Final Year Project Report

Hairstyle Modelling System

B.S. in Computer Engineering, Batch 2020

Project Advisor

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DEPARTMENT OF COMPUTER ENGINEERING

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February 2024

Sir Syed University of Engineering & Technology, Karachi
Computer Engineering Department
Rubrics for FYDP Report Assessment

Criteria (100%) 40 Marks	**Excellent (>=90%) 4.5 – 5 Marks**	**Good (70-89%) 3.5 – 4.4 Marks**	**Fair (50-69%) 2.5 – 3.4 Marks**	**Poor (<50%) 2.5 Marks**
C1 Abstract PLO-10 Communication 5 Marks	The abstract provides an excellent overview of the project	The abstract provides a good overview of the project	Abstract provides a reasonable description of the project but needs improvement	Abstract is poorly written.
C2 Literature & References PLO-2 Problem Analysis 5 Marks	Literature is well-written and structured as per standards and covered all relevant material to the project. References are cited properly using a standard format	Literature is well-written but not properly structured as per standards and covered most of the material relevant to the project. References are cited using a standard format	Literature is not properly written and structured as per standards, but covered most of the material relevant to the project. References are cited using a standard format	Literature is poorly written, poorly structured and does not covered the relevant material to the project. References are cited using a standard format.
C3 Problem Statement PLO-2 Problem Analysis 5 Marks	Problem statement is stated and covered sufficient justification. New reader can clearly understand its value and context	Problem statement is stated and covered necessary justification with reference.	Problem statement is stated but lacks necessary justification.	Problem statement is vaguely stated without any justification
C4 Methodology PLO-4 Investigation 5 Marks	The methods, approaches, tools, techniques, algorithms, or other aspects of the solution are well-described with sufficient details and supporting diagrams.	The methods, approaches, tools, techniques, algorithms, or other aspects of the solution are well-described. However further explanation is required.	The methods, approaches, tools, techniques, algorithms, or other aspects of the solution are described but not in a convincing manner.	Some aspects of the solution are described briefly but much ofthe description is left out.
C5 Implementation and Testing PLO-5 Modern Tool Usage 5 Marks	Both implementation and testing of a system, are precisely performed with accuracy and provide all necessary details for the reader.	Both implementation and testing of a system, are performed with the necessary details for the reader.	Implementation of a system, are performed with the necessary details for the reader. But testing of a system is not properly performed.	Both implementation and testing of a system, are not properly performed with lack of details.
C6 Results PLO-4 Investigation 5 Marks	Includes all key results of the project. Appropriate graphs, figures and tables are included for effective interpretation and explanation of the results.	Includes most of the key results of the project. Graphs, figures and tables are included for effective interpretation and explanation of the results.	Includes few key results of the project. Graphs, figures and tables are included with limited interpretation and explanation of the results.	Key results of the project are missing. Graphs, figures and tables are not included.

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C7 **Conclusion** **PLO-4** **Investigation** **5 Marks**	All important aspects of the project are well-summarized with the sense of closure and demonstrates the major outcome(s) of the project.	Most of the important aspects of the project are well-summarized with the sense of closure and demonstrates the outcome(s) of the project.	Few aspects of the project are summarized with the sense of closure and demonstrates the outcome(s) of the project.	Important aspects of the project are not clearly summarized with.
C8 **Language and Grammar, Formatting Style** **PLO- 8** **Ethics** **PLO- 10** **Communication** **5 Marks**	Almost no spelling or grammatical mistake with an acceptable similarity index. Formatting style of chapters, table of contents, title page, references and appendices are proper and relevant.	Occasional spellings and grammatical errors that have only minor impact on flow of reading with acceptable similarity index Formatting style of chapters, table of contents, title page, references and appendices are proper.	Occasional spellings and grammatical errors with high but acceptable similarity index Formatting style is proper but figures and tables don't follow standard practice (caption figure number etc.)	Frequent spellings and grammatical errors that impede the reading flow with very high similarity index. The formatting of the chapters may need improvement.

