE SPECIFICTAION

This chapter outlines the essential software and hardware components required for the successful implementation and deployment of the Hair Strand Detection using Image Segmentation project.

2.1 SOFTWARE REQUIREMENTS:

Integrated Development Environment (IDE): Utilize tools like PyCharm or Jupyter Notebook for efficient code writing, testing, and debugging of image segmentation algorithms.

Version Control System (VCS): Employ Git to manage project versions and facilitate team collaboration, ensuring traceability of changes.

Programming Languages: Python for its flexibility in image processing and machine learning, and SQL for managing any related data storage.

Data Analysis Libraries: Pandas and NumPy for data manipulation, and OpenCV for image processing tasks related to hair strand detection.

Machine Learning and Deep Learning Frameworks: TensorFlow, Keras, and Scikit-learn for building and training image segmentation models, with a focus on achieving high accuracy in hair strand detection.

Data Visualization Tools: Matplotlib and Seaborn for visualizing data distributions and analysis results.

Database Management Systems (DBMS): PostgreSQL or MySQL for reliable storage and retrieval of segmented images or related data.

Text Editors: Visual Studio Code or Sublime Text for quick code adjustments and script editing.

Virtual Environment Management: Anaconda or Virtualenv for creating isolated environments to manage project dependencies effectively.

2.2 HARDWARE REQUIREMENTS:

High-Performance GPU: A dedicated GPU, such as NVIDIA GTX 1080 or better, for accelerated training and processing of deep learning models for image segmentation.

Workstation/Desktop/Laptop: A powerful workstation or laptop with a high-performance CPU, at least 16GB of RAM, and SSD storage for efficient development and training tasks.

Networking Equipment: Router and Ethernet cables for stable network connectivity, particularly for remote collaboration or data transfer.

Input/Output Devices: Keyboard, mouse, and monitor for user interaction with computing resources during model training and testing phases.

Power Backup: Uninterruptible Power Supply (UPS) to prevent data loss and safeguard ongoing training sessions during power outages.

Cooling Systems: Adequate cooling, such as fans or liquid cooling systems, to maintain optimal temperatures, particularly during intensive GPU-based model training.

Cloud Services: AWS or GCP for access to scalable GPU resources and additional storage for large image datasets.

Internet Connectivity: Reliable broadband connection for accessing cloud resources, datasets, and collaboration tools.

Chapter 3
Problem Description

CHAPTER-3
PROBLEM DESCRIPTION

In this chapter, we delve into the specific issues within the domain of hair strand detection that our project aims to address. We provide a detailed description of the challenges faced in conventional methods of hair detection and the need for an automated and efficient solution through image segmentation.

3.1 CURRENT SCENARIO AND CHALLENGES

In this section, we paint a picture of the existing landscape of hair detection methods used in image processing. We highlight the limitations and shortcomings of traditional methods, such as manual segmentation by human operators or basic image processing techniques that struggle with precision in isolating fine hair strands. These approaches often lack accuracy, consistency, and scalability, making it challenging to achieve reliable results in diverse applications, including forensic analysis, cosmetology, and virtual try-on systems.

3.2 IMPORTANCE OF AUTOMATION

Here, we emphasize the importance of automating the hair strand detection process to improve accuracy and efficiency. We discuss the potential impact of automated hair detection on various fields, underscoring the benefits of precise and consistent segmentation techniques. By automating hair detection, we aim to streamline workflows, enhance the quality of image analysis, and enable more advanced applications, such as digital transformations in cosmetology and forensic science.

3.3 OBJECTIVES OF THE PROJECT

This section outlines the specific objectives that our project seeks to achieve in addressing the problem of hair strand detection. Our objectives include:

- Developing a robust and accurate hair detection system using advanced image segmentation algorithms.
- Leveraging machine learning and deep learning models to identify and segment hair strands in diverse image conditions.
- Providing an adaptable framework for hair detection that can be applied across various domains, such as forensics and digital cosmetology.
- Evaluating the effectiveness of the system through rigorous testing and validation on multiple datasets with varied hair types and backgrounds.

3.4 SCOPE OF THE PROJECT

Here, we define the scope of our project by outlining the boundaries and limitations within which we will operate. We specify the types of images targeted by our hair detection system, such as close-up hair images or full portraits, and the environments in which the system is intended to function, including forensic labs and cosmetology applications. Additionally, we highlight any constraints, such as hardware requirements or dataset limitations, that may impact the implementation and deployment of the system.

3.5 SUMMARY

To conclude the chapter, we summarize the key points discussed regarding the problem of hair strand detection, its significance in various fields, and the objectives and scope of our project. This chapter sets the stage for subsequent chapters, providing context and justification for the development of our automated hair strand detection system.

Chapter 4
Literature Survey

CHAPTER-4
LITERATURE SURVEY

Hair strand detection has progressed significantly, primarily driven by advancements in image segmentation techniques. Early methods focused on classical image processing, including edge detection and morphological operations, which provided initial success but were often limited by noise and background complexity [1]. Thresholding techniques, like Otsu's method, were similarly applied but struggled in non-uniform backgrounds [2].

With the rise of deep learning, convolutional neural networks (CNNs) such as U-Net have shown improved results by learning complex hair strand patterns, proving effective in diverse scenarios [3]. Generative Adversarial Networks (GANs) also gained traction, enabling high-quality segmentation even in challenging cases like overlapping hair strands [4]. Mask R-CNN, a popular instance segmentation model, further advanced hair strand detection by treating individual strands as unique instances, though it remains computationally intensive [5]. Hybrid methods combining classical feature extraction with deep learning models improved accuracy in backgrounds resembling hair color [6], and the use of attention mechanisms within CNNs has enhanced edge definition, especially where hair strands blend into the background [7].

Multi-scale processing methods address the challenge of varying strand size and orientation, further refining segmentation capabilities [8]. However, challenges such as real-time processing, variability in hair types, and overlapping strands remain, with future work aiming to develop more efficient and robust models.

