c7297990_Ayush_Thapa_Final_Year_Report

by Ayush Thapa

Submission date: 26-May-2024 08:00PM (UTC+0545)
Submission ID: 2388426263
File name: Final_Year_Report.docx (10.05M)
Word count: 11148
Character count: 60546

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Module name: Production Project

Module run: 23/24

Coursework title: Magic Mirror: Reflect your Hairstyle

Due Date: 2024/05/26

Module leader: (In LBU)

Module Supervisor: (In TBC) Sukant Kumar Sahu

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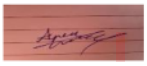
Signed:  Date: 2024/05/26

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Magic Mirror: Reflect your Hairstyle

Name: Ayush Thapa

University Id: c7297990

Level: 6

Sem: II

Subject: Production Project

Supervisor: Sukant Kumar Sahu

Abstract

Hairstyle one of the most important features for a person's physical appearance and plays an important role in person's self-expression and confidence. Choosing a suitable hairstyle mainly depends on the person's face shape, as different hairstyle suits different face shape which highlights the features of the face. This project aims to build a web application that identifies user's face shape with two approaches: SVM and Rule-based to classify the face shape of a person and recommend suitable hairstyles based on the identified face shape. Django was used to build the web application, as it provides user-friendly interface for image capture and upload and three SVM with different kernels of linear, radial basis function (RBF) and polynomial were compared and the best out of them was used. Additionally, a rule based was also create to identify the face shape. This allowed for comparative analysis for machine learning and rule-based approach. After comparison between SVM, RBF was selected with the accuracy of 98% while rule based had only accuracy of 20%.

Student Declaration

I, Ayush Thapa, hereby declare that the work presented in this document, titled "Magic Mirror: Reflect your hairstyle." is entirely my own effort, unless otherwise acknowledged. This work has been prepared in fulfillment of the requirements for BSc (Hons) Computing at Leeds Beckett University, under the supervision of Mr. Sukant Kumar Sahu.

I acknowledge that:

Any assistance I received in the preparation of this work and the sources from which such assistance was obtained are acknowledged within this document.

All primary sources of information have been cited appropriately within the text and listed in the bibliography.

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Date: 2024/05/26

Ayush Thapa

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BSc (Hons) Computing

Leeds Beckett University

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List of Abbreviations

Support Vector Machine: SVM

Rule Based System: RBS

Machine Learning: ML

Artificial Intelligence: AI

OpenCV: Open-Source Computer Vision Library

Acknowledgement

I would like to express my sincere gratitude to Teacher Sukant Kumar Sahu, my project supervisor and advisor, for his invaluable guidance and support throughout this project. His insightful feedback and encouragement were instrumental in shaping my research and ensuring its quality. I am also grateful to The British College for providing the resources and facilities necessary for this research.

Finally, I am grateful to my family and friends for their unwavering support and encouragement throughout my undergraduate studies. This project would not have been possible without them.

1. Introduction

In today's fashion world, hairstyle has become a significant form of self-expression and individuality, however choosing the right hairstyle that suits one's facial feature can be difficult task, often requiring the expertise of a professional stylist so, this project aims to create web application to help user to identify their face shape and provide recommendation on hairstyle based on their face shape. Utilizing both SVM and RBS for face shape detection, this application combines ML to offer user with smooth and interactive experience.

1.1 Background

Hairstyle, one of the way people express personal style, creativity and individuality. For some people, it's a form of self-expression and help people to boost their confidence and self-esteem, while others use it to stand out from the crowd. Some hairstyles like braids and buns can help to keep the hair out of the way during working physically. The increase of fashion has caused the rise in taking and beautifying hair and according to experts, a person needs proper hairstyle based on their face shape.

Face shape is crucial factor in determining the hairstyle for a person, different face shape require specific haircuts and styles to balance proportions, show the feature and create a visually appealing look, certain hairstyle look better with specific hairstyles like round face benefits from hairstyles that add height and length like pompadours hairstyles and square faces looks great with soft and layered cuts that soften the angles. Choosing the right hairstyle can enhance the best feature and minimize the less desirable ones for the user like user with round face shape can use bangs to cover their forehead, different hairstyle without considering face shape can result in unflattering look and a hairstyle which suit one may not suit person with different face shape. So, face shapes are extremely important to identify the best hairstyle suitable for a person.

Before the advancement in computer vision and machine learning, people used to manually determine the face shape and hairstyle, which required the expertise of stylist, but now with advancements in computer vision and machine learning techniques, the way of approaching this problem has changed, many domain of fashion and beauty use this new cutting edge-technology to automate the process of face shape detection and hairstyle recommendation making it more accessible and convenient for a user to find the perfect hairstyles for their unique facial features.

The web application used two techniques for face shape detection:

SVM: Supervised ML algorithm that classifies data by finding an optimal line that maximizes the distance between each class in a N-dimension space.

RBS: System that uses rules as the basis for making decisions or solving problems.

1.2 Objectives

The main objectives of this project are:

1) Develop a web application to allow people to predict their face shape and recommend hairstyles based on face shape.
2) Integrate Database containing wide range of hairstyle suitable for different face shape.
3) To implement and compare two different methods, SVM and RBS -for detecting face shape.

1.3 Scope

The scope of this project includes:

1) Developing user friendly web interface for uploading image or capturing image with webcam and displaying result
2) Implement of SVM and RBS for face shape detection

3) Integration of Databased of hairstyle recommendations on basis of different face shapes
4) Providing detailed documentation and analysis of the methodologies and results.

This project only covers this scope and doesn't look into more complex image processing of facial expression analysis or removal or effect off accessories like glasses or hats on face shape detection.

1.4 Structure of Report

The structure of report is organized with introduction providing an overview of the project, including background, objective and scope, while literature review discusses the previous work and research on the field of hair recommendation and face shape. The methodology section describes the technical approach used for this project and implementation give detail on how those technical approach was used to implement in the web application to make this app, after that the results are discussed along with the performance of those approaches and challenges encountered, and the report is concluded with a summarization of the project and direction for future work.

2. Review of Literature

There are several previous works which have been studied in the field of hairstyle recommendation based on face shape. Many researches have published various papers, for each different components which are required to predict the face shape and find the hairstyle based on that.

2.1 Face Shape Detection

Face shape detection is crucial in personalizing hairstyle recommendations. The ability to accurately determine the shape of a face allows to get best suggestion

that can enhance a person's physical appearance. Various methodologies have been used over the years to identify face shape, ranging from manual measurements to advanced machine learning techniques.

Traditional methods relied in hand-crafter features, such as edges and texture descriptors, combined with machine learning like PCA, LDA or SVM, Recently they have been rise in deep learning method based on CNN, as it can be trained with large dataset to learn best feature to represent the data (Trigueros et al., 2018).

2.2 Facial Feature Extraction Techniques

According to (Berkay Yilmaz et al., 2012), facial feature like eye corners, lip corners and nose tips are important in a human face and it is important to have a robust extraction for such facial features to use in wide range of applications, so they purposed a probabilistic framework and several methods which can help to extract theses points using both location and texture information. The principle of this framework is to maximize the joint distribution of location and texture parameters and these are achieved with multi-variate Gaussian and Gaussian mixture model. Also proposed a multi-candidate coordinate ascent search and a coarse-to-fine search strategy which depends on efficiently searching among multiple candidate points. The result show that this method outperforms the AAM-API implementation of AAM method and STASM implementation of ASM method for the same experimental setup.

Human facial traits and low-dimensional feature were extracted using orthogonal linear discriminant analysis (OLDA), and this was proposed by (Jung et al., 2016). This proposed feature, relies on a local binary pattern to represent texture information and random fern to build a structural model, it achieves a high-dimension description of input image by concatenation its feature vector. This method demonstrates, a higher recognition rate and low computational complexity compare to existing FR methods.

(Shlens, 2014) talks about how PCA, has widespread applications as it reveals simple underlying structure in complex data sets using analytical solutions from linear algebra, its importance comes from quantifying the importance of each dimension for describing the variability of dataset. PCA has a limit as it requires some each data must be perpendicular to previous, but the requirement is strict and data might be arranged along non-orthogonal axes.

2.3 Face Shape Classification

(Hossam et al., 2021) paper, represents a comparative study of different supervised learning algorithm used in face shape classification, and these classifications were based on extracted facial features for the different face shapes, classification models like KNN, SVM, MLP, RF, AdaBoost and Naïve Bayes were used. The dataset use was around 5000 images of female celebrities. Here different face shape characteristics were defined and all the facial feature were extracted with 68 facial landmarks library, then all the supervised ML were used to find the best model. The result showed the highest accuracy was achieved by SVM classifier with radial basis function kernel with overall accuracy of 82%.

(Sarakon et al., 2014) proposed a non-contact method to classify the face shape by using SVM techniques, these consisted of three steps of head segmentation, face plane identification and face shape classification. 3D data is captured and used as input, then eigenvector is used to define the frontal side then for head segmentation, chin neck junction, ellipsoid fitting techniques and mahala Nobis distance are combined to segment the 3D head, then face shape ca be observed when projected on a plane then are classified into different face shape, its accuracy rate is 73.68% and it also has an advantage that it is fully automatic and non-contact face shape classification for whole 3D human body data.

(Rifat et al., 2023) presents a pipeline to recommend eyeglasses based on the form of eyes using multiple transfer learning architecture to predict face shape from a given image, Inception V3, Inception V4, Vit Small, Dense Net, ResNet50

and VGG16 were utilized to predict the face shape from the images. Around 5500 photos with different face shape were used dot this experiment from Kaggle and GitHub, the data were merged, and split for train, test and validate on ration of 8:1:1 and run on these different models to select the best model for predicting face shape. The models used the fixed hyperparameters of image width, image height, Epochs, Batch size, Learning size, Mean, STD, Criterion, Optimizer. The inception V4 achieved the best accuracy with the test accuracy of 75.27% and test loss of 0.85, and during training it achieved accuracy of 91.77% and train loss of 0.23 and 68.18% on validation and loss of 1.19.

2.4 Existing Hairstyle recommendation Systems

(Sunhem et al., 2016) presents a paper for hairstyle recommendation system for women based on hairstyle experts' knowledge and face shape classification, in this paper, the face was classified by collecting various data of face image which were labelled and of different face shape, then the facial feature from the images were extracted using AAM and color-based face segmentation techniques. AAM was used to find feature points of face, eyes, mouth and eyebrows while color-based was applied to find a point which separated a forehead and a hair, then used with models like SVM, ANN, LDA and according to result, SVM with radial basis function kernel (RBF) was found to be best algorithm.

(Liu et al., 2019) proposes the overall design and implementation of the hair recommendation System Based on Face recognition platform, it considers the hair length, hair volume, face shape and other factors through the camera to achieve parameter acquisition, face recognition, facial features sampling for hairstyle recommendations and solve the problem of people not being able to get their face shape correctly, this system incorporates a scoring recommendation algorithm, which can recommend the appropriate hairstyle to the user according to the current aesthetic priority. This project proposed the hairstyle recommendation algorithm by studying the relationship between facial features and hairstyles, firstly the data were collected, the images were processed, the

feature extracted then hairstyle were recommended according to recommendation algorithm and face is combined with recommended hairstyle to obtain the face after the hairstyle is replaced. This still has some problem in recommendation algorithm as it didn't factor hair volume and hair quality and some distortion on the face after hair is replaced.

2.5 Summary of Literature Review

The literature indicates significant improvement and progress in the field of face shape detection and hairstyle recommendations. Traditional methods were able to lay the groundwork for the modern approaches. Recently. Deep learning approaches, particularly CNN has improved accuracy using best feature from large datasets.

Facial feature extraction techniques like locating eye corners, lip corners and nose tips are important for face shape analysis. Probabilistic frameworks using Gaussian mixture models can robustly extract these key points by considering both location and texture information. Othe methods like orthogonal linear discriminant analysis (OLDA) and random fern has also been proposed.

For face shape classification, comparative studies showed that SVM with RBF kernel achieved the highest accuracy around 82% on female celebrity face images and other methods like KNN, MLP, RF, and others has also been explored.

Existing hairstyle recommendation system used face shape classification along with hairstyle expert knowledge to suggest suitable hairstyles. AAM and color-based segmentation were used to extract facial feature which were then classified using SVM. Some system also integrates scoring algorithm to rank hairstyle based on factors like face shape, hair length and volume.

In summary, this literature review showed that face shape detection, facial feature extraction and face shape classification using machine learning are key components of hairstyle recommendation system. SVM has showed some

promising result in this domain. But there lacks research on prospect of rule based which may provide accurate result with greater speed.

3. Review of Technology

3.1 Image Processing Technologies

In this section, various technology which can be used this project are reviewed, so see its combability with the project

OpenCV:

Developed by intel, it's a free cross-platform computer vision library for real time image processing. It is one of the popular tools to perform task in computer vision, it's written in C and C++. Its library is vast containing over 2500 algorithms and extensive documentation and source code. It is used for maximum efficiency and performance in computing vision tasks (Boesch, 2024).

Dlib:

Dlib is a C++ toolkit, which helps by proving ML algorithms and tools for creating complex software to solve real world problems. It is widely used in fields of academics, robotics, embedded devices and mobile phones. Dlib library has features like documentation, portable codes, ML algorithms, Numeric algorithms, Graphical Model Interface algorithms, Image processing, Threading, Networking and others (Dlib C++ Library, 2022).

3.2 Facial Recognition Techniques

Haar Cascades

(Viola and Jones, 2001) proposed objection detection using Haar cascades. It is a ML approach where cascade function is trained from a lot of positive and negative images, then used to detect object in other images. It is simple to

implement and requires less computing power, but its not as accurate as modern object detection techniques.

Histogram of Oriented Gradients (HOG)

It is a feature descriptor which is used for the purpose of object detection as it focuses on the shape of the object, and counts the occurrence of radiant orientation in each local region and generates a histogram using the magnitude and orientation of the gradient (Tyagi, 2024).

Deep Learning-Based Techniques

Techniques which use multi-layered neural networks to simulate the complex decision-making power of the human brain. Deep learning can help to eliminate some data pre-processing as it can easily ingest image and automate feature extraction (IBM, 2024).

3.3 Machine Learning Frameworks

Scikit-Learn

Popular python library which offers various machine learning algorithms for tasks like classification, regression and clustering. It might not be good if deep learning is required (Code academy, 2024)

TensorFlow

A powerful open-source framework from Google, which is used for building and deploying deep learning models, and is a strong choice for projects requiring high accuracy and leveraging deep learning tools (TensorFlow, 2024).

PyTorch

PyTorch is an open-source deep learning framework and mostly known for its ease of use and flexibility. It is easy to learn and use and has excellent support for GPUs and use of reverse-mode auto-differentiation, that helps to enable

computation graphs to be modified on the fly which makes it fast experimentation and prototyping (NVIDIA, 2024).

3.4 Web Development Tools

Flask

Flask, created by Armin Ronacher, considered to be a micro web framework, which makes it more independent, flexible and simple. It gives a quick start for web developing having complex applications, and it supports WSGI templates that helps in flexibility and scalability in the web development process and has a support for secure cookie attribute, which ensure no unauthorized person access the text. It offers a built-in development server and fast debugger. But it is not suitable for big applications and projects and lacks database and ORM and all the library must be manually installed (Great Learning, 2024).

Django

Django, a high-level framework that speeds up the web development process and increase efficiency, it follows, Model View Controller pattern and is quite flexible and accessible. It is extremely fast and portable. It has high security with powerful authentication systems and protocols to avoid unauthorized access, it supports dynamic HTML pages and are mostly preferred for big projects. It also supports relational database. Django has its cons of codebase size being too big, auto reload restarts the entire server and only allows handling a single request at a time (Great Learning, 2024).

3.5 Integration of Webcam Functionalities

WebRTC

Web Real-Time communication (WebRTC), a technology used to capture and optionally stream audio, or video between browser without any intermediary. It consists of several interrelated APIs and protocols which work together to

achieve this. This can be used for metadata exchange, file transfer, back-channel information, game status packets or even as a primary channel for data transfer. It is connected using interfaces, dictionaries and types (MDN Web Docs, 2024).

JavaScript APIs

JavaScript APIs, can be used inside documents bundled with the extension, including browser action or page action popups, sidebars, option pages and others. There is a listing of JavaScript API like action, alarms, events, finds and others. It can also be used inside the extension's background scripts (MDN Web Docs, 2024).

3.6 Front-end Development

HTML

Hyper Text Markup Language (HTML), developed in the year 1990, by Tim Berners-Lee. It's a standard language for creating and displaying web pages, contents are written inside the HTML tags. It is easy to learn and understand as it has simple structure, its compatible with different web browser and devices and can combine with other technologies like CSS to enhance the visual appearance of web page and provide dynamic functionality and interactivity with JavaScript. But it has limited functionality of not being able to create interactive features, has lengthy codes and lack any designing capabilities (Vatsal, 2024).

CSS

Cascading Style Sheet (CSS), style sheet used for describing the presentation of a document, which was create wit HTML. CSS helps to control the layout and visuals of web pages, it provides tools necessary to create visually appealing, accessible and responsive websites. It helps to create responsive layout using media queries and provide previse control over the presentation of HTML elements, then can be used to structure contents to improve search engine visibility (Tutorials Point, 2024).