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Mapping of FYDP Report Chapters with the Programme Learning Outcomes (PLOs)

	PLO 10 Communication (C1)	**PLO 2** Problem Analysis (C2)	**PLO 2** Problem Analysis (C3)	**PLO 4** Investigation (C4)	**PLO 5** Modern Tool Usage (C5)	**PLO 4** Investigation (C6)	**PLO 4** Investigation (C7)	**PLO 8** Ethics **PLO 10** Communication (C8)
Chapter 1 Chapter Name								
Chapter 2 Chapter Name								
Chapter 3 Chapter Name								
Chapter 4 Chapter Name								
Chapter 5 Chapter Name								
Chapter 6 Chapter Name								
Chapter 7 Chapter Name								
Chapter 8 Chapter Name								

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Criteria	Excellent (>=90%)	Good (70-89%)	Fair (50-69%)	Poor (<50%)
C1 Abstract PLO-10	The abstract provides an excellent overview of the project	The abstract provides a good overview of the project	Abstract provides a reasonable description of the project but needs improvement	Abstract is poorly written.
C2 Literature & References PLO-2	Literature is well-written and structured as per standards and covered all relevant material to the project. References are cited properly using a standard format	Literature is well-written but not properly structured as per standards and covered most of the material relevant to the project. References are cited using a standard format	Literature is not properly written and structured as per standards, but covered most of the material relevant to the project. References are cited using a standard format	Literature is poorly written, poorly structured and does not covered the relevant material to the project. References are cited using a standard format.
C3 Problem Statement PLO-2	Problem statement is stated and covered sufficient justification. New reader can clearly understand its value and context	Problem statement is stated and covered necessary justification with reference.	Problem statement is stated but lacks necessary justification.	Problem statement is vaguely stated without any justification
C4 Methodology PLO-4	The methods, approaches, tools, techniques, algorithms, or other aspects of the solution are well-described with sufficient details and supporting diagrams.	The methods, approaches, tools, techniques, algorithms, or other aspects of the solution are well-described. However further explanation is required.	The methods, approaches, tools, techniques, algorithms, or other aspects of the solution are described but not in a convincing manner.	Some aspects of the solution are described briefly but much of the description is left out.
C5 Implementation and Testing PLO-5	Both implementation and testing of a system, are precisely performed with accuracy and provide all necessary details for the reader.	Both implementation and testing of a system, are performed with the necessary details for the reader.	Implementation of a system, are performed with the necessary details for the reader. But testing of a system is not properly performed.	Both implementation and testing of a system, are not properly performed with lack of details.

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C6 **Results** **PLO-4**	Includes all key results of the project. Appropriate graphs, figures and tables are included for effective interpretation and explanation of the results.	Includes most of the key results of the project. Graphs, figures and tables are included for effective interpretation and explanation of the results.	Includes few key results of the project. Graphs, figures and tables are included with limited interpretation and explanation of the results.	Key results of the project are missing. Graphs, figures and tables are not included.
C7 **Conclusion** **PLO-4**	All important aspects of the project are well-summarized with the sense of closure and demonstrates the major outcome(s) of the project.	Most of the important aspects of the project are well-summarized with the sense of closure and demonstrates the outcome(s) of the project.	Few aspects of the project are summarized with the sense of closure and demonstrates the outcome(s) of the project.	Important aspects of the project are not clearly summarized with.
C8 **Language and Grammar, Formatting Style** **PLO- 8 & 10**	Almost no spelling or grammatical mistake with an acceptable similarity index. Formatting style of chapters, table of contents, title page, references and appendices are proper and relevant.	Occasional spellings and grammatical errors that have only minor impact on flow of reading with acceptable similarity index Formatting style of chapters, table of contents, title page, references and appendices are proper.	Occasional spellings and grammatical errors with high but acceptable similarity index Formatting style is proper but figures and tables don't follow standard practice (caption figure number etc.)	Frequent spellings and grammatical errors that impede the reading flow with very high similarity index. The formatting of the chapters may need improvement.