Chapter 5
Software Requirement and Specification

CHAPTER-5
SOFTWARE REQUIREMENT AND SPECIFICATION

1. INTRODUCTION:

The Software Requirements Specification (SRS) outlines the functional and non-functional requirements of the Hair Strand Detection System using Image Segmentation. This document serves as a guide for software developers, designers, and stakeholders involved in the development process.

2. FUNCTIONAL REQUIREMENTS:

2.1. Image Acquisition:

The system shall acquire high-quality images from an imaging device or camera sensor.
It should support multiple image inputs for varied dataset analysis.
The captured images should have sufficient resolution to allow for precise hair strand segmentation.

2.2. Preprocessing:

Images shall undergo preprocessing to enhance quality and prepare them for segmentation.
Techniques such as resizing, normalization, and color adjustments shall be applied to ensure consistency across datasets.

2.3. Hair Detection and Segmentation:

The system shall detect hair regions within the images using advanced image segmentation algorithms.
It should accurately identify hair strands even under varied lighting and background conditions.

2.4. Feature Extraction:

Once hair regions are detected, the system shall extract specific features, such as strand density, thickness, and orientation.
Feature extraction techniques such as edge detection, contour analysis, or deep learning models shall be employed.

2.5. Classification and Analysis:

The system shall classify segmented hair regions based on specific attributes like color, texture, and length.
Analysis of extracted features will enable further applications, such as cosmetology, forensic analysis, or digital styling.

2.6. Output and Visualization:

The system shall provide visualized outputs highlighting detected hair regions and segmented strands.
Output formats may include annotated images or reports, depending on user requirements.

3. NON-FUNCTIONAL REQUIREMENTS:

3.1. Performance:

The system should process high-resolution images efficiently, with minimal latency, to provide timely and accurate segmentation results.
It should handle large datasets without significant performance degradation.

3.2. Accuracy:

The hair detection and segmentation algorithm should achieve high accuracy in identifying hair strands and avoiding background interference.

False positives/negatives should be minimized to ensure reliable operation.

3.3. Robustness:

The system should be robust against variations in lighting, image quality, and hair textures.
It should maintain effectiveness across different types of images, including close-ups and full portraits.

3.4. Usability:

The user interface should be intuitive and user-friendly, requiring minimal training for operation.
Outputs and visualizations should be clear and interpretable, facilitating user understanding of the segmentation results.

4. CONSTRAINTS:

4.1. Hardware Limitations:

The system's performance may be constrained by the processing power and memory of available hardware.
Camera sensors or imaging devices must provide adequate image quality and be compatible with the system's processing environment.

4.2. Regulatory Compliance:

The system should comply with relevant data privacy regulations, particularly regarding the handling and storage of image data.
For forensic applications, specific regulatory standards for data accuracy and quality may need to be adhered to.

5. DEPENDENCIES:

5.1. OpenCV Library:

The system relies on the OpenCV library for image processing and computer vision tasks. Compatibility with the latest version of OpenCV should be ensured to leverage new features and optimizations.

5.2. Python Programming Language:

Software development and implementation shall be done using the Python programming language.
Python libraries for machine learning, image processing, and data visualization will be utilized, including TensorFlow, Keras, and Scikit-learn for deep learning tasks.

Chapter 6
Software Design

CHAPTER-6
SOFTWARE DESIGN

6. SOFTWARE DESIGN

Software design is a crucial phase in the development process where the system architecture and components are structured to meet the specified requirements. This chapter outlines the design aspects of the Hair Strand Detection System using Image Segmentation.

6.1 Use Case Diagram

The Use Case Diagram illustrates the various interactions between users (actors) and the system. It identifies different use cases and describes how users interact with the system to achieve specific goals. In the context of the Hair Strand Detection System, the Use Case Diagram may include actors such as the user (e.g., cosmetologist, forensic analyst), imaging device or camera sensor, image processing module, and output/visualization component.

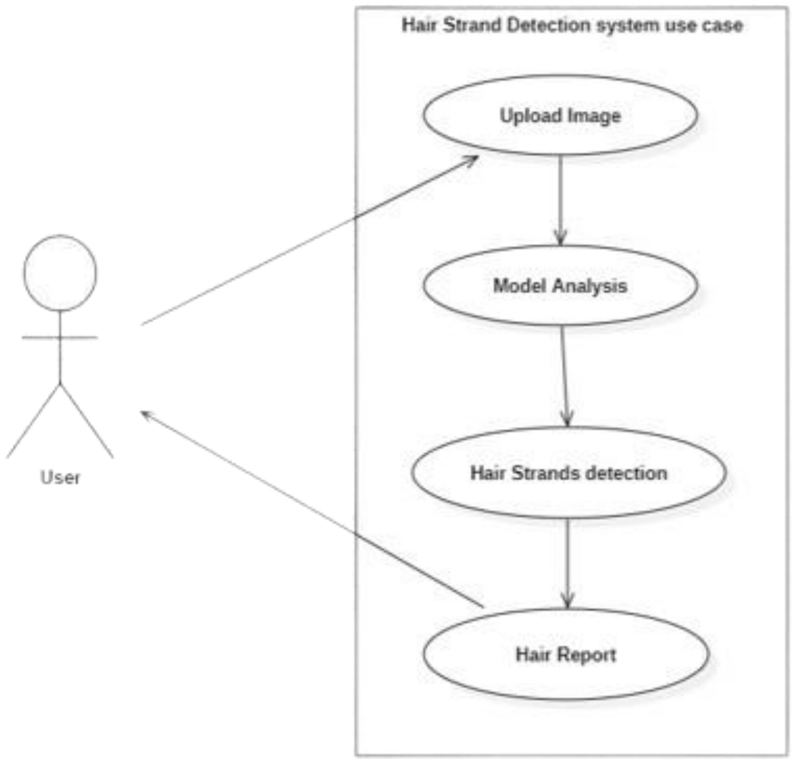


Figure 6.1 : Use Case Diagram

6.2 Data Flow Diagram (DFD)

The Data Flow Diagram (DFD) provides a visual representation of how data flows through the Hair Strand Detection System. It illustrates the processes, data stores, and data flows within the system, highlighting the transformation of data at each stage. In the context of the Hair Strand Detection System, the DFD may depict the flow of data from the imaging device or camera sensor to the preprocessing module, hair detection and segmentation process, feature extraction, and output visualization or report generation.