JavaScript

JavaScript, object-based scripting language which is lightweight cross-platform. It adds interactivity to the web application and can handle client-side operations such as capturing webcam images and sending data to the server, and displaying results. It can also be used to create a dynamic UI (JavaTpoint, 2024).

React

Open-source JavaScript library for building dynamic user interface, considered for frontend development to manage the application's state efficiently and provide a responsive user experience. Its prime role is to handle the view layer of the application, rather than dealing with whole user interface as a single unite, it encourages developers to separate these complex UI and combining the speed and efficiency of JS with more efficient method of manipulating DOM to render web pages faster and create highly dynamic and responsive web application (Herbert, 2023).

3.7 Back-end Development

Python and Django

Backend development with Django offers advantage of scalability and security. The application can also be built fast, Django also follows DRY principle which encourages reusable code and reducing redundancy. It has built-in security feature that protects against common web vulnerabilities and reduces the risk of security breaches. Django has a large community which contributes to its continuous improvement so there are extensive support and resources. It can also be pared with other frontend technology to create a good application.

PostgreSQL

PostgreSQL, an advanced enterprise-class open-source relational database that supports both SQL and JSON querying It is highly stable and has a large community and can be used as datastore for many web applications.

PostgreSQL has a rich features and extension as well as fault tolerance and reliability. It is more flexible than other relational database and using Object-oriented features, user can communicate with database servers with only objects, define complex custom data types, define functions that work with their own data types, and can define inheritance between tables (Amazon, 2024).

4. Methodology

4.1 Data Collection

4.1.1 Dataset Description

The dataset used to train the SVM model consists of folders, each based on face shapes where the images name corresponds to specific face shape category. It included diverse set of images to ensure the model's robustness across different face shapes, skin tones and lighting conditions. The face name will be used as a label to predict the face shape and recognize the input image. This organized structure helps in the systematic training and evaluation of the model, and with the inclusion of various face shape it aims to enhance the model's generalization capability when predicting face shapes and recognizing input images.

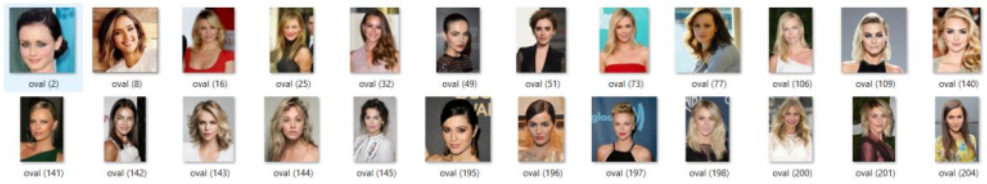

Figure 1: Sample of dataset used

4.1.2 Data Sources

The dataset for this project were sourced from Kaggle, a well-known platform for data science competition and datasets. It was publicly available facial image dataset which are essential for training the SVM model. Kaggle's datasets are reputable and widely used within the machine learning community, providing a solid foundation for developing robust predictive models. Link for the dataset [https://www.kaggle.com/datasets/niten19/face-shape-dataset].

4.1.3 Data Pre-processing

Before utilizing the dataset for model training, the data were preprocessed to ensure uniformity and enhance the quality of data. All the data were scaled to uniform size to maintain consistency. The resizing process ensures that each images has the same dimension which is crucial for model's training process and the pixel values were also made same to ensure uniform intensity levels across all images, then gray scaling was used to reduce to single color channel, this ensures that data are simplified and the computational complexity are reduced without impacting the model's ability to learn from image. Deep learning techniques were used to identify the face in the image. Library like OpenCV and Dlib were used to detect the face landmarks. This library provided great tools for data processing. Through these steps the data was transformed into a standardized and high-quality input, suitable for training the model to predict face shape accurately. MTCNN was used to detect the face, and for SVM the facial feature was extracted with Face Net.

Figure 2: Sample of grayscale image

4.2 Face Shape Detection

In this section, delve into detail of how face shape detection is implemented.

4.2.1 Support Vector Machine (SVM) Implementation

After the facial feature was converted into vector feature using Face Net, it captures the essential characteristics of each face. then, the data was used to train the multiple SVM model, SVM model with different kernel were selected i.e. Linear, RBF and Poly. Linear assumes a linear relationship between the features RBF, suitable for non-linear data, this kernel maps the feature into a higher-dimensional space. Polynomial kernel also for non-linear data, and this considers the polynomial relationships between features. After the data was fed into SVM

models, each model was trained using a labelled dataset, where face shape was the target variable, and different performance metrics like accuracy, precision, recall and F1 score were used to compare the model. The model with high metrics was polynomial kernel, but RBF was selected instead as RBF is less prone to overfitting compare to polynomial and it induces smoother decision boundaries in the feature space, which can be beneficial for shape classification (Baeldung, 2024).

4.2.2 Rule-based System Implementation

In addition to machine learning approach, a rule based was implemented to provide addition method to predict the face shape. This system uses predefined rules on facial measurement and proportions to categorize face shape. Face was detected with haar cascade and landmarks detected through shape predictor 68 face landmarks.

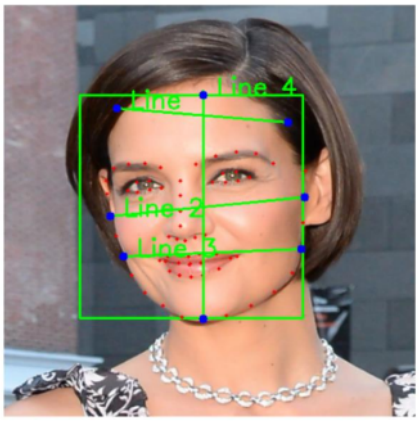

Figure 3: Lines drawn on image

Then K-means was used to separate the forehead from hair based on pixel value, after that use 8 vertices to draw 4 edges and the distance was calculated and the ratio of each line was taken, and using that face shape was identified.

4.2.3 Comparison of Methods

Both methods are used in this system, while SVM has higher accuracy and precision to predict the right face shape, it takes a lot of time and computational power to predict the face shape. RBS, has low accuracy and precision to but it takes significantly less time and less computational power to predict the face shape

4.3 Hairstyle Recommendation

4.3.1 Matching Face Shapes to Hairstyles

Various hairstyles were collected according to face shape, looked into different websites (Barbers, 2022), (Hall, 2024), (O'Connor, 2024) to find the best hairstyle for each face shape. And the hairstyle was stored in database and have a relation with face shape. The hairstyle is organized and stored in relational databased, and once face shape is predicted, then system queries the database to retrieve suitable hairstyles.

Figure 4: ERD for face shape and hairstyle

4.4 Blending

If user decides to upload a picture, then the user is able to see the effect of hairstyle on the images, for this process, a pretrained model from, [https://www.kaggle.com/code/rahuldshetty/hair-segmentation-using-u-net] is used, which gets the hair mask of the person and then after obtained the hair mask, the hair mask are replaced to get the different hair in the user's image.

Figure 5: Sample of hair mask

5. Product Design

5.1 User Interface Design

The User interface is created with design principles of simplicity where all interfaces are straight forward and free of unnecessary elements which makes sure that the users are not overwhelmed by the UI. All the buttons and style are created with uniformity to create consistency to ensure a cohesive user experience, another important feature of visibility where feature is easily visible without the need for extensive search.

5.1.1 Wireframes

Wireframes for this project was made using Figma, this project has a simple design so that user can easily navigate between each page, in total it has a home page, a page to upload photo and use SVM model, a page to use rule-based approach using photo, two page to use webcam but for different models, of rule based and SVM, and one hair color page where user can use the webcam to check different hair color on them, these are the page accessed by the user,

other pages like error page are also there, which can be accessed when there is some problem in the system

Below, you can see the wireframe of navbar of the project, it contains a home tab, to go to home page, a photo tab, which drops down and contains SVM and Rule Based, when click can go to that individual model page, also similar for the Webcam tab, and lastly a hair color tab, when click access the page to change the hair color.

Figure 6: Wireframe of Navbar

Figure 7: Wireframe for result page after prediction

Then we have the result page, which shows the predicted face shape as well as the recommended hairstyles, there are two result pages, one shows the result when used with photo approach and other if captured image from webcam, they are different, as with webcam approach can only have predicted face and list of

recommended hairstyles, but in photo approach, the user can also check the hairstyles on their image, to see how they look in that hairstyle. There is also a simple message area below, where user can send feedback if they don't like the hairstyle or face shape or anything from the website.

Figure 8: Wireframe for upload pic for Rule-based

This shows the wireframe to upload pic for rule-based approach, where user can arrive through navbar, then simply click on the choose pic button to upload a pic and click predict button to start the face shape prediction and hairstyle recommendation.

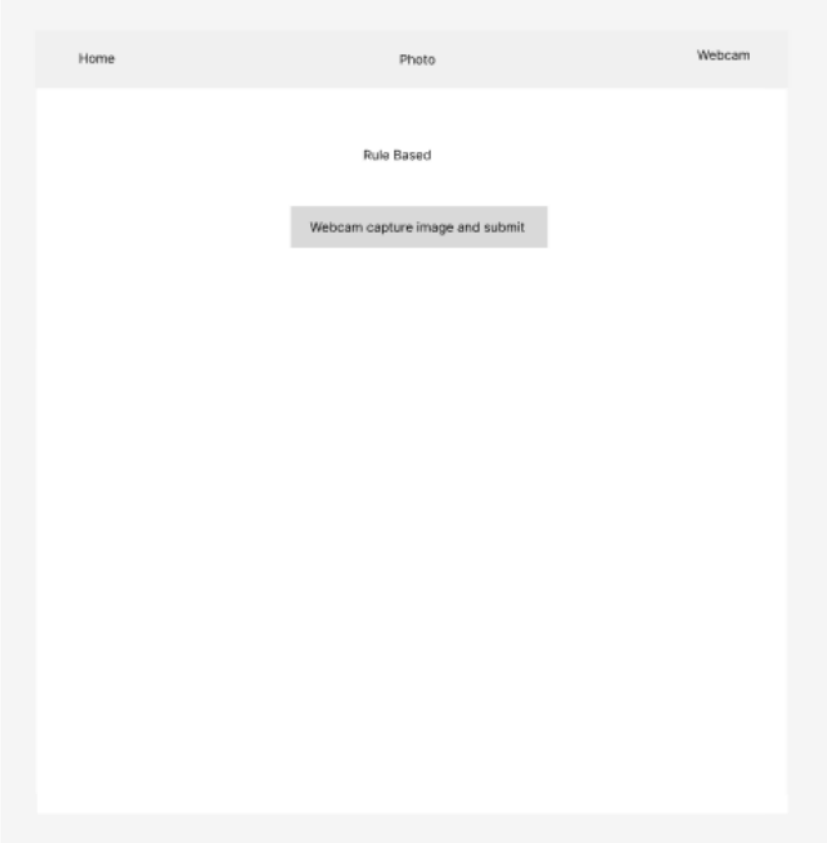

Figure 9: Wireframe for webcam capture for Rule-based

Similar as above, but instead of uploading photo, open the webcam and click on capture image button to start the face shape prediction and hairstyle recommendation.

Figure 10: Wireframe for upload pic for SVM

This shows the wireframe to upload pic for SVM approach, where similar to rule-based photo upload, user can simply click on the choose pic button to upload a pic and click predict button to start the face shape prediction and hairstyle recommendation.

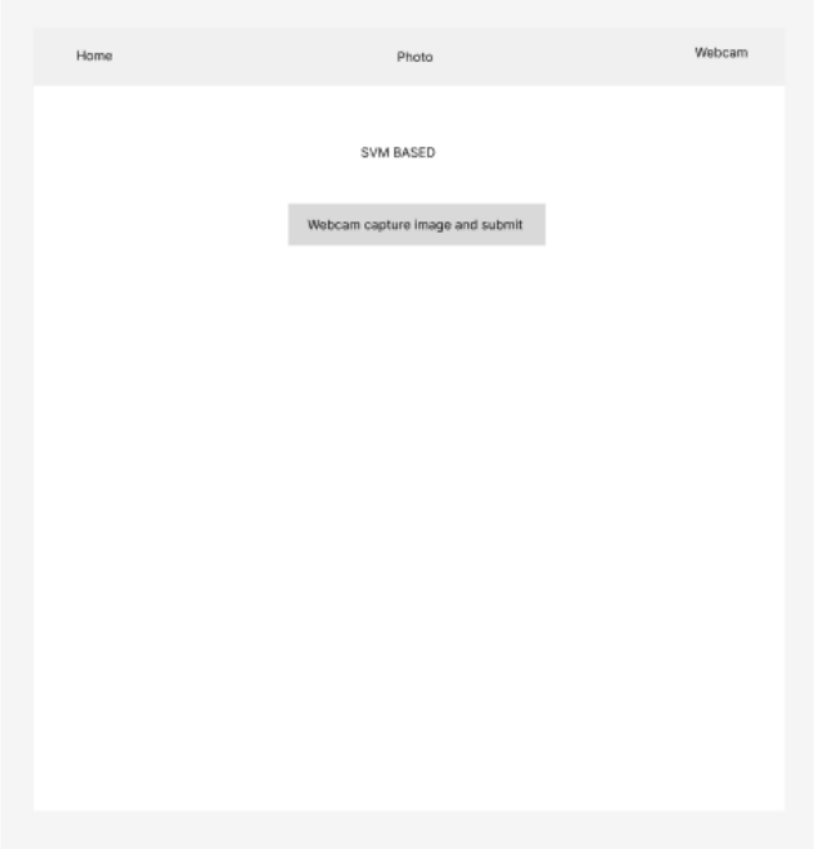

Figure 11: Wireframe for webcam capture for SVM

This is the wireframe where the user can use webcam to predict the face shape and hairstyles, but here the approach in which the face shape is detected is SVM.

Figure 12: Wireframe for error page

A wireframe for error page, where if there are any error, then users are redirected here and all the potential cause of errors are listed here, so that users can know what caused the error. Error page also has feedback form, where user can send their feedback which will be looked to make the product better.

Figure 13: Wireframe for homepage

This wireframe shows the home page, the initial page which will be seen by the user upon using the application, it consists of details of face shape its importance when choosing the hairstyles. Through homepage user can visit any page they want through the navbar.

5.2 User Experience

For better user experience, the website is made simple, where user can navigate to different pages simply by using the navbar.

Here user can navigate to each page using navbar, after a result is displayed, the user has a choice to send feedback if they didn't like the face shape or the hairstyle which was recommended. If any error is encountered on the application, then users are forwarded to error page, where the user can check, the possible reasons why the application may have crashed and also can provide feedback on that instance.

Below are some of the flowcharts, data flow diagram and use cases on how the user can move in the website.

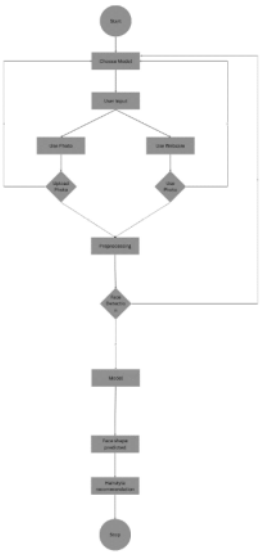

Figure 14: Flowchart of the app

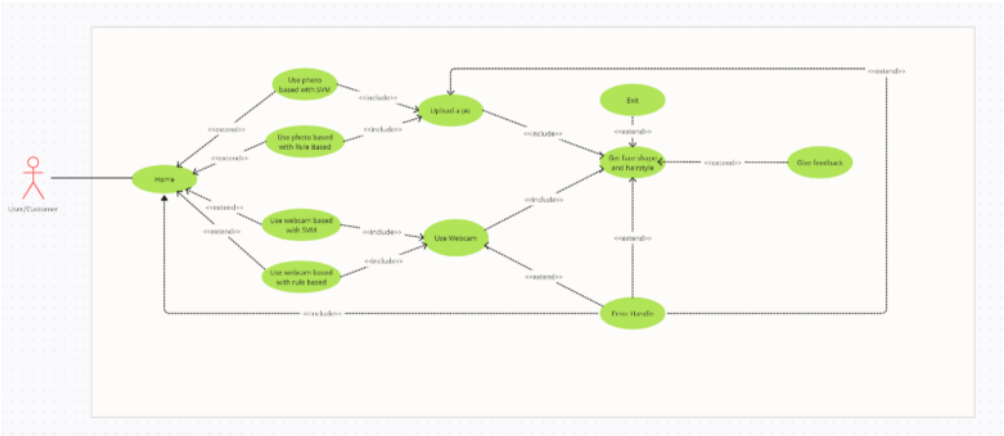

Figure 15: Use case diagram

Figure 16: Data flow diagram

Here, the above image show the data flow of the system of how the user can move around in the app and when user gives a input data that how that input data flows into the system, from figure it is shown that after the user inputs the data from either uploading the image or using webcam for image capture, the data is passed in backend, where the data/image will undergo preprocessing, in

preprocessing the data is resized, grayscaled and the face is detected, if no face detected, the system returns error. After detecting the face the landmarks are detected in the face region and the facial feature landmarks are extracted so that it can be used to identified the face shape, now in case of SVM, those points are used in order to identify and classify the face shape and in case it is rule-based then after detection of landmark, the hair and forehead are seperated using kmeans and after that lines are drawn to calculate the distance and get the ratio of lines to find the face shape. After face shape is classified, then it is used to query the database to get the hairstyles and if used a image instead of webcam then the image can be used to blend with the recommended hairstyle to check how it looks.