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Criteria	Description of Criteria	Programme Learning Outcome(s)	Performance Scale 1 = Excellent, 2 = Good, 3 = Fair, 4 = Poor				
			Roll #	Roll #	Roll #	Roll #	Roll #
C1	Abstract	PLO-10: Communication	1 ☐ 2 ☐ 3 ☐ 4 ☐	1 ☐ 2 ☐ 3 ☐ 4 ☐	1 ☐ 2 ☐ 3 ☐ 4 ☐	1 ☐ 2 ☐ 3 ☐ 4 ☐	☐ ☐ ☐ ☐
C2	Literature & References	PLO-02: Problem Analysis	1 ☐ 2 ☐ 3 ☐ 4 ☐	1 ☐ 2 ☐ 3 ☐ 4 ☐	1 ☐ 2 ☐ 3 ☐ 4 ☐	1 ☐ 2 ☐ 3 ☐ 4 ☐	☐ ☐ ☐ ☐
C3	Problem Statement	PLO-02: Problem Analysis	1 ☐ 2 ☐ 3 ☐ 4 ☐	1 ☐ 2 ☐ 3 ☐ 4 ☐	1 ☐ 2 ☐ 3 ☐ 4 ☐	1 ☐ 2 ☐ 3 ☐ 4 ☐	☐ ☐ ☐ ☐
C4	Methodology	PLO-04: Investigation	1 ☐ 2 ☐ 3 ☐ 4 ☐	1 ☐ 2 ☐ 3 ☐ 4 ☐	1 ☐ 2 ☐ 3 ☐ 4 ☐	1 ☐ 2 ☐ 3 ☐ 4 ☐	☐ ☐ ☐ ☐
C5	Implementation and Testing	PLO-05: Modern Tool Usage	1 ☐ 2 ☐ 3 ☐ 4 ☐	1 ☐ 2 ☐ 3 ☐ 4 ☐	1 ☐ 2 ☐ 3 ☐ 4 ☐	1 ☐ 2 ☐ 3 ☐ 4 ☐	☐ ☐ ☐ ☐
C6	Results	PLO- 4: Investigation	1 ☐ 2 ☐ 3 ☐ 4 ☐	1 ☐ 2 ☐ 3 ☐ 4 ☐	1 ☐ 2 ☐ 3 ☐ 4 ☐	1 ☐ 2 ☐ 3 ☐ 4 ☐	☐ ☐ ☐ ☐
C7	Conclusion	PLO-04: Investigation	1 ☐ 2 ☐ 3 ☐ 4 ☐	1 ☐ 2 ☐ 3 ☐ 4 ☐	1 ☐ 2 ☐ 3 ☐ 4 ☐	1 ☐ 2 ☐ 3 ☐ 4 ☐	☐ ☐ ☐ ☐
C8	Language and Grammar, Formatting Style, Originality	PLO-08: Ethics PLO-10: Communication	1 ☐ 2 ☐ 3 ☐ 4 ☐	1 ☐ 2 ☐ 3 ☐ 4 ☐	1 ☐ 2 ☐ 3 ☐ 4 ☐	1 ☐ 2 ☐ 3 ☐ 4 ☐	☐ ☐ ☐ ☐

Preface

In the diverse landscape of personal expression, the pursuit of an ideal look often encounters hurdles. Individuals eagerly embracing new hairstyles, beards, or moustaches may find themselves disheartened when the chosen style does not seamlessly complement their facial features.This realization prompted the creation of the "Hairstyle Modelling System," a web application designed to empower users. It offers a unique opportunity to preview and assess selected styles on a personalized 3D representation of their face. The genesis of this tool lies in the understanding that envisioning the visual harmony between facial features and chosen styles can be challenging.This introduction prepares us to learn more about how our application was created. It highlights the important problem it solves and how it has the potential to change the way we approach personal styling. In the upcoming pages, we'll go deeper into the details of our solution, not just talking about how it works technically but also how it can greatly boost confidence and create positive connections with personal style.

Acknowledgements

Starting with name of ALLAH [THE MOST MERCIFUL,THE MOST BENEFICIAL], Whom we are very thankful, Who give us strength for the accomplishment of our Final Year Project. We have taken efforts in our project. However, it would not have been possible without the help and support of many individuals and organizations. We would like to thank all of them. We are highly indebted to Sir Umair Naqvi for his guidance and constant supervision as well as for providing necessary information regarding this project and also for his support in completing this project.We would like to express our gratitude towards our parents and members of Sir Syed University for their kind co-operation and encouragement which helped us in completion of this project.

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CERTIFICATE OF COMPLETION

This is to certify that the following students

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Have successfully completed their Final Year Project named

Hairstyle Modelling System

In the partial fulfillment of the Degree of Bachelor of Science in Computer Engineering