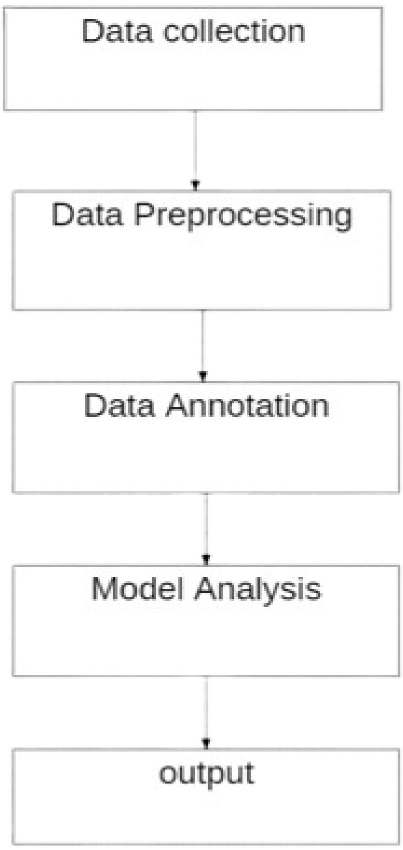


Figure 6.2 : Data Flow Diagram

Chapter 7
Machine Learning Module

CHAPTER-7
MACHINE LEARNING MODULE

7.1 DATASET DESCRIPTION

The dataset for the Hair Strand Detection System project was sourced from a reputable dermatology and trichology clinic in India. High-resolution hair images were collected from a diverse range of patients, representing various hair types, scalp conditions, and demographics. This clinical data was gathered under controlled lighting and imaging conditions to ensure clarity and consistency across images, which is crucial for reliable model training and segmentation tasks.

The dataset includes images from patients with different hair densities, lengths, and textures, such as straight, wavy, curly, and coiled hair types, capturing both common and uncommon hair characteristics. Additionally, it contains images of various scalp conditions, allowing the model to distinguish between healthy and affected areas. This diversity enables the model to generalize well to different hair and scalp conditions, making it suitable for practical application across a wide population.

7.2 PRE-PROCESSING STEPS

To ensure the dataset's quality and suitability for training, several pre-processing steps were applied:

Image Resizing: All images were resized to a uniform resolution, optimizing them for model input requirements and ensuring consistency across training data.

Normalization: Pixel intensity values were normalized to reduce variance in lighting, which enhances the model's focus on essential features such as hair strands and scalp texture.

Data Augmentation: Techniques like rotation, flipping, and zooming were applied to increase dataset diversity, helping the model handle different hair angles and conditions.

Annotation: Each image was carefully annotated to label hair strands, scalp areas, and other regions of interest. This annotation was crucial for training the model to distinguish between hair strands and other elements.