5.3 System Architecture

5.3.1 High-level Overview

The figure below shows the high-level overview, of input, process and output. In input, the user can either opt to upload a picture or capture the image using webcam, then after that user can click a button to send the image for processing, where depending on the user choice, the model will be used, but before the image was sent to model, the image undergoes pre-processing, after that if the model is able to predict the face shape it returns the face shape, which queries to database about hairstyles and both the face shape and hairstyles are displayed as the result on the web application. This product utilizes the client-server model where the front-end communicates with the back-end server using APIs. The frontend was developed using HTML, CSS and JavaScript, while to handle the request, a robust backend with Django was created, takes the input or any other request, processes it and returns the output which is render by frontend. Restful APIs are developed to facilitate the communication. The database used was PostgreSQL, a relational database for its structured data and ACID compliance.

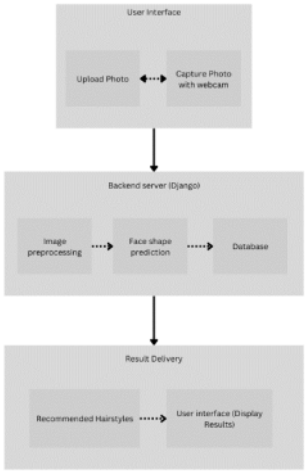

Figure 17: High level system architecture

6. Software Requirement Analysis

The software requirement analysis is an important step in the development of the project this ensuring that the project meets the functionalities and non-functional requirements. In this section, the functional, non-functional and technological stack are explored.

6.1 Functional Requirement

The project has some functional requirement according to MoSCoW rule. With around 8 functional requirements.

First requirement is, the product to recommend hairstyle if it was able to identify the face shape and it had Must have (M) category from Moscow prioritization and other requirement also has Must have (M)category and its requirement is for the user to be able to upload image and others are system to be able identify the user's face shape and the product to have a web interface. Moscow has other category like Should have (S), Could have (C) and Will not have (W). Should have contains requirement to have a database with diverse selection of hairstyles

and user to be able to choose between using SVM or rule based to predict their face shape. Could have includes the requirement to make the user be able to use webcam service to capture the image and Will not have (W), the product to have ability to try the recommended hairstyle on image.

- Functional Requirement

Requirement ID	Description	MoSCoW
1	Recommend hairstyle if face shape identified	M
2	User able to upload image	M
3	Identify user's face shape	M
4	Product has a Web interface	M
5	Database having diverse selection of hairstyle	S
6	User to select between SVM and Rule Based	S
7	User to be able to use Webcam	C
8	Try hairstyle on image	W

Figure 18: Functional Requirement

This functional requirement ensures that this project meets the core objective of providing personalized hairstyles recommendations based on face shape detection, while also considering additional feature to enhance the user experience.

6.2 Non-Functional Criteria

Along with functional requirement, there are some non-functional criteria for the product, which defines the quality attributes and constraints of this project and are categorized with Moscow prioritization category.

Must have (M) requirement for this product is that the product is tested and validated so that it can provide better performance and user satisfaction, it is also must to have this product be developed using free software products. In should have (S) category the product has the requirement to identify the face shape in a time limit, it should either show error or identify face shape in certain time frame and must not keep on buffering. In could have (C) requirement, the product must be user friendly.

- Non-Functional Requirement

Requirement ID	Description	MoSCoW
1	Product is tested and validated.	M
2	Developed using free software products	M
3	Product has time limit for identifying face shape	S
4	Product is user friendly	C

Figure 19: Non-Functional Requirement

These non-functional criteria ensure the web application is reliable, efficient, cost-effective and provides good user experience.

6.3 Technological Stack

The development of the web application involves the utilization of various programming languages, libraries and frameworks and they are given below:

6.3.1 Programming Languages

Python

JavaScript

HTML/CSS

6.3.2 Libraries and Frameworks

Django Framework

Django Rest Framework

Dlib

Face Net

Keras

Keras-core

Tensor board

Torch

TensorFlow

Scikit-learn

OpenCV

NumPY

Choosing the programming languages and libraries is very important in development of a product. Here, Python is widely used in the fields of ML and web development, so it makes a good choice to use python for this project and JavaScript, HTML and CSS are essential for creating dynamic and interactive frontend for web application so they will be used as well.

The Django framework and Django REST Framework are one of the popular python frameworks which provides a robust foundation to build web application's backend and API. It can be scaled as well. Libraries such are Dlib, FaceNet, Keras, TensorFlow, Scikit-learn and OpenCV help in the field of computer vision, Machine Learning and image processing, it helps to accurately detect the face shape which helps in hairstyle recommendation. Additionally, libraries like NumPy and TensorBoard are useful when working with numerical computations and visualization of model training and performance metrics.

7. Implementation and Testing

As see above about the technological stacks that were used to develop the software, other tools were also used, like VS Code was used as IDE or Development environment. A virtual environment called "test" was also create to provide an isolated space for this project. There are many python files used and all of the main functionalities are kept in function and called as function.

7.1 Implementation

7.1.1 Coding Practices

During the development of this project, various coding standards were followed to make sure the code's quality and maintainability, The PEP 8 standard was followed, which promoted a consistent and readable coding style. Additionally, code was reviewed after each commit to check the codes and if there are any errors. The codes are organized into function to achieve modularity to promote reuse and readability. The errors are handled and each function has a comment to describe what the function do.

7.1.2. Version Control

For version control of this system GitHub was used. The name of repository is Hair-Recommendation-System. It contains the code of Django framework along with requirement file required to download all the dependencies.

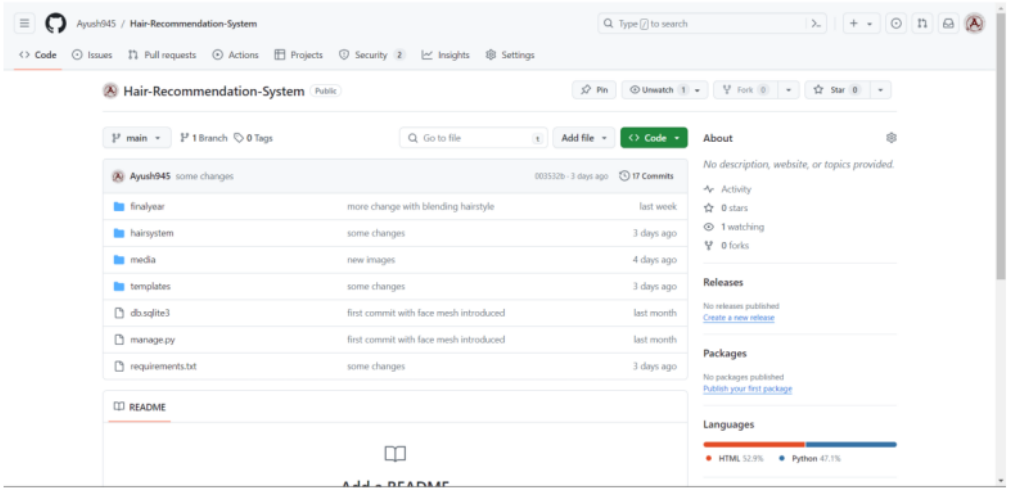

Figure 20: GitHub page

7.2 Testing

Product testing was performed to check if all the component and feature worked as intended,

Home page, was thoroughly tested to verify whether it was rendering properly and had all the functionality

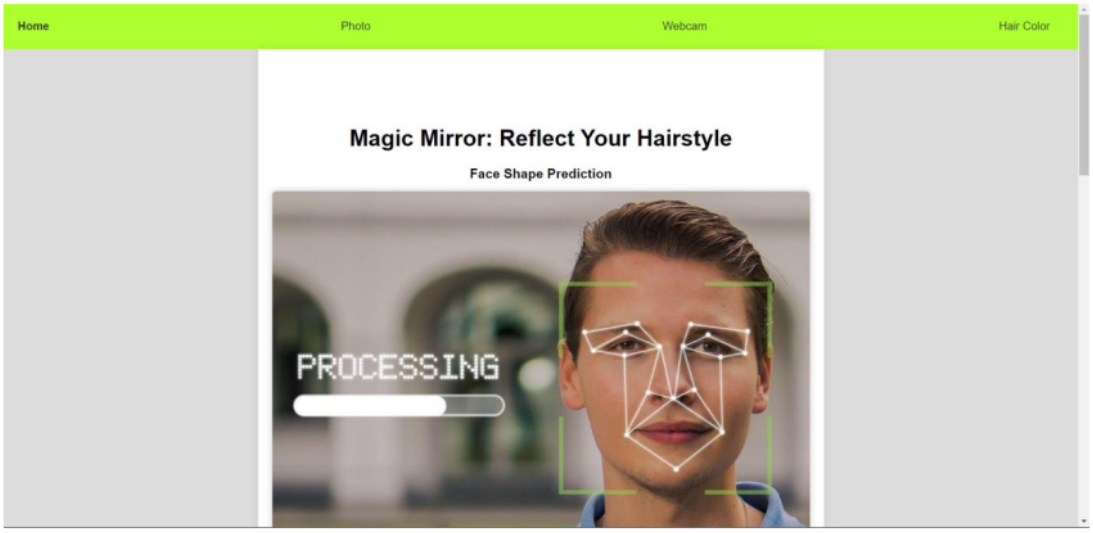

Figure 21: Home page

Navigate using Navbar, this navbar was also tested to insure there is smooth transition between pages and all the navbar components are working.

For hair color change, this feature was checked multiple times to see if the users were able to upload a picture or if users were are to select different color and in case of any error like face not detected, the error page was shown.

Figure 22: Hair color page

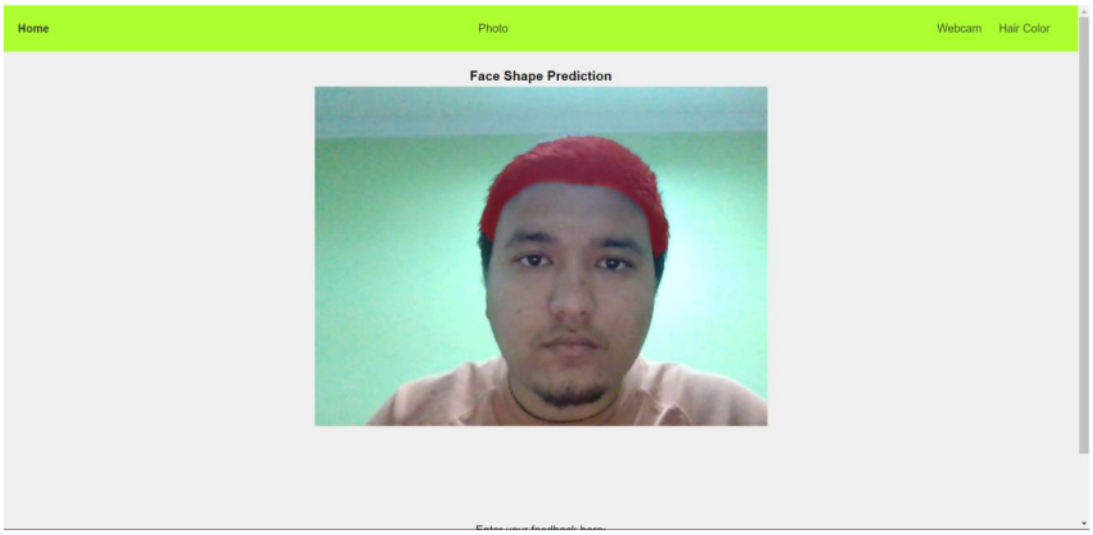

Figure 23: Change hair color to red

Change in hair color

If there is no face when trying to change the color, it shows nothing.

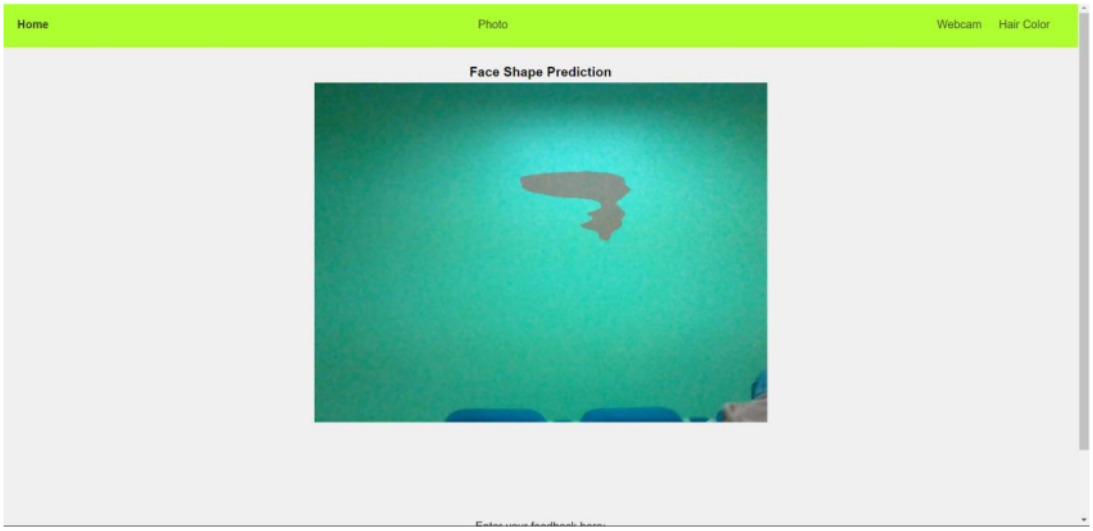

Figure 24: No face detected in image

In photo upload for SVM and Rule based, this function was also tested to see if the user is able to interact with it and whether it shows some alert incase of problems.

If user tries to predict without using image, alert is shown.