_____

Engr. Umair Naqvi

Lecturer

SSUET

Abstract

The "Hairstyle Modelling System" deals with the problem that people frequently have with choosing haircuts, beards, and mustaches that go well with their facial features. Individuals eagerly embracing new hairstyles, beards, or moustaches may find themselves disheartened when the chosen style does not seamlessly complement their facial features.By allowing users to input a 2D image, which is then effortlessly converted into a 3D model using a Maya plugin, this web application provides a user-friendly solution. Following mesh adjustments, brightness improvements using the Meta-Human Plugin in Unreal Engine 5.1 polish the model. The Meta-Human designer allows users to further personalize their appearance by choosing from a variety of skin tones, hairstyles, beards, and moustaches.The translation from 2D to 3D, powered by the Maya Script File using sophisticated computations and machine learning algorithms, is the project's key component. Object Files (OBJ), Material Files (MTL) establishing color and texture properties, ISOMAP for dimension reduction, Points Files (pts) providing Point Cloud data, and PCA Shape. Text, a product of Principal Component Analysis, are among the key files generated by this method for exact results. Information about points, nodes, and critical facial expressions is stored in text files.Hairstyle Modelling System delivers highly accurate and effective results by precisely adapting chosen styles to individual facial features. Its advanced technologies ensure a realistic 3D representation, allowing users to confidently visualize how different hairstyles, beards, and mustaches will look on their own unique face. The system's attention to detail, from skin tones to facial expressions, guarantees that the virtual transformations closely align with real-life outcomes, providing users with a reliable and authentic preview of their desired looks.In conclusion, the development of the 'Hairstyle Modelling System' addresses a significant and relatable challenge faced by individuals seeking the perfect look. The integration of cutting-edge technologies, including the use of the Maya plugin, Meta-Human Plugin in Unreal Engine 5.1, and Machine Learning algorithms, offers a groundbreaking solution. By allowing

users to visualize and customize their chosen hairstyles, beards, and moustaches in a 3D representation of their own face, the system empowers them to make informed decisions about their personal style.

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Chapter 1

Introduction

1.1 Overview

1.1.1 Background And Context of the Project

The 'Hairstyle Modelling System' addresses the common problem of people being dissatisfied with how certain hairstyles, beards, or moustaches look on their faces. Our web application allows users to select and preview different styles on their 3D model generated from a 2D image using the Maya plugin. Mesh modifications and enhancements in Unreal Engine 5.1 further refine the model, and the Meta-Human creator enables the application of various skin colors and styles. The conversion process involves a Maya Script File employing Machine Learning algorithms to create crucial files for accurate and realistic results, offering users an immersive and personalized styling experience.

1.1.2 Problem Statement And Motivation

People frequently experience disappointment when the haircut they have chosen does not enhance their characteristics or facial shape. This can make people unhappy and prompt them to look for better alternatives. The goal of this project is to provide a platform that allows users to digitally try on various looks in order to reduce potential

discouragement and improve their overall personal grooming experience.

1.2 Objectives

The objectives of the "Hairstyle Modelling System" project are as follows:

- ***To Enable Virtual Styling Experiences*** **:**

  Create a user-friendly web application that enables users to apply different skin colors and also try on virtual beards, moustaches, and hairstyles with different colors in real-time.

- ***Realistic 2D To 3D Conversions*** **:** Use machine learning methods in conjunction with Maya and Meta-Human plugins to assure accurate and dependable conversions of 2D facial pictures into dynamic 3D models.

- ***User Participation And Customization*** **:** Create an interactive platform where users can preview and adjust the styles they choose, solving the issue of choosing styles that go well with particular facial traits.

  1) ***What do you hope to learn or demonstrate*****?**

  The project intends to show how well sophisticated imaging technologies and machine learning algorithms work together to give customers a customized and realistic virtual styling experience.

  2) ***What kind of issue are you tackling*****?**

  This project addresses the difficulty of choosing hairstyles, beards, and mustaches that complement a person's distinctive face traits. It tackles the widespread problem of unhappiness when selected fashions conflict with individual aesthetic preferences.

  3) ***What motivates your work on this issue*****?**

  The goal of the initiative is to increase customer pleasure and confidence with their personal grooming choices. We hope to reduce any potential discourage-

ment brought on by incompatible styles by offering a platform for virtual styling, ultimately enabling people to confidently express themselves.

4) *What did your adviser think you would learn by working on this challenge*?

My advisor saw the nexus between cutting-edge technology and individual aesthetics when he gave me this project. The assignment is made to teach important abilities in using plugins, machine learning, and cutting-edge 3D imaging methods. Additionally, it provides a chance to investigate user-centric design and the potential effects of technology on confidence and self-perception.