7.3 DATA VISUALIZATION

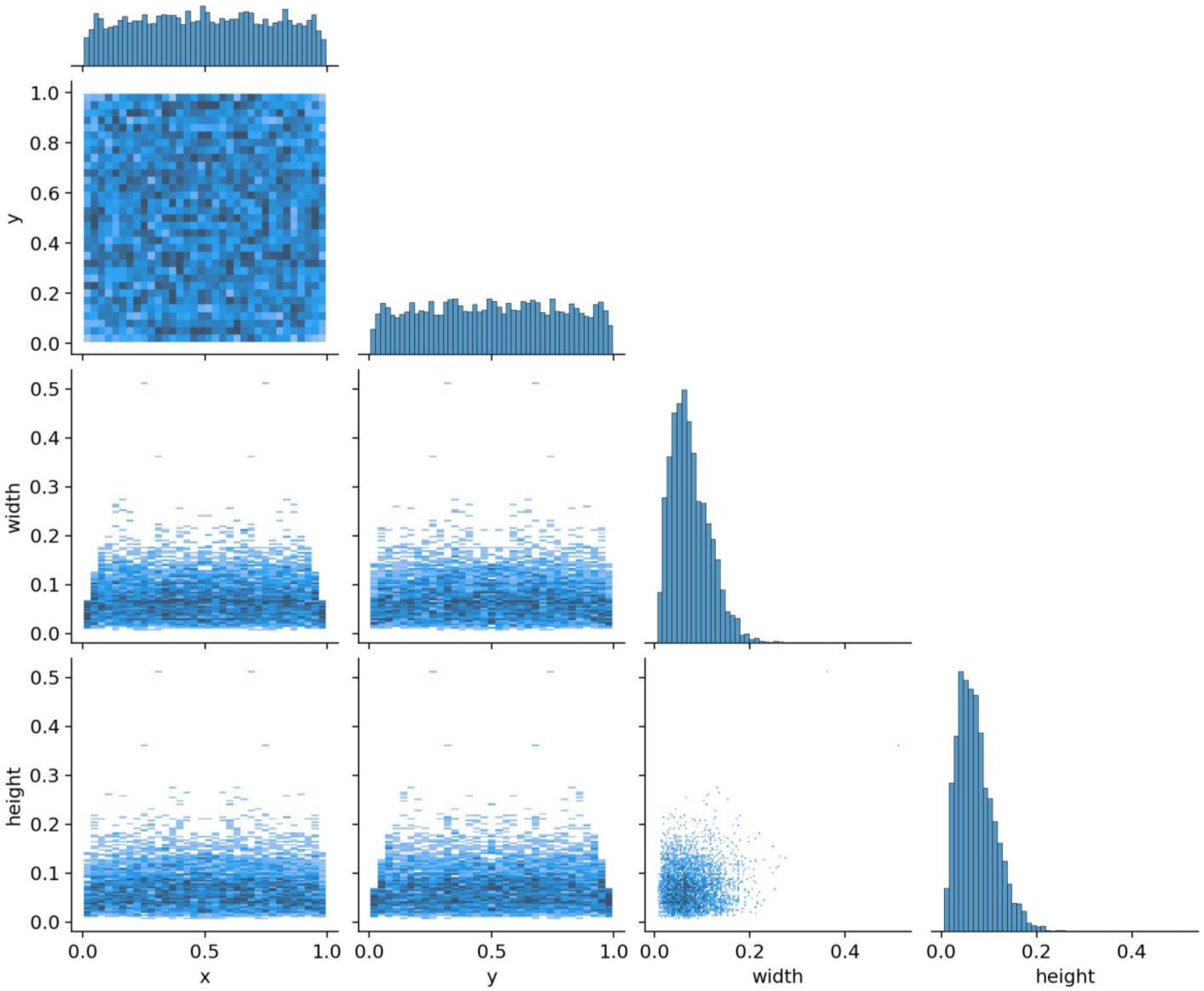


Figure 7.1 : Pair plot

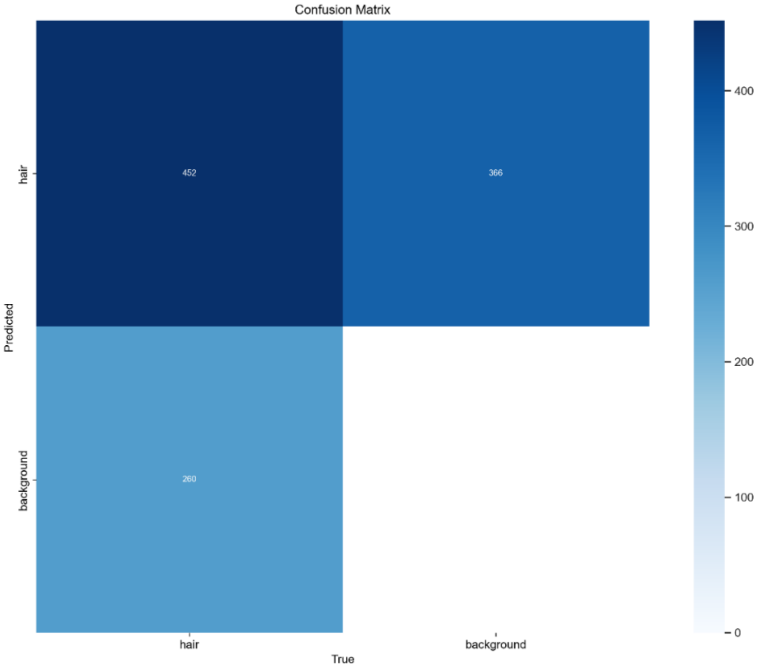


Figure 7.2 : Confusion Matrix

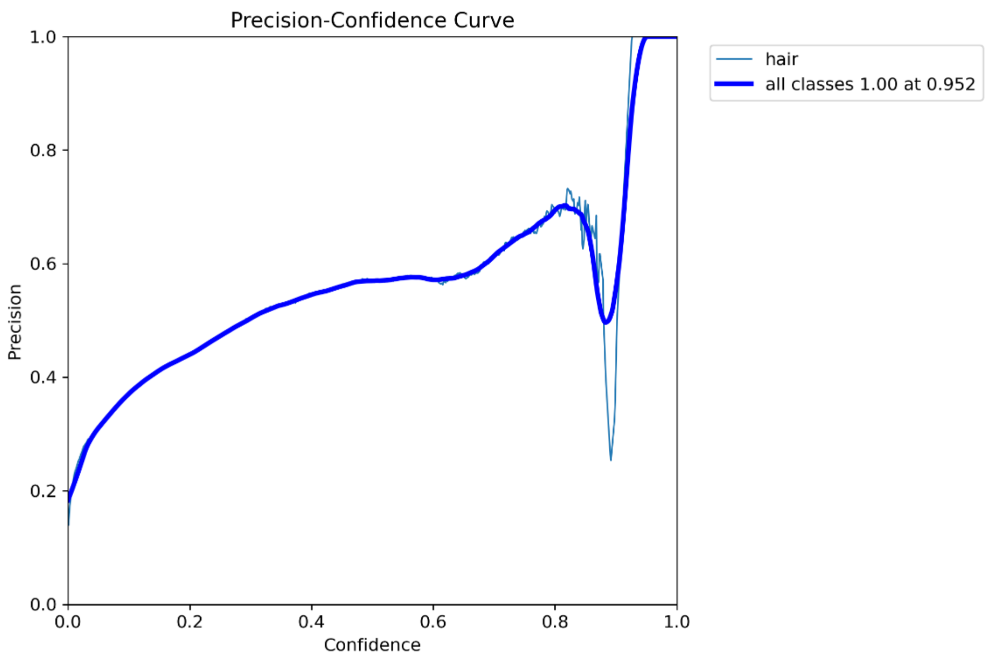


Figure 7.3 : Mask P curve

7.4 ML MODEL DESCRIPTION

For this project, we employed YOLOv11l-segment, a pre-trained model known for its high performance in object detection and segmentation tasks. YOLOv11l-segment, an advanced version of the YOLO (You Only Look Once) family, provides a strong balance between speed and accuracy, making it well-suited for real-time applications. Its segmentation capabilities allow it to identify and separate individual hair strands and regions of interest with high precision, which is essential for our purpose of detecting and analyzing hair features effectively.

The choice of YOLOv11l-segment as the backbone model was based on its adaptability to various detection tasks and its capability to handle complex image segmentation challenges. By fine-tuning this pre-trained model on our clinical hair dataset, we aimed to enhance its ability to detect even subtle features, such as thin hair strands or dandruff particles, under diverse conditions..