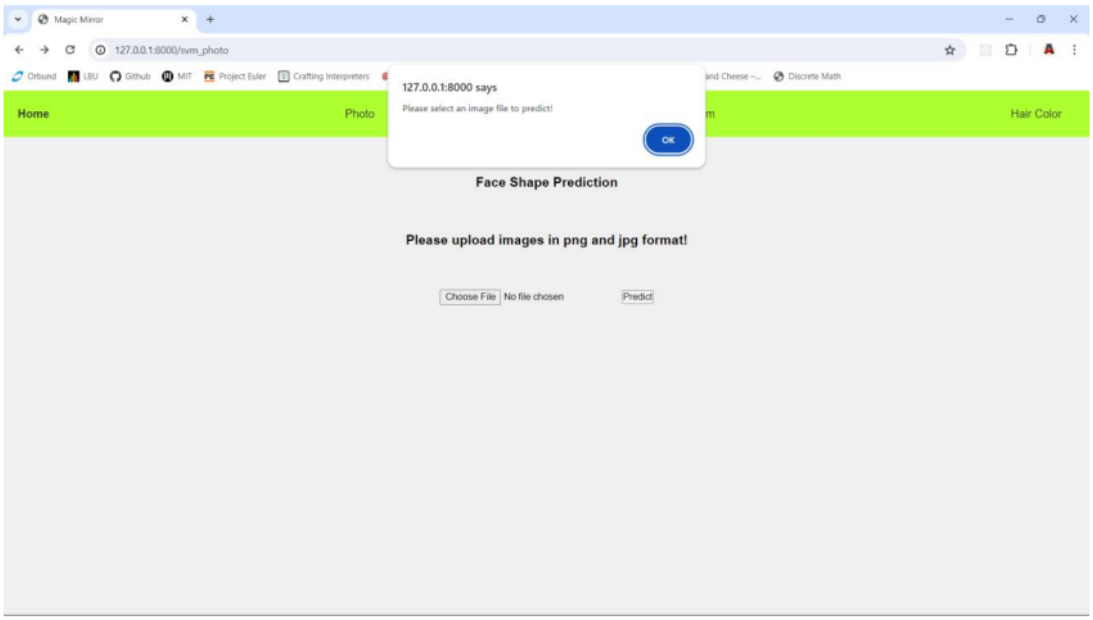

Figure 25: No photo uploaded

After an image is uploaded

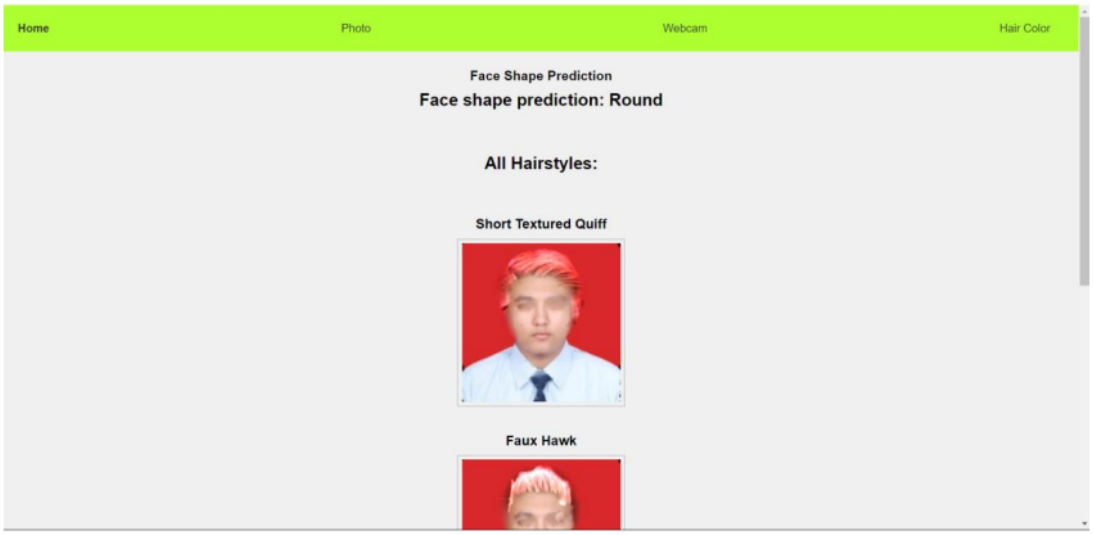

Figure 26: After photo uploaded

If user have a problem with the face shape, can send feedback,

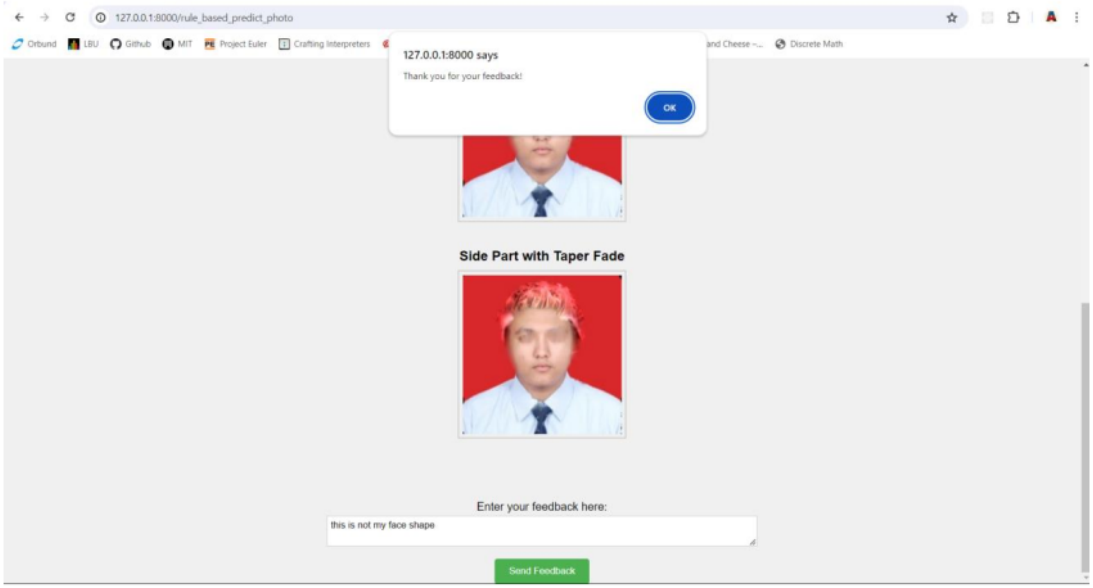

Figure 27: Feedback section

If there is a problem in model or face detection then, Error page is displayed.

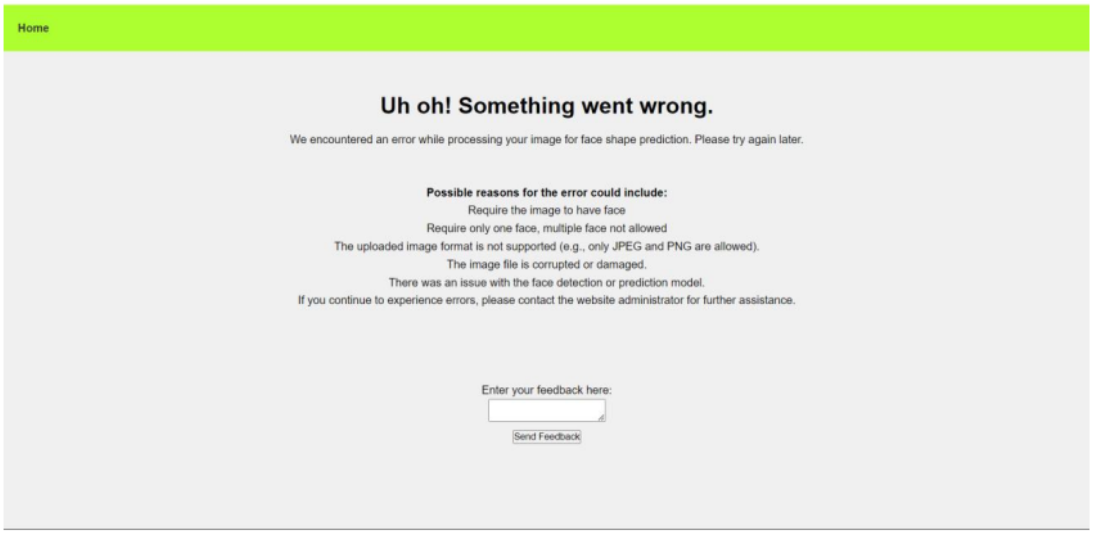

Figure 28: Error page

When working with face shape prediction model if there is no person in webcam, then

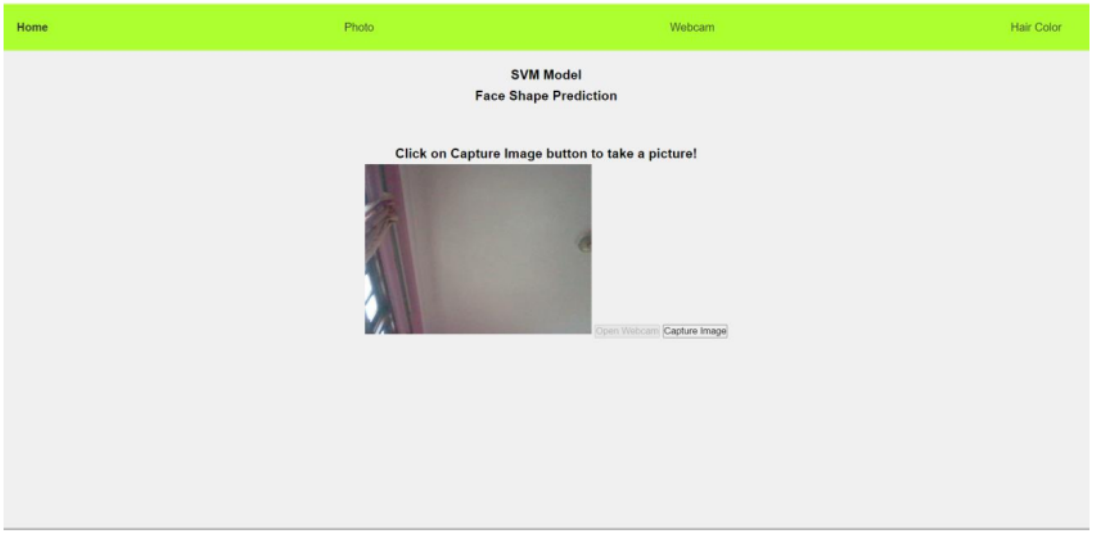

Figure 29: Webcam page

Error page is displayed

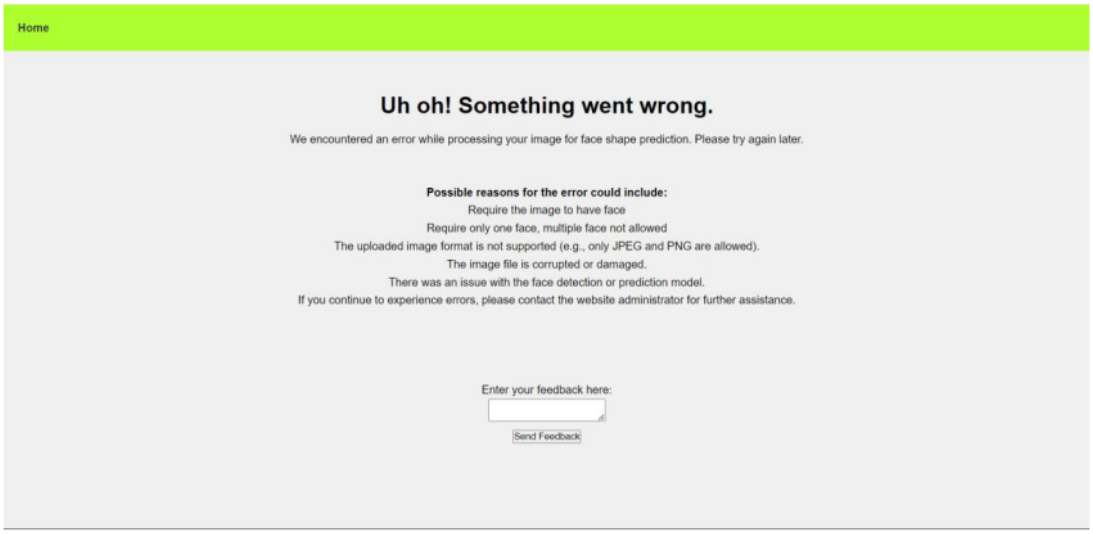

Figure 30: Error page upon not detecting face

After utilizing webcam, for SVM or Rule based, only hairstyle is show:

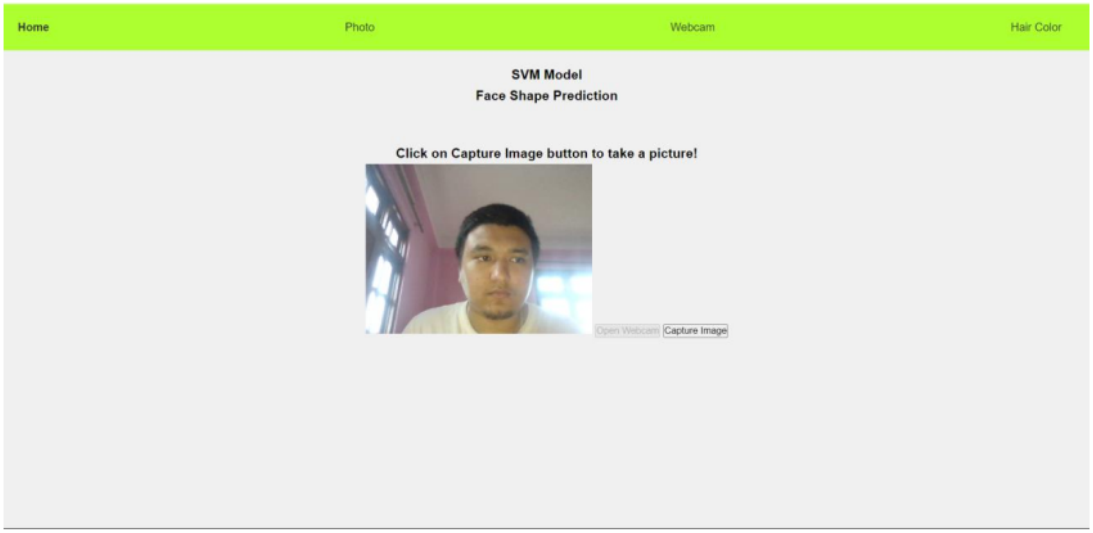

Figure 31: Use of webcam to take picture

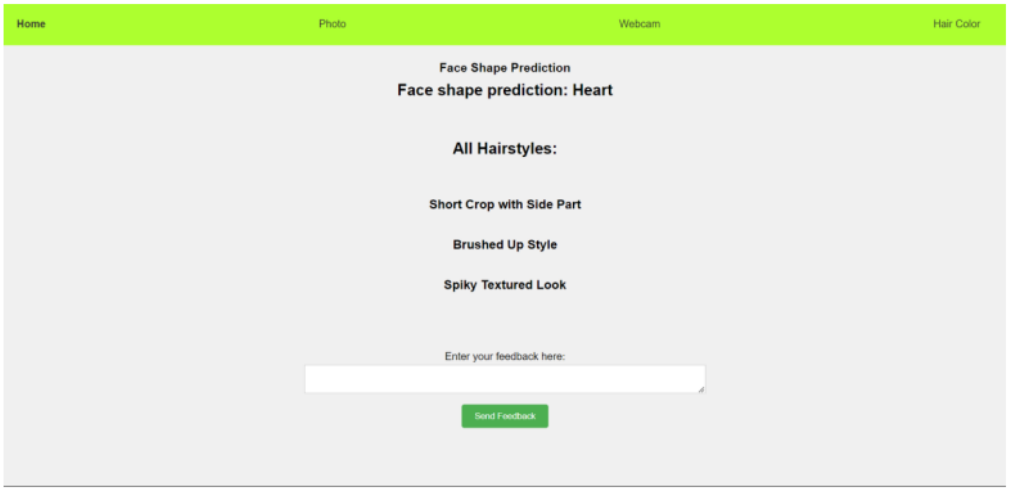

Figure 32: Result after using webcam for hair recommendation

7.3 Bug Tracking and Resolution

In this project, encountered many errors and bugs and they all were addressed, All of the API was tested with postman to identify and resolve any issue related to API of not being able to send data, or not receiving any data.

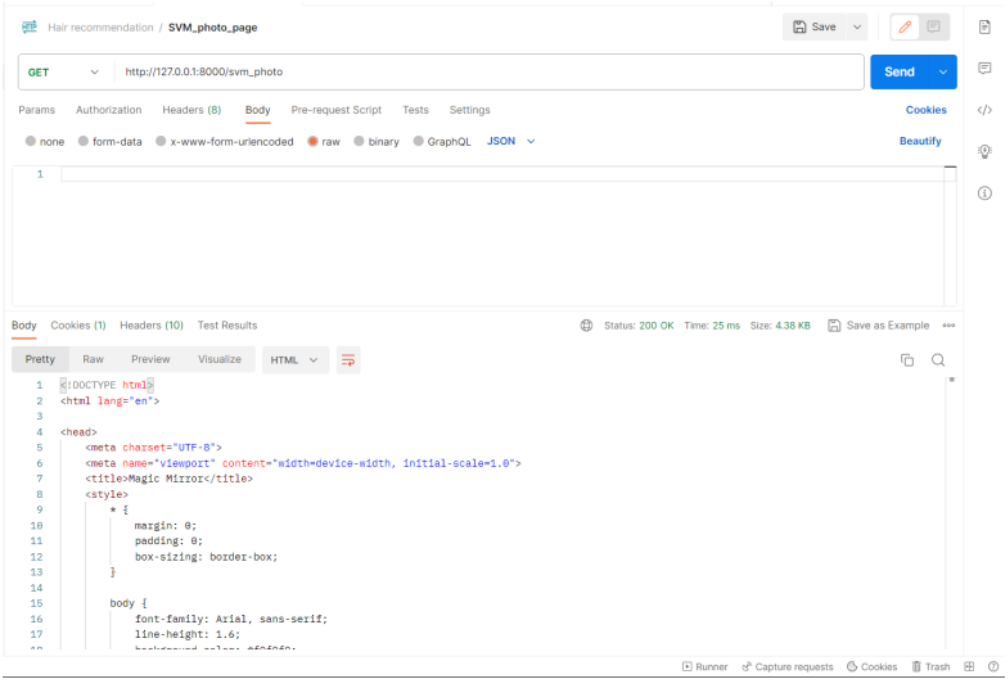

Figure 33: Testing API with postman

The codes were reviewed to check for errors, and version control like GitHub was used to track changes and isolate bugs. Conducted a survey with friends to gather information about user-reported bugs.

For frontend debugging used tools like Chrome DevTools, were employed to identify and resolve issue related to the user interface and client side functionalities.

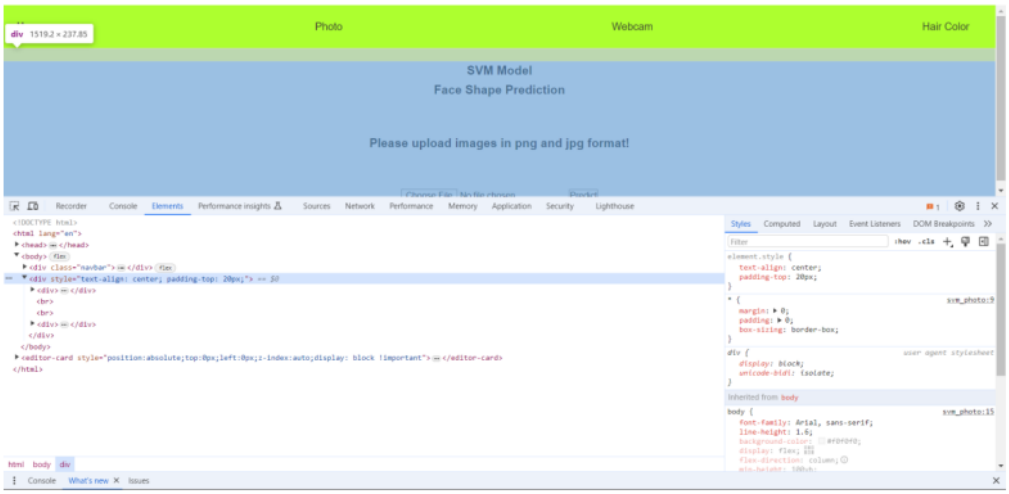

Figure 34: Chrome Dev Tool for frontend debugging

Overall, the implementation and testing phrase involved rigorous coding practices, version control, comprehensive testing of all features and components, and effective bug tracking and resolution strategies, and these measure helps to deliver a better hair recommendation system.

8. Product Evaluation

To evaluate the product, the most important part of the product is the face shape detection, as with the face shape detection, the product is able to produce the recommendation for the hairstyles, and in this product, two approaches have been used to predict the face shape of a person i.e. Rule-based and SVM.