1.2.1 System Features

The following salient characteristics of the "Hairstyle Modelling System":

- **2D-to-3D Conversion:** Uses the Maya plugin to seamlessly convert user-provided 2D Photos into interactive 3D models.
- **Real-time preview:** This feature enables users to instantly see how certain haircuts,beards,and mustaches will look on them.
- **Mesh Refinement:** This process applies mesh adjustments to improve the 3D model's accuracy and representation.
- **Brightness Enhancement:** Makes use of the Meta-Human Plugin in Unreal Engine 5.1 to improve the 3D model's overall brightness and visual quality.
- **Customization Options:** Offers several skin tones, haircuts, beards, and mustaches for customers to select from, giving a fully customized experience.
- **File Generation:** During the 2D to 3D conversion process, important files are automatically created (e.g., OBJ, MTL, ISOMAP, points, PCA Shape. Text, Text Files), improving the precision and fidelity of the result.

1.3 Summary

The "Hairstyle Modelling System" marks a significant advancement in the field of customized grooming. Users can confidently experiment with a variety of styles thanks to the seamless integration of cutting-edge technologies, including Maya and MetaHuman plugins, and machine learning algorithms. This idea not only solves a common aesthetic problem, but it also shows how technology has the power to change how we view ourselves and how confident we are.

Chapter 2

Literature Review

2.1 The value of a Literature Survey

[1] The study presented by Adela Subrtova, Jan Cech, and Vojtech Franc at the IEEE Face and Gestures 2021 conference explores a cool idea called "Hairstyle Transfer between Face Images." Imagine you could easily change hairstyles in pictures while keeping the face natural and realistic. The researchers are using advanced computer techniques, especially a smart program called StyleGAN2, to make this happen. StyleGAN2 is like a super-smart artist that already knows how to create high-quality images. In their research, the authors explain how StyleGAN2 is a crucial part of their method. It helps seamlessly blend different hairstyles with different faces, creating a smooth and lifelike effect. They don't just talk about the technical details; they also show how their method works in real-life situations. They might demonstrate changing hairstyles in pictures, creating hairstyles for 3D models, and smoothly transitioning between different hair looks. The study is not only about making things look good but also making sure people like it. They even conducted a study where people looked at the generated images and probably asked for their opinions. This tells us that the researchers care about how regular people, not just experts, feel about the hairstyles they generate. By presenting their work at the IEEE Face and Gestures con-

ference, the authors are sharing their findings with a group of people who are really interested in faces and expressions. So, their research adds a lot of cool ideas to the bigger conversation about using smart computer programs to create awesome virtual looks.**[2]** In the realm of 3D facial shape reconstruction from 2D images, Guptil and Colin proposed the UH-E2FAR approach which stands out for its innovative use of deep neural networks. Unlike other methods, it performs the entire reconstruction in a single step, simplifying the process. Notable enhancements include a specialized performance evaluation and a neural network for improved facial expression capture. This approach demonstrates intelligence by distinguishing neutral and expressive facial shapes. Empirical tests confirm its superiority in accuracy compared to existing methods, making it a promising avenue for applications like our Hairstyle Modelling System. **[3]** The paper presented by Waqar Ali presents an innovative approach to the challenging task of creating detailed 3D facial models from single images. Utilizing a Convolutional Neural Network (CNN), the method differs from traditional techniques by analyzing the entire facial image rather than specific facial points. Training the program effectively requires a substantial dataset of labeled images, which is challenging to obtain for 3D facial data. To address this, the authors propose a unique strategy: generating synthetic facial images that closely resemble real faces and already possess known 3D structures. Remarkably, the CNN-based model successfully deduces the shapes of real faces, even in cases of significant variations or diverse lighting conditions. This suggests that the proposed method offers a rapid and dependable approach for constructing 3D facial models from a single image. The research was presented at the IEEE International Conference on 3D Vision held in Stanford, CA, USA, from October 25 to 28, 2016, and was subsequently added to the IEEE Xplore database on December 19, 2016, under the DOI 10.1109/3DV.2016.56. The publication is affiliated with IEEE. **[4]** The work conducted by Yangyu Fan, Yang Liu, Guoyun Lv, Shiya Liu, Gen Li, and Yanhui Huang introduces an innovative method for creating detailed 3D face models from single everyday photographs. Their approach involves combining a foundational model with a highly detailed face model, where the foundational

model serves as the core structure and is developed using an advanced technique called multilinear optimization. Complementing this, the detailed face model adeptly captures intricate facial features, particularly under specific lighting conditions. A significant challenge addressed in this study is the inclusion of missing texture details in parts of the face not visible in the input photograph. To overcome this, the researchers utilize a sophisticated technique known as a generative adversarial network (GAN) to generate a comprehensive and realistic texture. Through extensive testing, the authors demonstrate that their method can produce accurate and realistic 3D models from various perspectives. A noteworthy aspect of their approach is its efficiency; it requires less input information while surpassing other existing methods and commercial tools in capturing detailed facial features. This research, associated with IEEE, makes a substantial contribution to the field of 3D facial modeling and holds promise for diverse applications, making it a valuable reference for further exploration in this domain.