7.5 MODEL WORKFLOW

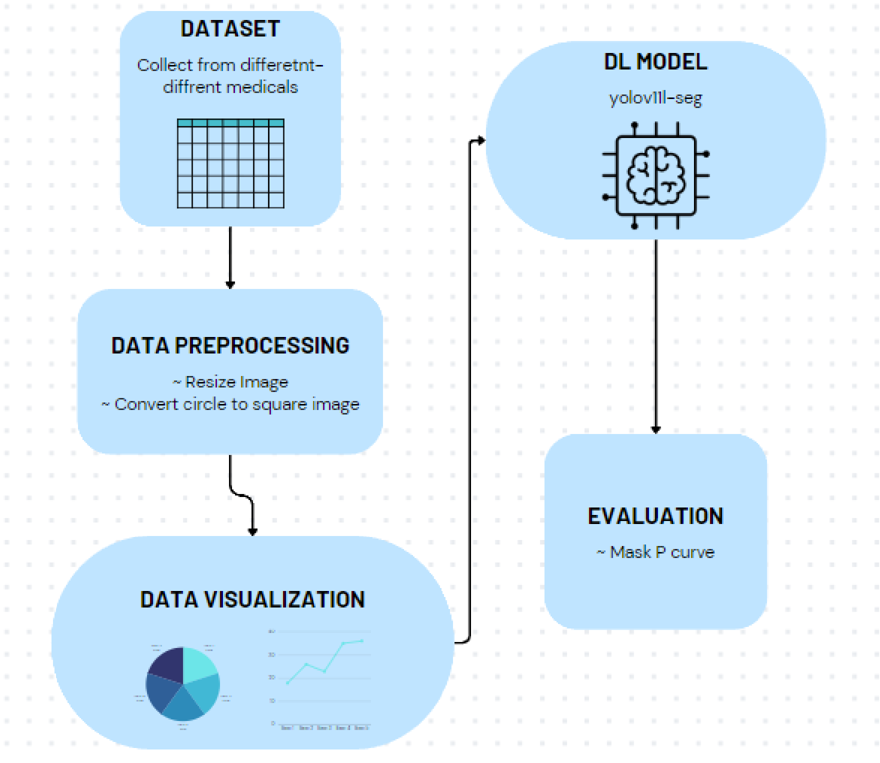


Figure 7.4 Model Workflow

Chapter 8
Front End connectivity

CHAPTER-8
FRONT-END CONNECTIVITY

8.1 STEPS OF FRONT-END CONNECTIVITY

1. HTML Structure & Layout: The HTML defines the layout for the Hair Strand Segmentation tool, including sections for navigation, an image upload feature, and an about section. CSS (in "styles.css") is used to style the layout.

2 Image Upload & Preview: A file input element is triggered by a button to allow users to upload an image. Once an image is selected, the previewImage JavaScript function reads the file and displays a preview of the image on the page.

3 Predict Button & Request Handling: After uploading, a "Predict Segmentation" button appears. When clicked, the predictSegmentation function is triggered, which prepares the image file data in a FormData object.

4 Data Transfer to Backend (Flask Server): The image file is sent to the backend Flask server (http://localhost:5000/detect) through a fetch API POST request for processing.

5 Displaying Results: Once the server returns a response containing the segmented image and hair width data, the JavaScript updates the image preview with the processed image and displays details about hair width measurements on the page.

6 Error Handling: If there’s an issue with the segmentation request or response, an alert is shown, informing the user to try again.

Chapter 9
Future work

CHAPTER-9
FUTURE WORK

8.1 INTRODUCTION

In this chapter, we explore potential avenues for future enhancements and developments in the Hair Strand Detection System (HSDS). By identifying areas for improvement and novel research directions, we aim to advance the capabilities and effectiveness of the HSDS in accurately detecting and analyzing hair strands. Future enhancements may include integrating additional imaging modalities, enabling real-time processing, and employing advanced deep learning models to improve accuracy. Additionally, expanding the system's functionality to support scalp health analysis represents a valuable opportunity for dermatological applications.

8.2 INTEGRATION OF ADDITIONAL IMAGING MODALITIES

One direction for future work involves the integration of additional imaging modalities beyond the trichoscope currently used in the HSDS. Incorporating devices such as multispectral or polarized imaging tools could provide complementary data, enhancing the detection of finer hair strands and improving segmentation accuracy under varying hair types and conditions.

8.3 REAL-TIME PROCESSING AND ANALYSIS

Enhancing the HSDS to enable real-time processing and analysis represents a promising area for development. Implementing real-time segmentation capabilities would allow immediate visualization and assessment, enabling users to obtain instant feedback for applications such as dermatological assessments.

8.4 ADVANCED DEEP LEARNING MODELS

Future iterations of the HSDS could benefit from advanced deep learning models and techniques. Exploring architectures such as transformer-based models or generative adversarial networks (GANs) could enhance segmentation accuracy, particularly in challenging conditions such as overlapping strands or varying lighting. Fine-tuning these models with larger and more diverse datasets could improve robustness.

8.5 CONCLUSION

The future work outlined in this chapter underscores the potential for continued refinement and expansion of the Hair Strand Detection System. By leveraging advancements in imaging technologies, deep learning, and additional detection capabilities, researchers can enhance the system’s accuracy, adaptability, and practical usability, thereby broadening its impact and effectiveness.