8.1 SVM

In SVM, three kernel, Linear, Polynomial and Radial Basis Function were tested on basis of Accuracy, Precision, Recall and F1 score, and the results show that Polynomial has the highest score on these metrics and RBF with the second highest and linear with the lowest score in these metrics, below figure shows the plot of these metrics in a bar chart.

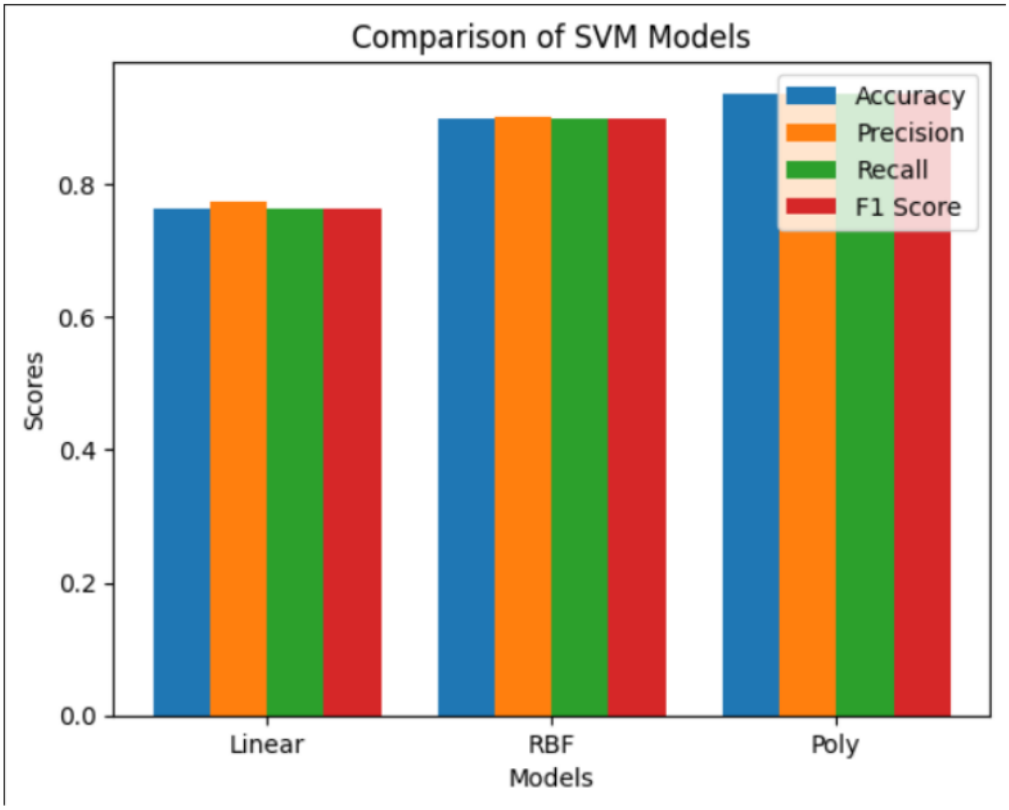

Figure 35: Comparison of SVM with different kernel

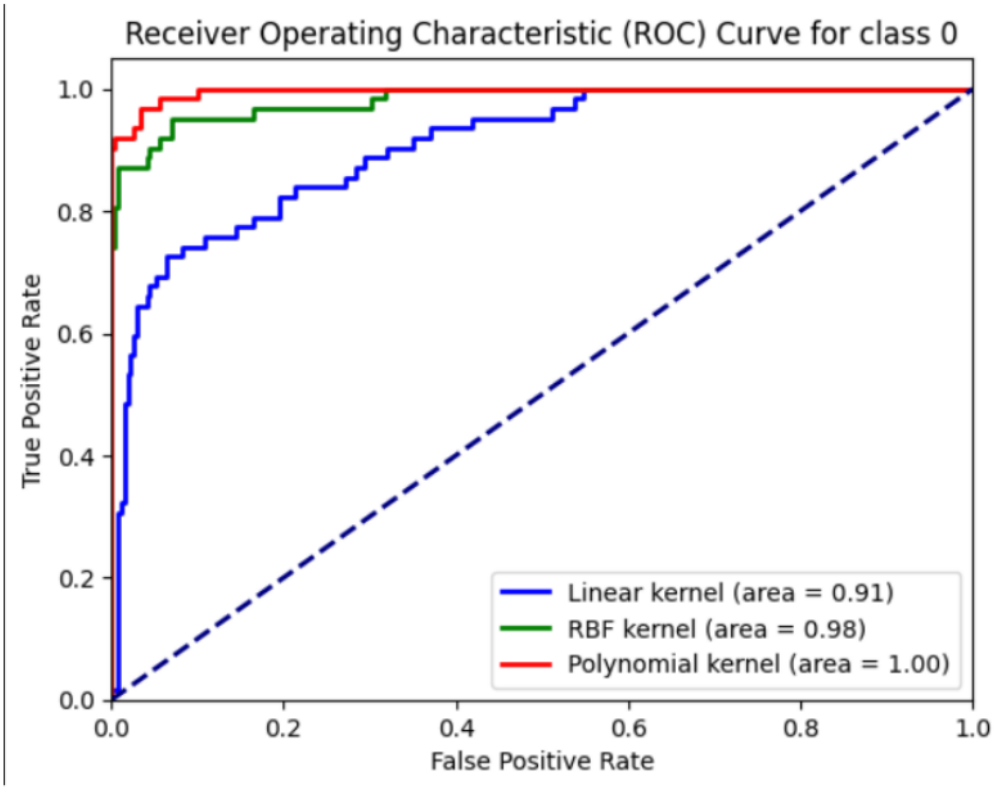

Figure 36: ROC curve for three kernels

The receiver operating characteristics (ROC) was also plotted for Heart class and the results for the three kernels can be seen above. This curve can be used to identify which kernel can be useful to compare the performance of every kernel and find the tradeoff between true positive rate (TPR) and false positive rate (FPR) as it plots TPR against FPR for different classification threshold, the kernel with the highest Area Under the Curve (AUC) value can be identified as the kernel with highest is said to be most suitable.

Through the above comparison, for the face shape detection, RBF kernel SVM was selected instead of polynomial as the polynomial kernel SVM have been affected by overfitting, and RBF is less likely to have problem with overfitting, below figure shows the overall metrics of RBF on all face shapes.

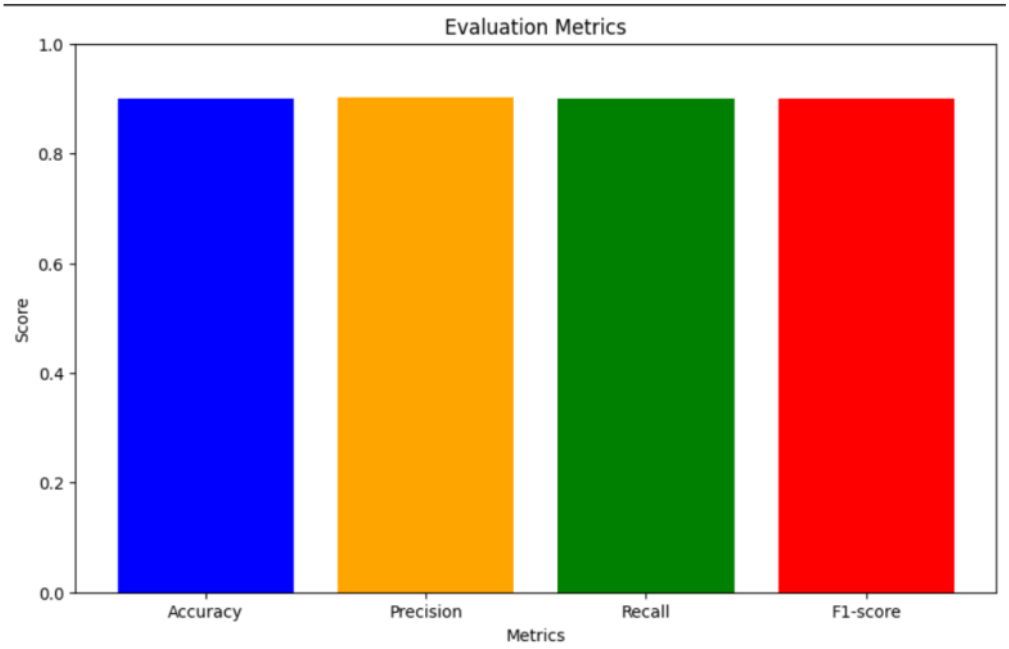

Figure 37: Overall Accuracy, precision, recall and f1-score for RBF kernel

Now, after looking at the metrics of RBF SVM on each overall class, this below figure show the metrics of performance evaluation of each and every category of face shape where, class 0 denotes Heart face shape, class 1 denotes oblong face shape, class 2 denotes oval face shape, class 3 denotes round face shape and lastly, class 4 denotes square face shape.

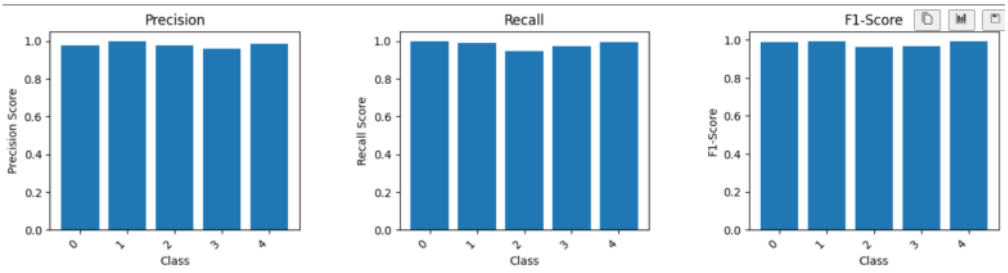

Figure 38: Performance metrics for each face shape with RBF kernel

Now, there may be class imbalance, but looking at the above figure and the confusion matrix below, it showed that there is no class imbalance, the confusion matrix also showed the number of misclassified cases on each face shape category.

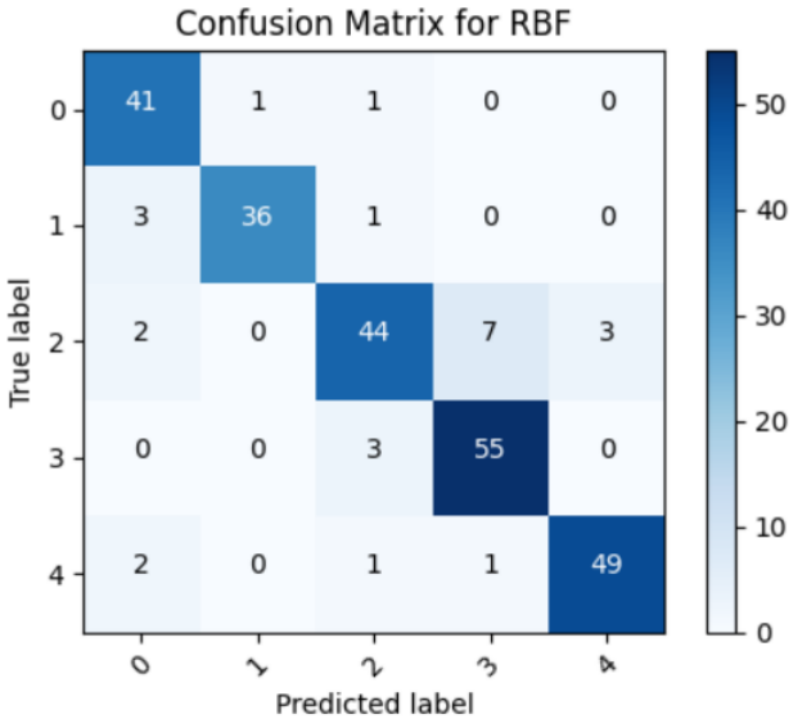

Figure 39: Confusion matrix for RBF kernel

8.2 Rule Based System

Now, after SVM, another approach for face shape detection is Rule-based

In Rule-based, the performance metrics are used to find its accuracy, precision, recall and f1 score, for this the test data from the Kaggle dataset was used, with around 1000 labelled images. Testing with the data shows that the, Accuracy: 0.208

Precision: 0.23851056856140646

Recall: 0.208

F1 Score: 0.10494784000040516

Below is the figure, which shows the plot of these metrics and values.

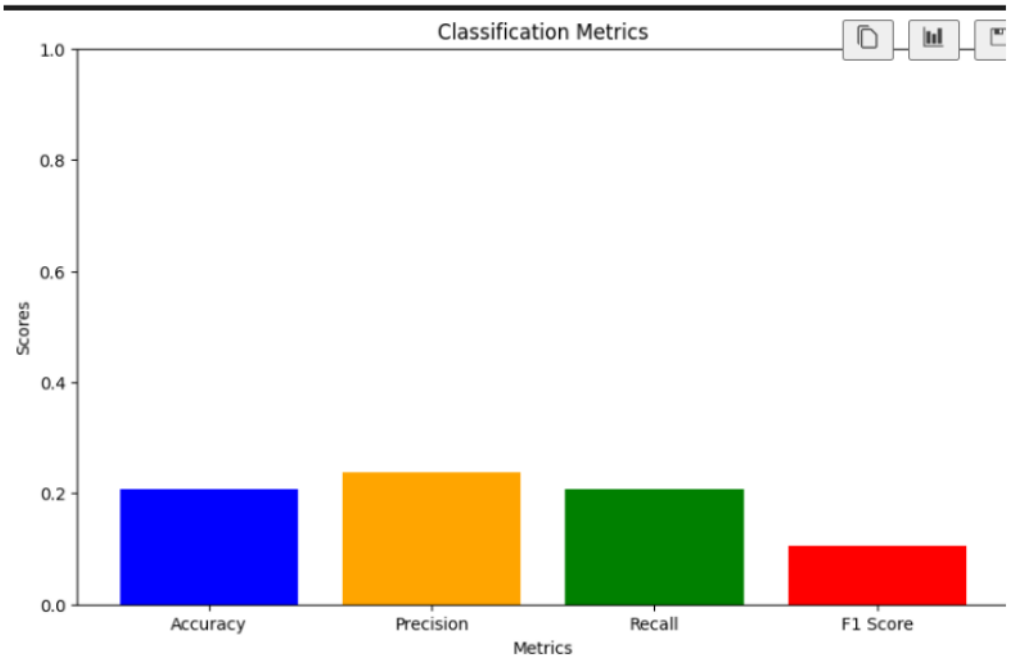

Figure 40: Classification metrics for Rule based

As, the metrics are low, we also take a look at the confusion matrix for rule-based system, to check if there is any class imbalance or misclassification. Through there is a additional label, where if it is not able to predict the face shape, it returns unknown as the label.

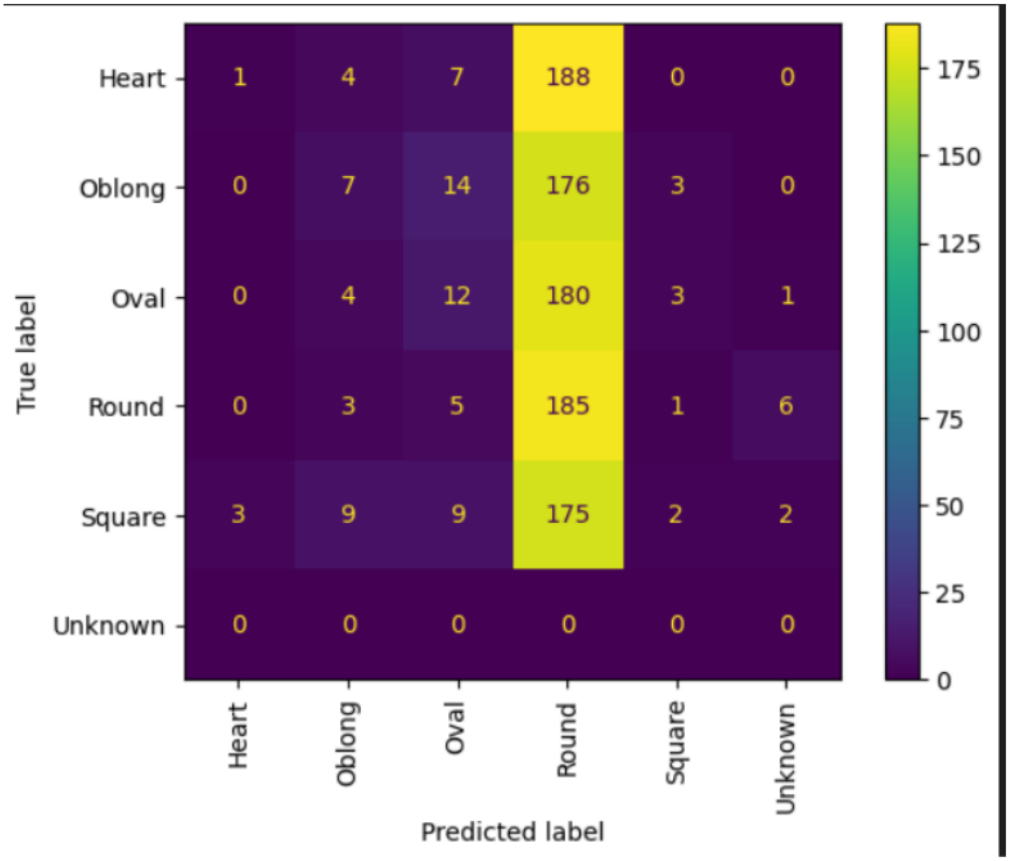

Figure 41: Confusion matrix for Rule based

8.3 Hair recommendation

As for hair recommendation, the hairstyles are obtained after querying the database with the obtained face shape, and if the face shape is unable to be identified, it returns with no hairstyle and a message saying unable to classify the face shape. The hairstyle depends upon the face shape, as there are list of hairstyle on the database and they are obtained on basis of face shape from database where each face shape have a unique id, and is also a foreign key in hairstyle entity.