2.2 Gaps In Above Literature

2.2.1 Gaps in Existing Literature:

- **Hairstyle Transfer Realism:** The study by Adela Subrtova, Jan Cech, and Vojtech Franc focuses on "Hairstyle Transfer between Face Images" using StyleGAN2. However, there may be a gap in addressing the realism and seamless integration of different hairstyles onto different faces. Users might be looking for a more realistic representation of how a chosen hairstyle suits their unique facial features.
- **Integration of Deep Neural Networks:** The UH-E2FAR approach proposed by Guptil and Colin introduces deep neural networks for 3D facial shape reconstruction. While this approach is innovative, there may be a gap in understanding how well it performs in real-time applications and its adaptability to user preferences, especially in the context of a Hairstyle Modelling System.

- **Dataset Challenges:** The paper by Waqar Ali tackles the challenge of obtaining a substantial dataset for effective training of a Convolutional Neural Network (CNN) for 3D facial models. However, there may be a gap in discussing the practical limitations of dataset collection and how well the proposed method generalizes to various facial structures.
- **Texture Generation:** The work by Yangyu Fan et al. introduces an advanced method for creating detailed 3D face models from everyday photographs. However, there may be a gap in addressing the challenge of missing texture details in parts of the face not visible in the input photograph and how well their method performs in generating comprehensive and realistic textures.

2.2.2 How Hairstyle Modelling System Fills these Gaps:

- **Realistic Hairstyle Integration:** Hairstyle Modelling System aims to address the gap in hairstyle transfer realism by allowing users to preview how different hairstyles look on their unique facial features. This system emphasizes not only technical details but also user satisfaction, incorporating opinions through studies.
- **User-Friendly Adaptation:** In comparison to the UH-E2FAR approach, this system aims to be user-friendly by providing an accessible platform for users to choose and visualize their preferred hairstyles. It focuses on simplifying the 3D facial shape reconstruction process, ensuring adaptability to diverse user preferences.
- **Practical Dataset Implementation:** Considering the challenges of dataset collection discussed in the paper by Waqar Ali, Our system could address this gap by implementing practical strategies for dataset creation, ensuring a diverse and representative set of facial structures for effective training.

- **Comprehensive Texture Generation:** Building on the work of Yangyu Fan et al., Our system may aim to enhance the texture generation process by ensuring comprehensive coverage of missing details in invisible facial parts. The utilization of generative adversarial networks (GANs) could be further explored to improve texture realism.

2.3 Summary

The existing literature on 3D facial modeling reveals gaps in realistic hairstyle integration, user-friendly adaptation, practical dataset implementation, and comprehensive texture generation. The Hairstyle Modelling System aims to fill these gaps by providing a user-centric platform for visually previewing diverse hairstyles on individual faces. By simplifying the 3D facial shape reconstruction process, ensuring adaptability to user preferences, and addressing dataset challenges, the system seeks to enhance realism and user satisfaction. It stands as a potential contribution to the field by combining technical innovation with practical usability.

Chapter 3

Problem Statement

3.1 We don't have an effective virtual try-on hairstyling system for addressing pursuit of an ideal look

The absence of an effective virtual try-on hairstyling system presents a significant challenge for individuals seeking to achieve their ideal aesthetic. Current systems fall short in delivering satisfactory solutions for users to preview and assess different hairstyles, beards, and moustaches in harmony with their facial features. This limitation becomes apparent as users often face difficulties in accurately visualizing how a particular style will suit their unique facial characteristics. As a result, there is a notable gap in the grooming industry, where individuals lack a comprehensive tool that allows them to experiment with various looks virtually before making grooming decisions. Recognizing this issue, our project, the 'Hairstyle Modelling System,' emerges as a solution to bridge this gap, providing users with an innovative platform to explore, customize, and confidently choose styles that complement their individuality.