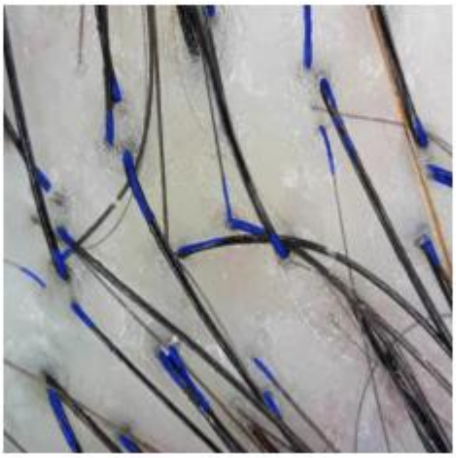
Chapter 10
Coding

CHAPTER-10
Coding

```
import torch
from ultralytics import YOLO
import os

# Set the environment variable to reduce memory fragmentation
os.environ['PYTORCH_CUDA_ALLOC_CONF'] = 'expandable_segments:True'

# Clear CUDA cache
torch.cuda.empty_cache()

# Load the model from the last checkpoint
model = YOLO('yolo11l-seg.pt')  # Update this path to your actual
checkpoint file



# Set training parameters
epochs = 50  # Total number of epochs
imgsz = 640  # Image size
batch_size =8  # Adjust batch size if needed to avoid out of memory error
use_half_precision = True  # Enable mixed precision training to save
memory

# Train the model with the provided data
model.train(
    data='Hair-strands-segmentation-6\data.yaml',  # Path to your data
conFigurefile
    epochs=epochs,
    imgsz=imgsz,  # Reduce this if you still face memory issues (e.g.,
imgsz=512 or 320)
    task='segment',
    batch=batch_size,  # For gradient accumulation
    half=use_half_precision  # Enable mixed precision (FP16) for lower
memory usage
)

# Clear the model and cache after training to free GPU memory
del model
torch.cuda.empty_cache()

from ultralytics import YOLO
import matplotlib.pyplot as plt
import cv2
import os
```

```python
# Load the trained model
model = YOLO(r'runs\segment\train71\weights\best.pt')

# Set the image path
image_path = r'Dataset\images\1518.jpg'

# Run the model prediction
results = model.predict(
    source=image_path,
    conf=0.3,
    iou=0.2,
    save=True,
    show_boxes=False,
    imgsz=1024,
    retina_masks=True,
    agnostic_nms=False,
    task='segment'
)

# Load and display the predicted image
predicted_image_path = os.path.join(results[0].save_dir, '1518.jpg')  # Get the path of the saved predicted image
predicted_image = cv2.imread(predicted_image_path)  # Load the predicted image
predicted_image = cv2.cvtColor(predicted_image, cv2.COLOR_BGR2RGB)  # Convert to RGB for Matplotlib

# Show the image in the notebook
plt.figure(figsize=(3, 3))
plt.imshow(predicted_image)
plt.axis('off')
plt.show()
```

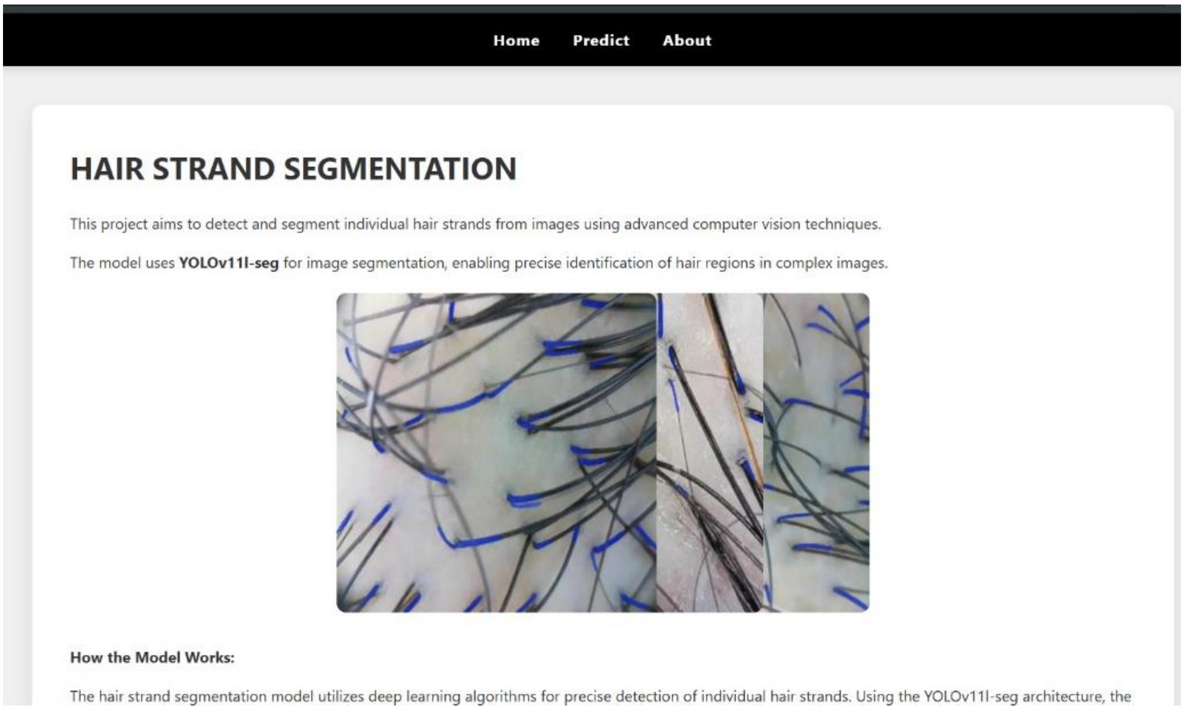
```
image 1/1 c:\Users\PROFESSOR\Desktop\Mohit\SM-INTERNSHIP\hair-strand-model-api\Dataset\images\1518.jpg: 1024x1024 28 hairs, 157.0ms
Speed: 10.1ms preprocess, 157.0ms inference, 0.0ms postprocess per image at shape (1, 3, 1024, 1024)
Results saved to runs\segment\predict247
```