8.4 Future improvement on model

For future improvement of this product, there are a lot of places this product need improvement, first the accuracy, precision, recall and f1 score of rule-based is low, so need to increase the metrics for this approach, and this can be done by increasing the number of edges drawn and the vertices used, right now it uses 4 edges and 8 vertices, in future the plan is to increase the number by more than 200%. After increasing the metrics for the rule-based approach, product will have a scoring algorithm implementation which will provide the user the ability to see the quality of hairstyle recommended, as the product shows multiple hairstyles, each hairstyle will have a score, personalizing based on the users input image. After this the plan is to implement a generative AI, which will help the user to see how the hairstyle looks on them, right now, we have an approach of blending the hairstyle on user image, but in future, plan to generate the hair so that user is able to check how different hairstyle looks on them. The generative AI can also be used by the user to enhance their looks and this product will be able to provide a platform for user to change or enhance their looks to see how different they look.

This are the future improvement for the product to make it have more robust functionality.

9. Project Evaluation

This project was about developing a hair recommendation system using face shape, and it was decided that it will be developed as a web application, so for this project, the methodology used was scrum methodology, from agile framework, as scrum methodology emphasize on iterative development and feedback, and to keep the track of the project process. Project management tools called MS Project was also utilized, it helped to keep track of progress of the project with its helpful feature of using grant chart and timelines. This management of project helped in completing this project in time.

9.1 Objective Achieved

The main objectives of this projects were to

Develop a web application to allow people to predict their face and recommend hairstyle based on face shape identified. This objective was achieved by creating a user-friendly web interface that enabled the user to upload a picture or use their webcam to capture their face image and after the image captured it was sent as input, the system identified the user's face shape and provided recommendation on suitable hairstyles based on face shape.

Integrate Database containing wide range of hairstyles suitable for different face shapes, a database was created in PostgreSQL for Django to store various kinds of hairstyles categorized by face shape with face shape id as foreign key, this allowed the system to provide accurate hairstyle recommendation to the user based on face shape.

SVM and RBS both approach was implemented in this project and they were compared based on their performance metrics and the speed for detecting a face shape from an image as well, in terms of performance metrics SVM was able to come on top by miles, while in terms of speed, it was Rule-based who was on top.

9.2 Methodology and Tools

The scrum methodology was useful in helping in this project due to its iterative process, as scrum divided problem into small, manageable sprints and these sprints contained planning, executing and reviewing the problem which allowed for adjustments and retry in the code and this approach was helpful many times as a lot of bugs and problems were solved due to this.

Microsoft Project played a vital role in project management. It helped to visualize the project timeline, assign tasks and monitor progress. The Grantt chart feature provided a clear picture of task, and deadlines which made sure the project stayed on track.

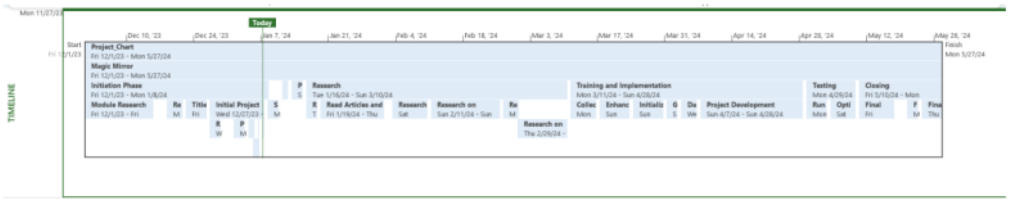

Figure 42: Timelines

GANTT CHART

		Task Mode	Task Name	Duration	Start	Finish	Predecess
1			**Magic Mirror**	**129 days**	**Fri 12/1/23**	**Mon 5/27/24**	
2			**Initiation Phase**	**29 days**	**Fri 12/1/23**	**Mon 1/8/24**	
3			Module Research	11 days	Fri 12/1/23	Fri 12/15/23	
4			Research on Title	4 days	Mon 12/18/23	Thu 12/21/23	
5			Title Finalization	3 days	Fri 12/22/23	Tue 12/26/23	
6			**Initial Project Planning Report**	**10 days**	**Wed 12/27/23**	**Sun 1/7/24**	
7			Research on Articles, Reports	3 days	Wed 12/27/23	Fri 12/29/23	
8			Project Specification	3 days	Mon 1/1/24	Wed 1/3/24	
9			Project Management (MS Project)	2 days	Thu 1/4/24	Fri 1/5/24	
10			Report Completio	2 days	Fri 1/5/24	Sat 1/6/24	
11			Ethical Consent Form	1 day	Sat 1/6/24	Sat 1/6/24	
12			Initial Project Plan Submission	1 day	Sun 1/7/24	Sun 1/7/24	
13			**Planning Phase**	**6 days**	**Mon 1/8/24**	**Mon 1/15/24**	
14			Skill Assessment	3 days	Mon 1/8/24	Wed 1/10/24	
15			Resource Identificat	2 days	Thu 1/11/24	Fri 1/12/24	
16			Project Schedule Refinement	2 days	Sat 1/13/24	Mon 1/15/24	

Figure 43: Project planning part 1

GANTT CHART

	Task Mode	Task Name	Duration	Start	Finish	Predeces
17		**Research**	**40 days**	**Tue 1/16/24**	**Sun 3/10/24**	
18		Research on Data S	3 days	Tue 1/16/24	Thu 1/18/24	
19		Read Articles and Reports	10 days	Fri 1/19/24	Thu 2/1/24	
20		Research on Model	7 days	Sat 2/3/24	Sat 2/10/24	
21		Research on classification Algorithm	12 days	Sun 2/11/24	Sun 2/25/24	
22		Research on Database	4 days	Mon 2/26/24	Thu 2/29/24	
23		Research on Image processing	8 days	Thu 2/29/24	Sun 3/10/24	
24		**Training and Implementation**	**35 days**	**Mon 3/11/24**	**Sun 4/28/24**	
25		Collection of image	6 days	Mon 3/11/24	Sat 3/16/24	
26		Enhance knowledge reading further articles and	7 days	Sun 3/17/24	Sat 3/23/24	
27		Initialization of TensorFlow and image processing	7 days	Sun 3/24/24	Sat 3/30/24	
28		GUI implementaion	3 days	Sun 3/31/24	Tue 4/2/24	
29		Database Management	4 days	Wed 4/3/24	Sat 4/6/24	
30		Project Development	17 days	Sun 4/7/24	Sun 4/28/24	

Figure 44: Project planning part 2

GAI

31		**Testing**	**9 days**	**Mon 4/29/24**	**Thu 5/9/24**
32		Runing application with different images	5 days	Mon 4/29/24	Fri 5/3/24
33		Optimizing codes with comments	5 days	Sat 5/4/24	Thu 5/9/24
34		**Closing**	**12 days**	**Fri 5/10/24**	**Mon 5/27/24**
35		Final Report Finalization	6 days	Fri 5/10/24	Fri 5/17/24
36		Final Report Submission	3 days	Mon 5/20/24	Wed 5/22/24
37		Final Presentation	3 days	Thu 5/23/24	Mon 5/27/24

Figure 45: Project planning part 3

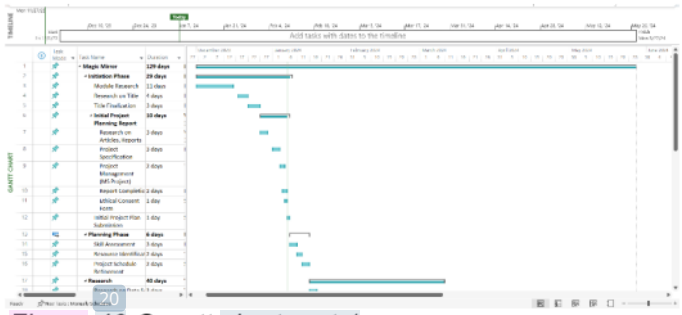

Figure 46:Grantt chart part 1

Figure 47:Grantt chart part 2

Figure 48:Grantt chart part 1

9.3 Risk Management

Several risks were identified during the project planning phase for this project. One of the impactful risks was the lacking training data which may cause huge impact on the project, another risk was facial recognition accuracy with model not being able to identify the face shape. Additionally, other risks include database of hairstyle, as many hairstyles may be outdated or may not cover different

hairstyles available. Integration of these into a web application may also cause problem with compatibility challenges.

ID	Risk	Risk Description	Likelihood	Impact	Severity	Owner	Mitigation	Status
1	Inadequate Training Data	There may be lack of face portrait image to train the model	High	High	High	Ayush	Diverse Data Collection	Open
2	Facial Recognition Accuracy	Model may not accurately identify and analyze face shapes	Medium	High	High	Ayush	Test model with diverse data	Open
3	Hairstyle Database Relevance	Hairstyle may be outdated or may not cover diverse preference	Medium	Low	Low	Ayush	Update the database with new trends	Open
4	Integration Challenges	Integrating facial recognition module, hairstyle database and user interface may encounter challenges in compatibility	Medium	High	High	Ayush	Conduct comprehensive integration testing to identify and address compatibility issue	Open

Figure 49: Risk Register

To mitigated these risks in this project, various diverse data were collected to ensure a robust training dataset also tested multiple models in diverse data to enhance facial recognition accuracy. The hairstyle database was updated according to tends and conducting comprehensive integration testing to identify and address compatibility issue.

9.3.1 Logistical Challenges

Collecting a diverse set of data suitable for different face shapes was a logistic challenge and developing a user-friendly interface that is easy to navigate and to make interface look good, was also a logistic challenge as well and to test these

the survey conducted and seeking feedback from different users was quite a challenge.

Despite these challenges, the project was completed by overcoming the obstacles and achieving the objectives of this project.

9.3 Lesson Learned

Through this project, several valuable lessons were learned. First about ML, with this being a new topic, a lot of things were learned including, how to preprocess the data or use a model. How to read and interpret ML documentation was a crucial lesson as it allowed to leverage the existing models and libraries effectively.

Testing was another critical area of learning. The importance of testing in development was taught by the numerous bugs and issue encountered during development. Learned, how to test a product and see the errors and implement solutions to the error. This experience highlighted the importance of robust testing strategy to ensure the final product's reliability and performance.

Time management came out as a key skill. Following the Scrum methodology required good planning and following the timeline, this method of having a task completed within a sprint duration, helped in project tracking and meeting deadlines.

9.4 Areas for Improvement

While the project was largely successful, several areas for improvement were identified in this project, one of the technical challenge was integrating React using CORS (Cross-Origin Resource Sharing) policies, as this error forced the project's frontend to be written in pure HTML and CSS instead of more dynamic React framework.

Documentation was another place where improvement was required as the lack of good documentation created problem, particularly during testing phase. Better documentation would have made the development process smoother.

10. Summary and Conclusion

10.1 Recap of Key Findings

This project was successful, and a web application was created that is able to identify the user's face shape and give recommendation for suitable hairstyles based on detected face shapes. This web application uses two methods to detect face shape one is SVM and another is Rule-based. For SVM, it has 3 kernels with linear, radial basis function (RBF) and polynomial, and among them, RBF was chosen and it had an accuracy of 98%. This accuracy is extremely high than rule-based method which had an accuracy of around 20%, which is extremely low, but with addition of more edges by using more vertices, the rule-based has the potential to achieve high accuracy. Rule-based can be useful as it requires less computational power and speed than machine learning and this can make it viable in device which lacks more computational more than other stronger devices. So, there is potential research on rule based to make it viable for the face shape prediction and hair recommendation. In this project the hairstyle recommendation is totally dependent on the face shape predicted by those approaches.

10.2 Implications and Applications

There were some findings on this project and these findings may have some impact on the industry of hairstyle and personal grooming. With the high accuracy received by RBF kernel SVM when tested, it suggests that machine learning methods can be used to find personalized hairstyle for a person, which can help the person to feel more confident. This method can also be used in different field of beauty industry to virtualize makeover, to get different color of hair to test them, to applying different shades of lipsticks. As for rule-based-method, if it is enhanced then it can be used on device like smartphones and

tablets, as it will require less computational power. With this product, the users can gain confidence in their physical appearance by trying the recommended hairstyles.

10.3 Final Thoughts

This project shows how machine learning can be combined with web application to create user-friendly applications, that can be used by people to personalize the hairstyles. Here, SVM with RBF kernel showed its effectiveness with its high accuracy to predict the face shape, while rule-based approach shows the importance of stronger algorithms to increase the accuracy of face shape prediction. In future, there could be focus on improving the accuracy of rule-based by using more edges and vertices to draw line on the face from landmarks. There could be more different hairstyle options based on recent trends to populate the databased and there could be a new feature to generate hair on the images so that user can checks how the hairstyle looks on them. Overall, the project highlights the huge potential of computers in field of personal grooming and self-expression.

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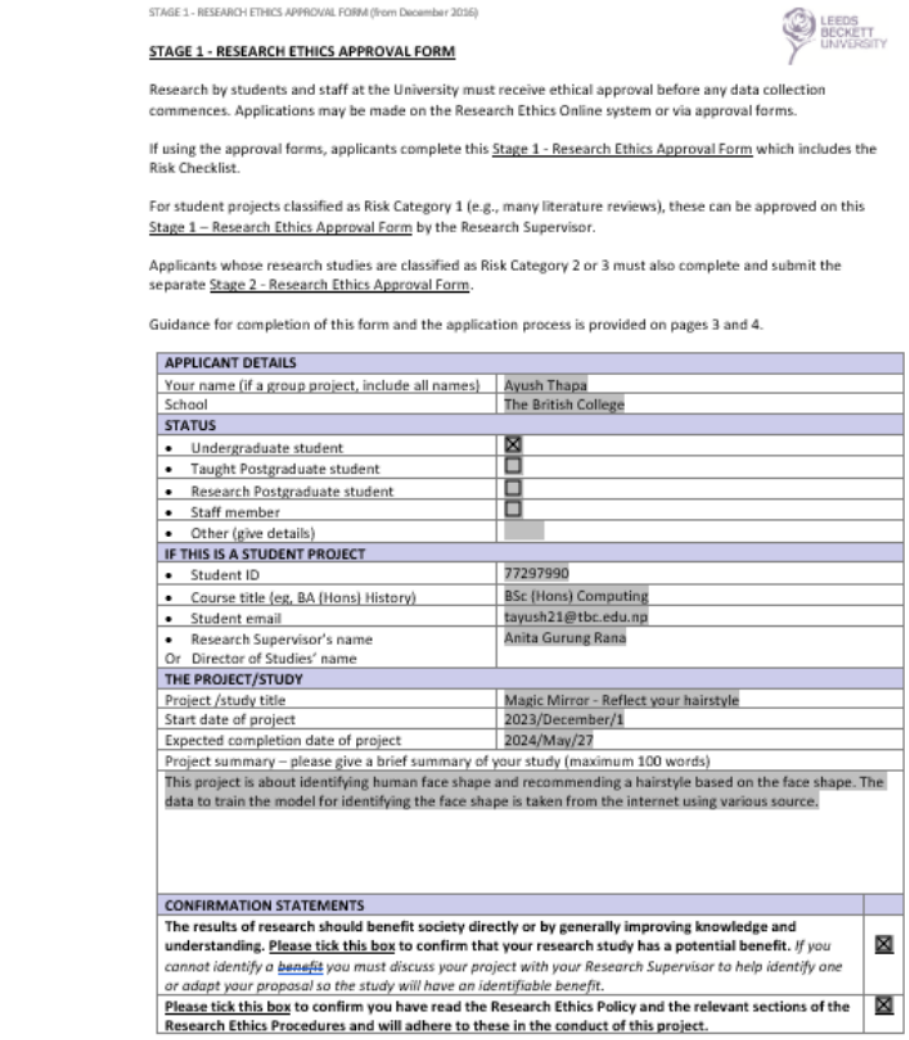
12. Appendices

1) Consent Form

a. Stage 1



STAGE 1 - RESEARCH ETHICS APPROVAL FORM (from December 2016)

STAGE 1 - RESEARCH ETHICS APPROVAL FORM

Research by students and staff at the University must receive ethical approval before any data collection commences. Applications may be made on the Research Ethics Online system or via approval forms.

If using the approval forms, applicants complete this Stage 1 - Research Ethics Approval Form which includes the Risk Checklist.

For student projects classified as Risk Category 1 (e.g., many literature reviews), these can be approved on this Stage 1 – Research Ethics Approval Form by the Research Supervisor.

Applicants whose research studies are classified as Risk Category 2 or 3 must also complete and submit the separate Stage 2 - Research Ethics Approval Form.

Guidance for completion of this form and the application process is provided on pages 3 and 4.