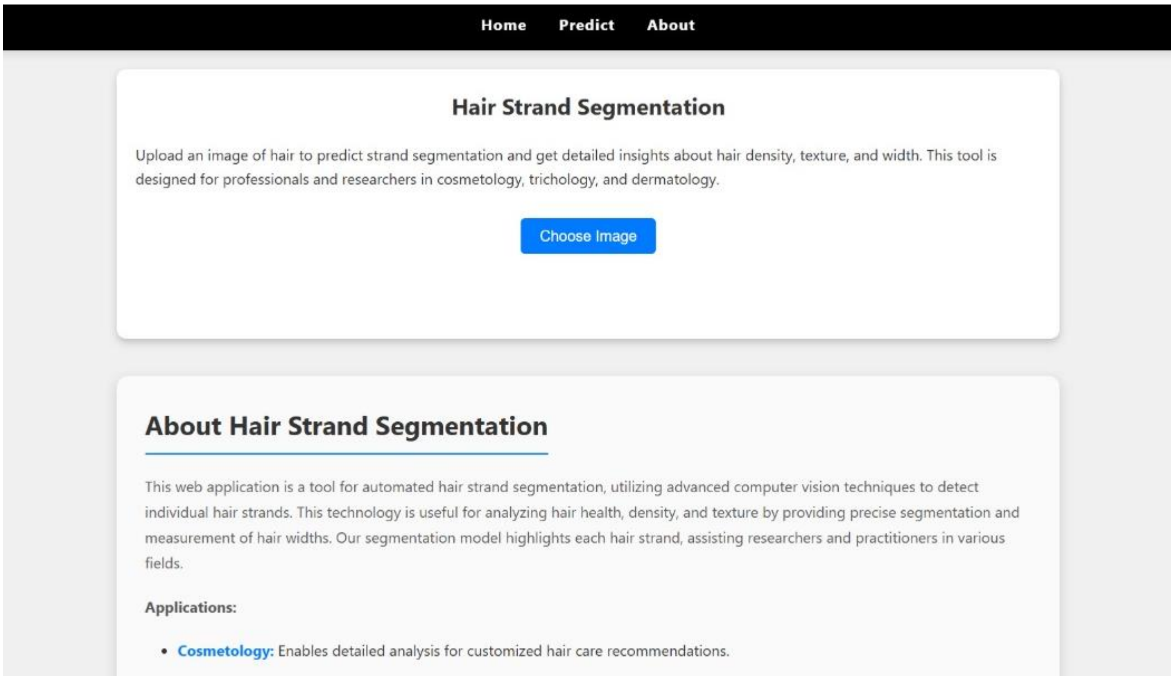
Chapter 11
Output Screens

CHAPTER-11
Output Screen

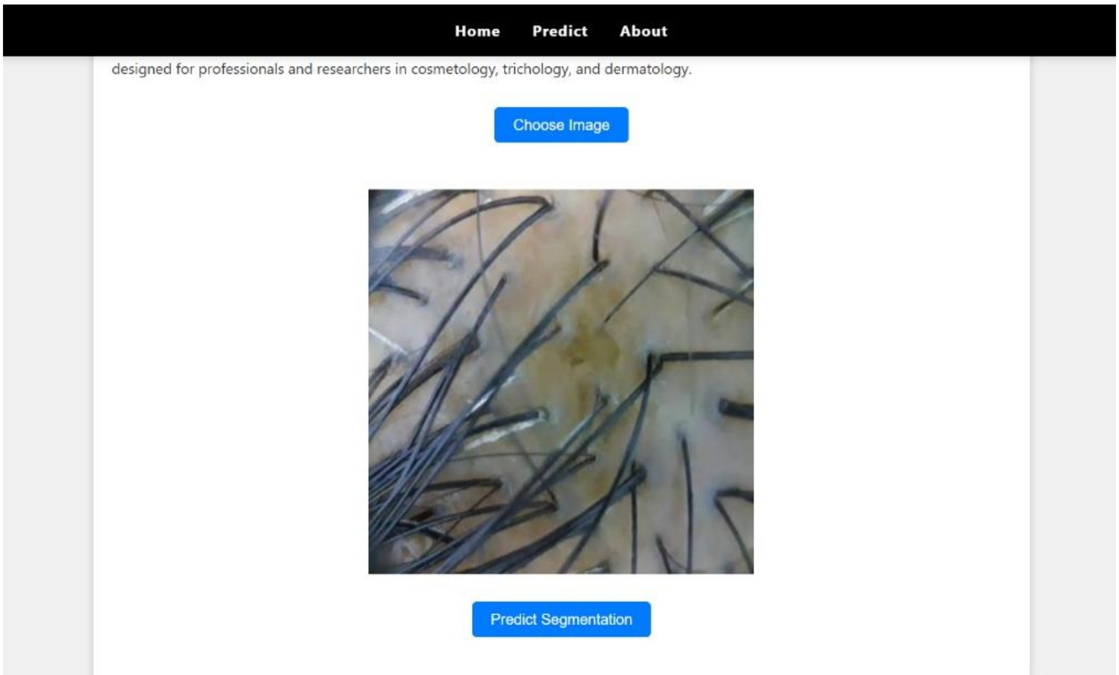
1- HOME PAGE



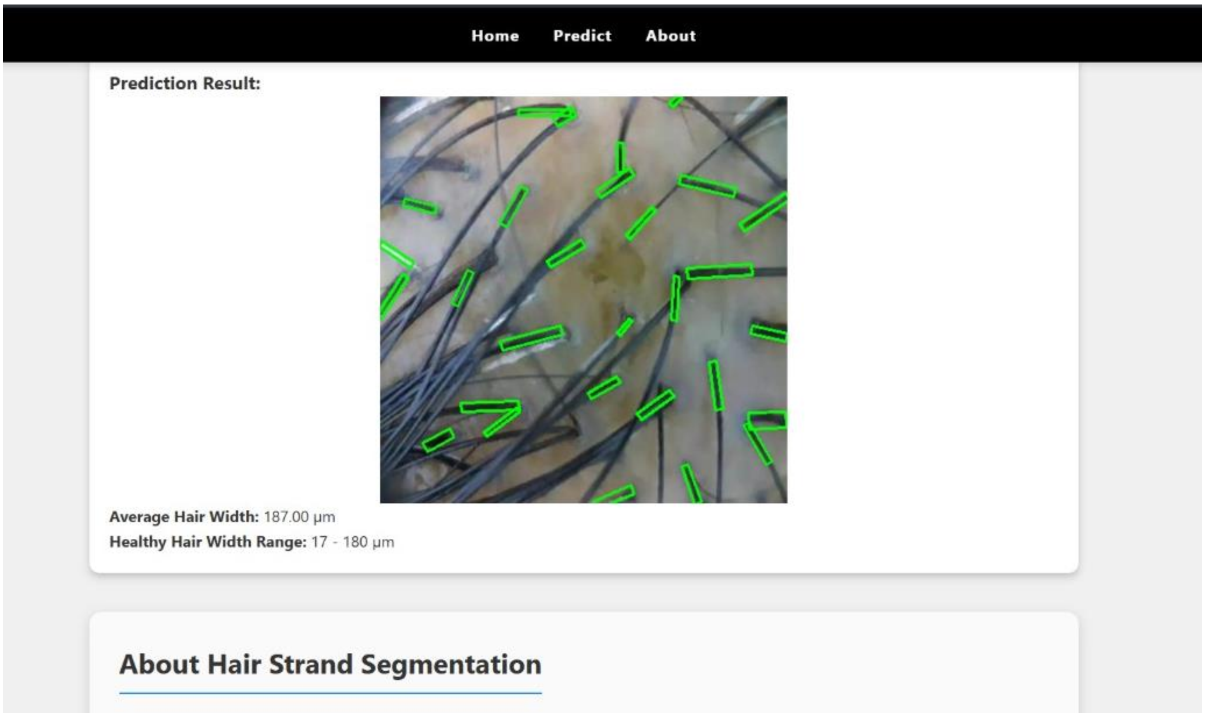
2- PREDICT PAGE



3- INPUT SECTION



PREDICTED IMAGE



REFERENCES

[1] Lee, H., Lee, J., & Kim, S. (2004). Hair segmentation method using edge detection and morphological processing. IEEE Transactions on Image Processing.