APPLICANT DETAILS	
Your name (if a group project, include all names)	Ayush Thapa
School	The British College
STATUS	
• Undergraduate student	☒
• Taught Postgraduate student	☐
• Research Postgraduate student	☐
• Staff member	☐
• Other (give details)	
IF THIS IS A STUDENT PROJECT	
• Student ID	77297990
• Course title (eg, BA (Hons) History)	BSc (Hons) Computing
• Student email	tayush21@tbc.edu.np
• Research Supervisor's name Or Director of Studies' name	Anita Gurung Rana
THE PROJECT/STUDY	
Project /study title	Magic Mirror - Reflect your hairstyle
Start date of project	2023/December/1
Expected completion date of project	2024/May/27
Project summary – please give a brief summary of your study (maximum 100 words)	
This project is about identifying human face shape and recommending a hairstyle based on the face shape. The data to train the model for identifying the face shape is taken from the internet using various source.	

CONFIRMATION STATEMENTS	
The results of research should benefit society directly or by generally improving knowledge and understanding. Please tick this box to confirm that your research study has a potential benefit. *If you cannot identify a benefit you must discuss your project with your Research Supervisor to help identify one or adapt your proposal so the study will have an identifiable benefit.*	☒
Please tick this box to confirm you have read the Research Ethics Policy and the relevant sections of the Research Ethics Procedures and will adhere to these in the conduct of this project.	☒

Figure 50: Consent form stage 1 pic 1

RISK CHECKLIST - Please answer ALL the questions in each of the sections below – tick YES or NO WILL YOUR RESEARCH STUDY.....?		YES	NO
1	Involve direct and/or indirect contact with human participants?	☐	☐
2	Involve analysis of pre-existing data which contains personal or sensitive information not in the public domain?	☐	☒
3	Require permission or consent to conduct?	☐	☒
4	Require permission or consent to publish?	☐	☒
5	Have a risk of compromising confidentiality?	☐	☒
6	Have a risk of compromising anonymity?	☐	☒
7	Collect / contain sensitive personal data?	☒	☐
8	Contain elements which you OR your supervisor are NOT trained to conduct?	☐	☒
9	Use any information OTHER than that which is freely available in the public domain?	☐	☒
10	Involve respondents to the internet or other visual/vocal methods where participants may be identified?	☐	☒
11	Include a financial incentive to participate in the research?	☐	☒
12	Involve your own students, colleagues or employees?	☐	☒
13	Take place outside of the country where you are enrolled as a student, or for staff, outside of the UK?	☐	☒
14	Involve participants who are particularly vulnerable or at risk?	☐	☒
15	Involve any participants who are unable to give informed consent?	☐	☒
16	Involve data collection taking place BEFORE informed consent is given?	☐	☒
17	Involve any deliberate deception or covert data collection?	☐	☒
18	Involve a risk to the researcher or participants beyond that experienced in everyday life?	☐	☒
19	Cause (or could cause) physical or psychological harm or negative consequences?	☐	☒
20	Use intrusive or invasive procedures?	☐	☒
21	Involve a clinical trial?	☐	☒
22	Involve the possibility of incidental findings related to health status?	☐	☒
23	Fit into any of the following security-sensitive categories: concerns terrorist or extreme groups; commissioned by the military; commissioned under an EU security call; involves the acquisition of security clearances? If yes, see the guidance.	☐	☒

CLASSIFICATION The following guidance will help classify the risk level of your study	Tick the box which applies to your project
If you answered **NO** to all the above questions, your study is provisionally classified as **Risk Category 1** (literature reviews will be Risk Category 1).	☐
If you answered **YES** to any question from 1-13 and **NO** to all questions 14-22, your study is provisionally classified as **Risk Category 2**.	☒
If you answered **YES** to any question from 14-22, your study is provisionally classified as **Risk Category 3**.	☐
If question 23 has been answered **YES**, your application will be reviewed by the Chair of the University Research Ethics Sub-committee	☐

Figure 51: Consent form stage 1 pic 2

DECLARATION AND SIGNATURE/S

I confirm that I will undertake this project as detailed above. I understand that I must abide by the terms of the approval and that I may not make any substantial amendments to the project without further approval.

Signed		*Date*	2023/January/30

FOR RISK CATEGORY 1 STUDENT PROJECTS

Approval from the Research Supervisor or Director of Studies for a student project:

I have discussed the ethical issues arising from the project with the student. I approve this project.

Name	Sukant Kumar Sahu	*Signed*		*Date*	2023/January/30

NEXT STEP

RISK CATEGORY 1 PROJECTS: IF YOUR PROJECT HAS BEEN CLASSIFIED AS RISK CATEGORY 1:

- Students: The Research Supervisor should return the signed form to the student and send a copy to the Local Research Ethics Co-ordinator and where relevant, the Research Module Leader, for information.
- Staff: Submit this form to your Local Research Ethics Co-ordinator.

RISK CATEGORY 2 OR 3 PROJECTS: IF YOUR PROJECT HAS BEEN CLASSIFIED AS RISK CATEGORY 2 OR 3 please complete the Stage 2 - Research Ethics Approval form and submit both forms together with supporting documentation.

QUESTION 23: If this question has been answered **YES**, your application will be reviewed by the Chair of the University Research Ethics Sub-committee, and the forms should be submitted directly to Professor Karl Spracklen, k.spracklen@leedsbeckett.ac.uk. You will need to submit the Security-sensitive research form available from the Research Ethics web page.

Research ethics application forms will be retained in the ~~School~~ for the purposes of quality assurance of compliance and audit for THREE years

NOTES FOR COMPLETION

University Research Ethics Policy and Procedures: The University Research Ethics Policy and Research Ethics Procedures should be read prior to commencing this application. Consideration of the application by the reviewer/s will be undertaken in accordance with the Policy and Procedures.

External requirements for the project: Applicants should consider if there are requirements by any relevant professional, statutory or regulatory body, or learned society, which may be relevant to the project or if the project also requires external approval.

Submission

- Student applicants: email the typed form/s to your Research Supervisor or Director of Studies.
- Staff applicants: email the typed form/s to your Local Research Ethics Co-ordinator.

How to complete the form

You can navigate through the form by using the tab keys. If you prefer to complete a normal Word document, you can unlock the form by selecting the 'Restrict Editing' button on the Developer tab, then click on 'Stop Protection'. The boxes should expand to allow space for your text.

Figure 52: Consent form stage 1 pic 3

Signatures

Electronic/typed signatures are acceptable for emailed forms, as the emails provide the audit trail for all parties' agreement and approval of the forms (e.g., student applicant →Research Supervisor →Local Research Ethics Co-ordinator).

Outcome

Applicants will be advised of the outcome of the application by receipt of the signed form fromm:

- The Research Supervisor or Director of Studies for Risk Category 1 student projects;
- The Local Research Ethics Co-ordinator or the School level group for Risk Category 2 and 3 projects.

YOU MAY ONLY BEGIN ANY DATA COLLECTION ONCE YOU RECEIVE NOTIFICATION THAT THE PROJECT HAS ETHICAL APPROVAL. If the circumstances of your research study change after approval it is your responsibility to revisit the Risk Checklist and complete a further application.

Advice

When completing the Stage 1 - Research Ethics Approval ~~Form~~, if you are uncertain about the answer to any question, read the relevant section of the Research Ethics Procedures document, and if you are still unsure:

- if you are student, seek guidance from your Research Supervisor or Director of Studies;
- if you are a staff member, contact your Local Research Ethics Co-ordinator.

Figure 53: Consent form stage 1 pic 4

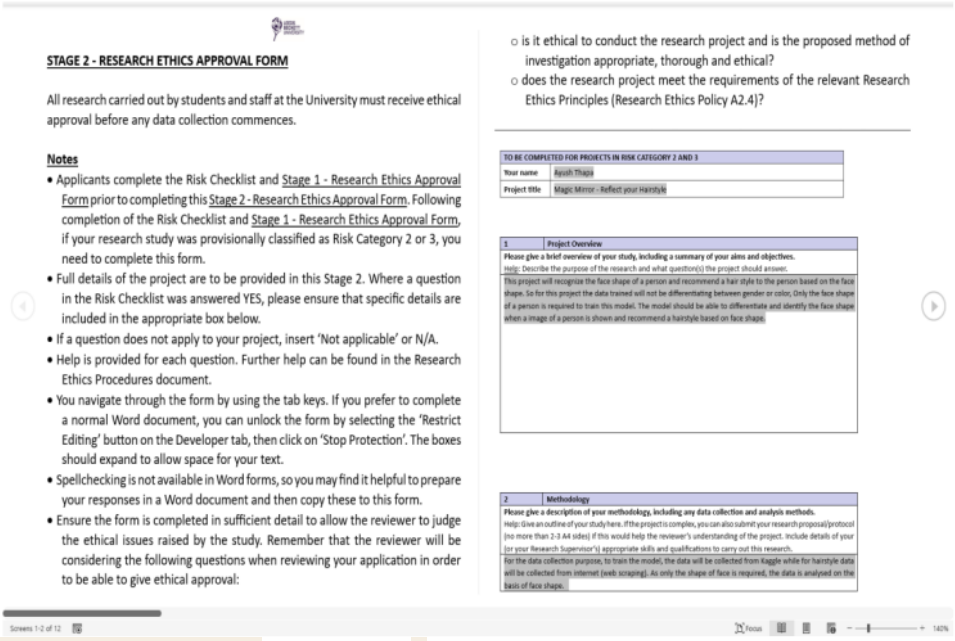
APPROVAL PROCESS

- Local Research Ethics Co-ordinator = LREC
- School level group (if your School uses a different review process, please follow your ~~School~~ guidance)
- University Research Ethics Sub-Committee = URESC

Category	Student applicants	Staff applicants
Risk Category 1	If your study has been provisionally classified as Risk Category 1, your Research Supervisor (or Director of Studies) can normally give approval for the project. You must complete this form and submit it to your Research Supervisor for consideration. A copy of the signed form if approved must be given or emailed to the LREC and, where relevant, the Research Module Leader, for information.	If your study has been classified as Risk Category 1, you do not need ethical approval for the project. You must complete the remainder of this form so that your research project is registered with the University. Please submit this form to your LREC.
Risk Category 2	If your study has been provisionally classified as Risk Category 2, your ~~Supervisor~~ (or Director of Studies) can recommend approval for your study by the LREC. You must complete this application form and also the separate Stage 2 - Research Ethics Approval form. Once you have completed the ~~forms~~ please submit both forms and supporting documentation to your Research Supervisor for consideration. Your ~~Supervisor~~ may disagree with your assessment and ask you to make revisions or reject your application. When the Research Supervisor is happy to recommend the application for approval, they will send the forms to the LREC. The LREC will review your project and then decide to approve it, ask for revisions, reject it or pass it on for review by the ~~School~~ level group.	If your study has been provisionally classified as Risk Category 2, your project will be considered for ethical approval by the LREC. You must complete this application form and also the separate Stage 2 - Research Ethics Approval form. Please submit both forms and supporting documentation to your LREC for consideration. The LREC will review your project and then decide to approve it, ask for revisions or pass it on for review by the ~~School~~ level group.
Risk Category 3	**Postgraduate Research Students** If your study has been provisionally classified as Risk Category 3, your ~~Supervisor~~ or Director of Studies can recommend approval for your study by the LREC. You must complete this application form and also the separate Stage 2 - Research Ethics Approval form and submit both forms to your Director of Studies. If your Director of Studies recommends approval of your ~~project~~ they will refer it to the LREC who will review your project and decide whether to grant ethical approval, request revisions, reject the application or refer it to the School level group for review. **Undergraduate and Taught Postgraduate Students** If your study has been provisionally classified as Risk Category 3, you should consult with your Research Supervisor immediately as it is unlikely you will be able to proceed and you should negotiate a project that is of lower risk. However, if you have already discussed the project with your ~~Supervisor~~ and they have agreed that a case for approval is warranted, proceed in line with the details above for Research Students.	If your study has been provisionally classified as Risk Category 3, your project will be considered for ethical approval by an appropriate LREC. You must complete this application form and also the separate Stage 2 - Research Ethics Approval form and submit both forms with supporting documentation to your LREC. The LREC will review your project and then decide to approve it, ask for revisions or pass it on for review by the ~~School~~ level group.
Q23	If question 23 has been answered 'yes', your application will be reviewed by the Chair of the University Research Ethics Sub-committee. The answer does not affect the Risk Category.	

Figure 54: Consent form stage 1 pic 5

b. Stage 2



STAGE 2 - RESEARCH ETHICS APPROVAL FORM

All research carried out by students and staff at the University must receive ethical approval before any data collection commences.

Notes

- Applicants complete the Risk Checklist and Stage 1 - Research Ethics Approval Form prior to completing this Stage 2 - Research Ethics Approval Form. Following completion of the Risk Checklist and Stage 1 - Research Ethics Approval Form, if your research study was provisionally classified as Risk Category 2 or 3, you need to complete this form.
- Full details of the project are to be provided in this Stage 2. Where a question in the Risk Checklist was answered YES, please ensure that specific details are included in the appropriate box below.
- If a question does not apply to your project, insert 'Not applicable' or N/A.
- Help is provided for each question. Further help can be found in the Research Ethics Procedures document.
- You navigate through the form by using the tab keys. If you prefer to complete a normal Word document, you can unlock the form by selecting the 'Restrict Editing' button on the Developer tab, then click on 'Stop Protection'. The boxes should expand to allow space for your text.
- Spellchecking is not available in Word forms, so you may find it helpful to prepare your responses in a Word document and then copy these to this form.
- Ensure the form is completed in sufficient detail to allow the reviewer to judge the ethical issues raised by the study. Remember that the reviewer will be considering the following questions when reviewing your application in order to be able to give ethical approval:
  - is it ethical to conduct the research project and is the proposed method of investigation appropriate, thorough and ethical?
  - does the research project meet the requirements of the relevant Research Ethics Principles (Research Ethics Policy A2.4)?

TO BE COMPLETED FOR PROJECTS IN RISK CATEGORY 2 AND 3	
Your name	Ayush Thapa
Project title	Magic Mirror - Reflect your Hairstyle

1	Project Overview
Please give a brief overview of your study, including a summary of your aims and objectives.	
Help: Describe the purpose of the research and what question(s) the project should answer.	
This project will recognize the face shape of a person and recommend a hair style to the person based on the face shape. So for this project the data trained will not be differentiating between gender or color, Only the face shape of a person is required to train this model. The model should be able to differentiate and identify the face shape when a image of a person is shown and recommend a hairstyle based on face shape.	

2	Methodology
Please give a description of your methodology, including any data collection and analysis methods.	
Help: Give an outline of your study here. If the project is complex, you can also submit your research proposal/protocol (no more than 2-3 A4 sides) if this would help the reviewer's understanding of the project. Include details of your (or your Research Supervisor's) appropriate skills and qualifications to carry out this research.	
For the data collection purpose, to train the model, the data will be collected from Kaggle while for hairstyle data will be collected from internet (web scraping). As only the shape of face is required, the data is analysed on the basis of face shape.	

30

Figure 55: Consent form stage 2 pic 1

Research supervisor's appproriate skills and qualification: Not available.

3	Main Ethical Considerations
Please give a brief description of the main ethical considerations involved in the study. Help: All research projects will have ethical issues, and you will be asked later in the process on recruitment, voluntary participation and the right to withdraw, but highlight here the main ethical considerations for your study (which may concern, e.g., the type of participants, the sensitive nature of the study, the data collection process, a lone researcher carrying out research off-campus, security-sensitive research) and advise how you will address the main issues. If the project is funded, give details here, and whether there are any potential conflicts of interest involved in the study.	
All the data will be collected from the internet the involvement of any other direct people is not required , so the ethical issue of the voluntary participation and right to withdrawn is not applicable.	

4	Human Participants
If your study includes Human Participants (or their data), please give a description of who will be included. Help: • Please note this should include sample size/number of participants, whether the project will focus on any particular groups/individuals, if it will include any at risk or vulnerable participants, participants aged 16 years or under, etc. Please also specify your rationale for including / excluding groups of participants. • If the research involves secondary data not in the public domain, give details in this section.	
No direct human participants, all the data are available in public domain.	

5	Recruitment, Voluntary Participation, Consent and Right to Withdraw
If your study includes Human Participants, please give a brief description of the recruitment process, how you will ensure voluntary participation, if (and how) informed consent will be obtained prior to participants taking part in the study, and the right of withdrawal from the research process. Help: • This should include clear information on how participants will be identified, approached and recruited; whether the study will include any covert research or deliberate deception; whether help is required from a third party/ gatekeeper to access participants; what information you will give participants, etc. • If expenses or any incentives are to be offered to participants, give full details. • If your research involves students, colleagues and/or other employees then you must specify the rationale for this and how you will address issues of coercion or feelings of obligation. • Regarding withdrawal from the study, discuss the different stages/dates a participant could withdraw or withdraw their data, and how they could do this.	
Not applicable	

6	Risks and Benefits
Please give a brief description of how, when and where the research will take place and whether there are any risks and/or benefits involved. Help: • This should include information on what participants will be required to do, the rationale for this and the level of risk involved. • When considering risks, please refer to risks to the participants (e.g., for research in sensitive areas), the researcher, any other parties to the research; and also any health and safety issues for anyone involved (e.g., for lone researchers carrying out fieldwork). • If participants will be exposed to ionising radiation, separate approval documentation must be submitted with this application.	
Not applicable	

Figure 56: Consent form stage 2 pic 2

7	Personal Data, Anonymity and Confidentiality
Please specify what type of information/data will be collected/analysed and the source(s). In addition, specify if and how you will ensure the anonymity of participants and keep information confidential. Help: This should include information on whether you are collecting new information/data or using that that is already in the public domain; whether the data you are using includes personal details; how the data will be processed and stored; who will have access to it; how and when it will be destroyed; the Data Protection requirements for any sensitive personal data, etc. In addition, include whether there may be any requirements for disclosure of information to other parties due to professional practice or legal reasons. If there are limits to confidentiality, explain clearly how the participants would be advised about these limits and possible outcomes.	
The data are already available in public domain, the data include the image of people sperated based on face shape. The data will only be used to train the model and after the completion of training of model the data will be destroyed.	