[2] Otsu, N. (1979). A threshold selection method from gray-level histograms. IEEE Transactions on Systems, Man, and Cybernetics, 9(1), 62-66.

[3] Chen, X., Wang, Y., & Li, Z. (2017). Hair segmentation using U-Net. Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition.

[4] Zhang, T., Zhang, H., & Xu, Y. (2018). High-quality hair strand segmentation with GANs. IEEE Transactions on Multimedia.

[5] He, K., Gkioxari, G., Dollar, P., & Girshick, R. (2017). Mask R-CNN. Proceedings of the IEEE International Conference on Computer Vision.

[6] Zhu, S., Lu, W., & Yu, X. (2020). Hybrid approach for hair strand segmentation. Pattern Recognition Letters.

[7] Lu, C., Ma, Q., & Sun, R. (2022). Attention-based hair segmentation network. IEEE Access.

[8] Li, Y., Chen, X., & Liu, Q. (2023). Multi-scale hair strand detection network. IEEE Transactions on Pattern Analysis and Machine Intelligence

APPENDIX-1 GLOSSARY OF TERMS

B	
Bias in Data	Unintended patterns in the data that can affect the model's predictions, often requiring mitigation during preprocessing to avoid skewed results.
D	
Data Collection	The process of gathering relevant data (such as high-resolution images from a trichoscope) for training the hair strand detection model.
Data Preprocessing	Cleaning and preparing the raw image data to ensure its quality and suitability for the deep learning model’s training.
Deep Learning	We used YOLO pre-trained model
F	
Feature Engineering	Feature Engineering: The process of selecting and creating relevant features from the dataset (such as specific pixel patterns or textures in hair images) to improve the model's predictive accuracy.
Feature Extraction	The technique used in image processing to extract relevant information from raw data (e.g., detecting individual hair strands) for use in deep learning models.
H	
Hosting Environment	The platform or cloud service (such as AWS or Google Cloud) where the trained model and the

	hair strand detection system will be deployed
M	
Model Evaluation	The process of assessing the performance and accuracy of the deep learning model using various metrics, such as precision, recall, and F1-score, specifically in hair strand detection.
Monitoring and Maintenance	A plan for continuous monitoring and upkeep of the model, ensuring the system remains accurate and efficient over time, particularly when handling real-world data.
S	
Scalability	The system's ability to process a growing number of hair strand images and adapt to increasing amounts of data without significant performance degradation.
Segmentation Mask	A binary image used to represent the areas of interest, in this case, the regions of hair in the input image, for model training and analysis.
U	
User Interface	The graphical interface that allows users to interact with the hair strand detection system, such as uploading images for analysis or viewing segmentation results.
V	
Version Control	The practice of tracking changes made to code, models, and other project files, often using tools like Git, to ensure proper management of project development and updates.

Appendix 2 – PROJECT SUMMARY

About Project

Title of the project	Design and Development of Hair strands Detection System using image segmentation
Semester	7
Members	3
Team Leader	Mohit Sharma
Describe role of every member in the project	**Mohit Sharma -** is responsible for training the deep learning model for the Hair Strand Detection System, focusing on developing and fine-tunning **Nazil Sheikh -** is responsible for sourcing and preparing the dataset required for training the Hair Strand Detection System, including gathering high-resolution images of hair strands for segmentation and annotation. **Harsh Singh Rajput -** create a functional system for hair strand detection and analysis.
What is the motivation for selecting this project?	The motivation for selecting the Hair Strand Detection System project stems from the growing need for advanced technologies in the fields of dermatology, hair care, and cosmetic industries. Accurate and automated analysis of hair strands can significantly enhance diagnostic procedures, improve personalized hair treatment recommendations, and provide a non-invasive approach to monitor hair health
Project Type **(Desktop Application, Web Application, Mobile App, Web)**	Web Application

Tools &Technologies

Programming language used	Python
Interpreter used	Python (above 3)

IDE used	Jupyter Notebook 7.1.2

Project Requirements

MVC architecture followed **(Yes / No)**	No
If yes, write the name of MVC architecture followed **(MVC-1, MVC-2)**	
Design Pattern used **(Yes / No)**	No
If yes, write the name of Design Pattern used	
Interface type **(CLI / GUI)**	GUI
No. of Actors	1
Name of Actors	User

Testing

Which testing is performed? **(Manual or Automation)**	Automation
Is Beta testing done for this project?	NO

Write project narrative covering above mentioned points

The motivation for selecting the Hair Strand Detection System project arises from the increasing demand for advanced technologies in dermatology, hair care, and cosmetic industries. Hair health is an essential aspect of personal well-being, and accurate, automated analysis of hair strands offers great potential for improving diagnosis, treatment, and consumer experiences. Traditional hair analysis methods often rely on manual inspection, which can be time-consuming, subjective, and limited in scope. This project aims to leverage deep learning and image segmentation techniques to develop an innovative system for real-time detection and analysis of hair strands. By doing so, it will enable more precise and objective monitoring of hair conditions, such as thinning, breakage, and scalp health. The system could be particularly beneficial in both medical and cosmetic settings, helping dermatologists, hair specialists, and even individuals to detect early signs of hair-related issues and implement personalized treatments.

Mohit Sharma	Nazil Sheikh	Harsh Singh Rajput	Guide Signature
0187AD211025	0187AD211028	0187AD211017	Prof. Ruchi Jain