8	Reporting and Dissemination
Please give details of the planned dissemination and specify if the findings from the research will be published and whether any permission is required for this. Help: This should include information on the methods of dissemination (e.g., dissertation/thesis) and/or what will be published and where (research papers, conference presentations). Specify if any permission is needed (e.g., from participants, clients, gatekeepers, etc.) prior to publication, and whether there are any potential issues relating to Intellectual Property Rights when creating or using materials.	
Not applicable	

9	Location of research
Will the research take place outside of the country where you are enrolled as a student, or for staff, outside of the UK?	
YES ☐ NO ☒ **If yes, give details below.** Help: If yes, please specify where the research will take place and what will be involved. Research must comply with the laws of the country where it is taking place and also comply with local Data Protection and Intellectual Property legislation: you must confirm that your research is compliant with local requirements and how you have ascertained this. Advise if the project requires ethical approval in-country and how this has been ascertained. If approval is required, a copy of this should be included in the application or details of the process of how it will be obtained. Please make reference to insurance and indemnity cover for the project where relevant.	
Not applicable	

10	Collaborative Projects
Is the research is a collaborative project (i.e., it involves more than one institution)?	
YES ☐ NO ☒ **If yes, give details below.** Help: If yes, please specify the other institutions involved and if ethical approval needs to be / has been given by them. Please also specify what procedures have been put in place to ensure ethical compliance from all partners.	

11	Any other permission or external ethical approval required to undertake the project

Figure 57: Consent form stage 2 pic 3

Please specify if the project requires any other ethical approval or permissions not mentioned previously in this application and how and when these will be obtained. Help: • Other permissions: ethical approval does not give the right of access to the University's students, staff or the use of University premises to carry out research, and you may need to contact an appropriate University gatekeeper for agreement to approach potential participants or for the use of premises, so please give details. • Gatekeepers: permission of a gatekeeper for initial access to participants may be required or to carry out data collection on their premises. • If your project requires approval from an external ethics committee, this should normally be obtained prior to submitting this application. • If a Disclosure and Barring Service check is required due to the specific participant group, give details. • Regarding insurance and indemnity cover, some projects will require individual confirmation of cover. See the Research Ethics Procedures document for more details.
Not applicable

FOR PROJECTS INVOLVING RISK CATEGORY 2 AND 3: DECLARATION AND SIGNATURE/S			
APPLICANT (STUDENT/STAFF MEMBER/RESEARCHER)			
I confirm that I will undertake this project as detailed in stage one and stage two of the application. I understand that I must abide by the terms of this approval and that I may not make any substantial amendments to the project without further approval. I understand that research with human participants or their data must not commence without ethical approval.			
I have read an appropriate professional or learned society code of ethical practice:	Yes ☒ N/A ☐		
Where applicable, give the name of the professional or learned society:	Ayush Thapa		
Signed	[redacted]	*Date*	2024/January/30

RESEARCH SUPERVISOR/DIRECTOR OF STUDIES RECOMMENDATION FOR STUDENT PROJECTS					
I confirm that I have read stage one and stage two of the application. The project is viable and the student has appropriate skills to undertake the project. Where applicable, the Participant Information Sheet and recruitment procedures for obtaining informed consent are appropriate and the ethical issues arising from the project have been addressed in the application. I understand that research with human participants must not commence without ethical approval. I recommend this project for approval.					
Name	Anita Gurung Rana	*Signed*	[redacted]	*Date*	2024/January/30

Figure 58: Consent form stage 2 pic 4

2) Meeting Records

School of Computing, Creative Technologies and Engineering 2022/23

Level 6 Production Project

MEETING RECORD SHEET: Meeting Number: 01

Student: Ayush Thapa	**Student I.D.:** 7729990
Date of Meeting: 2024/02/20	**Supervisor:** Sukant Kumar Sahu

Actions agreed at previous meeting (completed or comment):

1		☐
2		☐
3		☐
4		☐
5		☐
6		☐

Comments of student (if any):

ABOVE here – student to complete before Meeting with supervisor. BELOW here – complete at the Meeting.

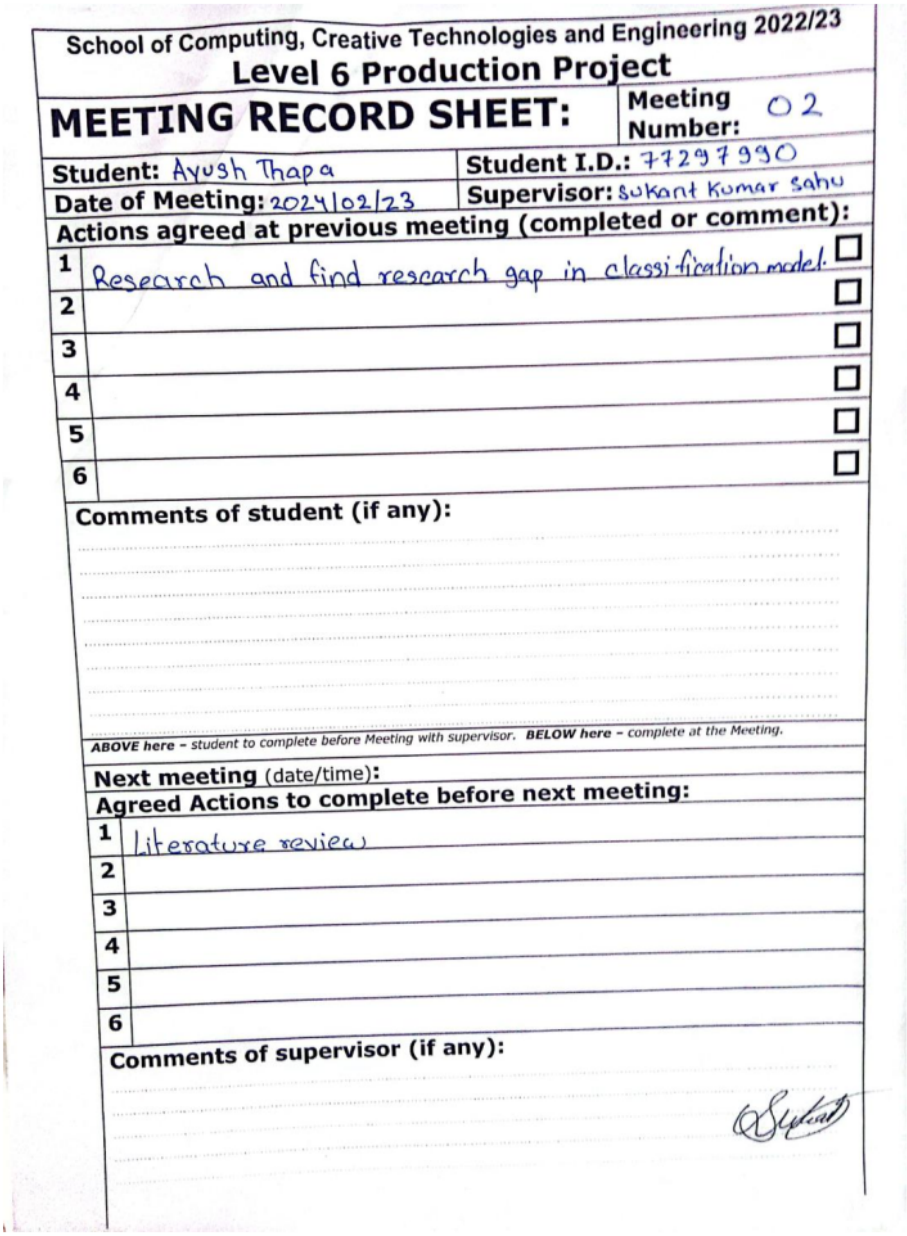
Next meeting (date/time):

Agreed Actions to complete before next meeting:

1	Research and find research gap in classification model.
2	
3	
4	
5	
6	

Comments of supervisor (if any):

Figure 59: Supervisor meeting number 1



School of Computing, Creative Technologies and Engineering 2022/23

Level 6 Production Project

MEETING RECORD SHEET: Meeting Number: 02

Student: Ayush Thapa | Student I.D.: 77297990

Date of Meeting: 2024/02/23 | Supervisor: Sukant Kumar Sahu

Actions agreed at previous meeting (completed or comment):

1	Research and find research gap in classification model.	☐
2		☐
3		☐
4		☐
5		☐
6		☐

Comments of student (if any):

ABOVE here – student to complete before Meeting with supervisor. BELOW here – complete at the Meeting.

Next meeting (date/time):

Agreed Actions to complete before next meeting:

1	Literature review
2	
3	
4	
5	
6	

Comments of supervisor (if any):

Sukant

Figure 60: Supervisor meeting number 2

School of Computing, Creative Technologies and Engineering 2022/23

Level 6 Production Project

MEETING RECORD SHEET: Meeting Number: 03

Student: Ayush Thapa	**Student I.D.:** 77297990
Date of Meeting: 2024/02/27	**Supervisor:** Sukant Kumar Sahu

Actions agreed at previous meeting (completed or comment):

1	Literature Review for classification model	☐
2		☐
3		☐
4		☐
5		☐
6		☐

Comments of student (if any):

ABOVE here – student to complete before Meeting with supervisor. BELOW here – complete at the Meeting.

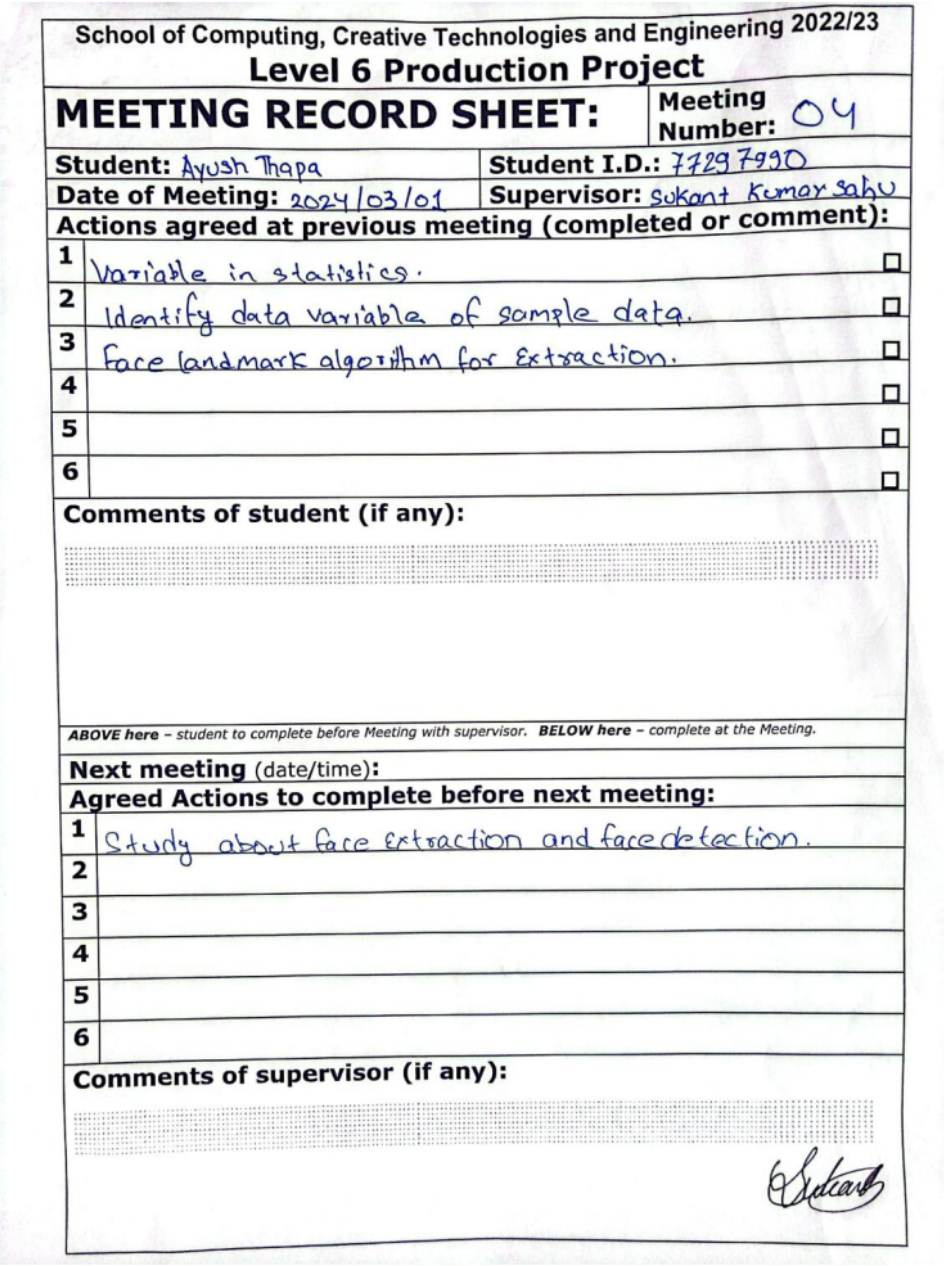
Next meeting (date/time):

Agreed Actions to complete before next meeting:

1	Variable in statistics.
2	Identify data variable of sample data.
3	Face landmark etraction algorithms.
4	
5	
6	

Comments of supervisor (if any):

Figure 61: Supervisor meeting number 3



School of Computing, Creative Technologies and Engineering 2022/23

Level 6 Production Project

MEETING RECORD SHEET: Meeting Number: 04

Student: Ayush Thapa	**Student I.D.:** 77297990
Date of Meeting: 2024/03/01	**Supervisor:** Sukant Kumar Sahu

Actions agreed at previous meeting (completed or comment):

1	Variable in statistics.	☐
2	Identify data variable of sample data.	☐
3	Face landmark algorithm for extraction.	☐
4		☐
5		☐
6		☐

Comments of student (if any):

***ABOVE here** – student to complete before Meeting with supervisor. **BELOW here** – complete at the Meeting.*

Next meeting (date/time):

Agreed Actions to complete before next meeting:

1	Study about face extraction and face detection.
2	
3	
4	
5	
6	

Comments of supervisor (if any):

Figure 62: Supervisor meeting number 4

School of Computing, Creative Technologies and Engineering 2022/23

Level 6 Production Project

MEETING RECORD SHEET: **Meeting Number:** 05

Student: Arush Thapa **Student I.D.:** 77297990

Date of Meeting: 2024/3/05 **Supervisor:** Sukant Kumar Sahu

Actions agreed at previous meeting (completed or comment):

1	Study about face extraction and face detection	☐
2		☐
3		☐
4		☐
5		☐
6		☐

Comments of student (if any):

ABOVE here *– student to complete before Meeting with supervisor.* ***BELOW here*** *– complete at the Meeting.*

Next meeting (date/time)**:**

Agreed Actions to complete before next meeting:

1	Looking into Image preprocessing
2	
3	
4	
5	
6	

Comments of supervisor (if any):

Sukant

Figure 63: Supervisor meeting number 5

School of Computing, Creative Technologies and Engineering 2022/23

Level 6 Production Project

MEETING RECORD SHEET: Meeting Number: 08

Student: Ayush Thapa	**Student I.D.:** 77297990
Date of Meeting: 2024/03/15	**Supervisor:** Sukant Kumar Sahu

Actions agreed at previous meeting (completed or comment):

1	More research on ways to identify face shape	☐
2	Learn about different types of classification model	☐
3		☐
4		☐
5		☐
6		☐

Comments of student (if any):

***ABOVE here** – student to complete before Meeting with supervisor. **BELOW here** – complete at the Meeting.*

Next meeting (date/time):

Agreed Actions to complete before next meeting:

1	Learn about ways to recommend hairstyles.
2	
3	
4	
5	
6	

Comments of supervisor (if any):

Figure 64: Supervisor meeting number 8

School of Computing, Creative Technologies and Engineering 2022/23

Level 6 Production Project

MEETING RECORD SHEET: Meeting Number: 10

Student: Aayush Thapa | Student I.D.: 77257990

Date of Meeting: 2024/04/16 | Supervisor: Sukant Kumar Sahu

Actions agreed at previous meeting (completed or comment):

1	Implementation of prototype to start working	☐
2		☐
3		☐
4		☐
5		☐
6		☐

Comments of student (if any):

ABOVE here – student to complete before Meeting with supervisor. BELOW here – complete at the Meeting.

Next meeting (date/time):

Agreed Actions to complete before next meeting:

1	Working on prototype to learn Image processing.
2	
3	
4	
5	
6	

Comments of supervisor (if any):

Sukant

Figure 65: Supervisor meeting number 10

3) User guidelines

Figure 66: User guidelines

c7297990_Ayush_Thapa_Final_Year_Report

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