3.2 Summary

People are fond of having different hairstyles, beards and moustaches in order to get a cool look. But sometimes hairstyle, beard or moustache doesn't suit with a person's face and the person gets dishearted. The "Hairstyle Modelling System" is a revolutionary marriage of technology and individual expression. Each element—from the original 2D image to the final preview and customization—plays a crucial part in making sure that the chosen styles perfectly match the individual face features of the user. This methodical technique ensures accuracy and precision, giving consumers the freedom to express their unique distinctive preferences with assurance in the field of personal grooming.

Chapter 4

Technical Documents

4.1 DFD Diagram

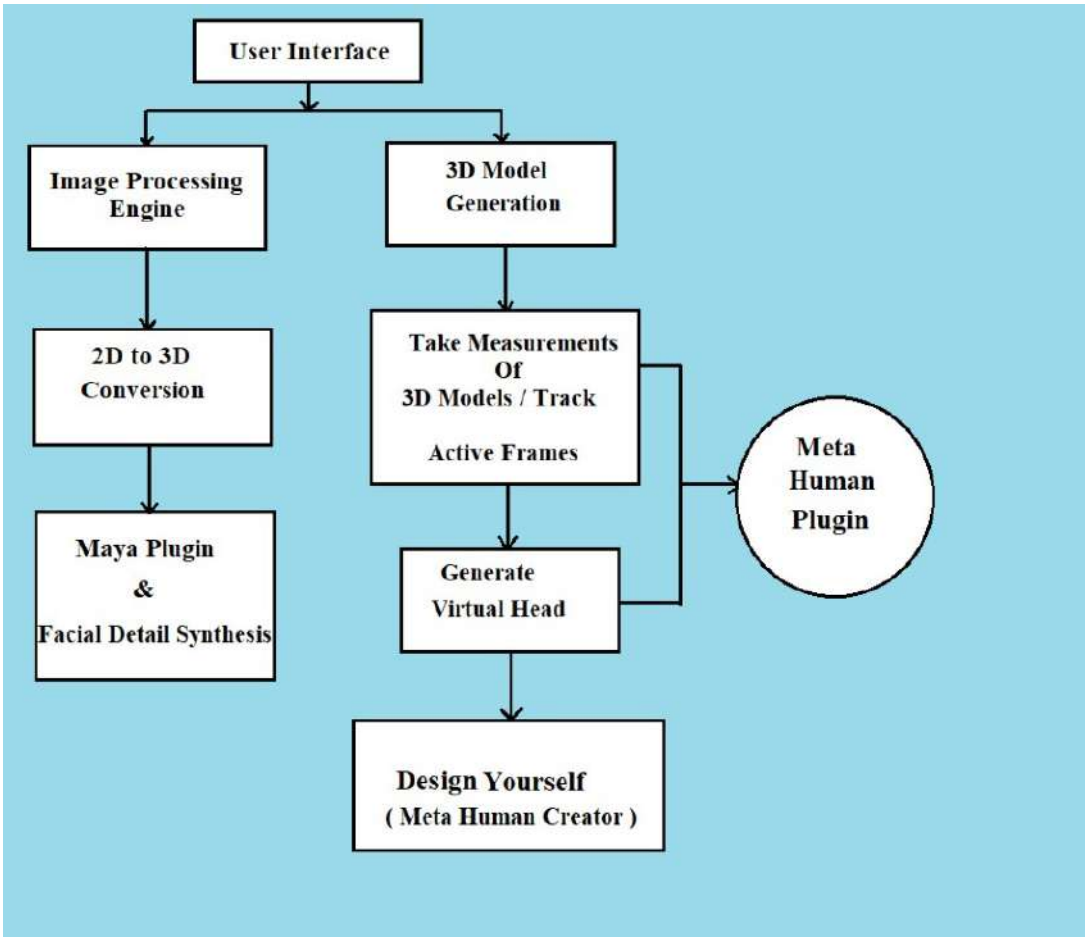


Figure 4.1: DFD Diagram

4.2 Stakeholder Register

Stakeholder Name	Title	Role	Requirements	Concerns
End Users (Customers)	[User Representative]	Utilizes the application for customization	User-friendly interface, accurate 3D modeling, a variety of customization options	User satisfaction, ease of use, diversity in available styles
Development Team	[Umer, Haris]	Designs & implement the application	Clear requirements, effective communication, timely feedback on changes	Resource availability, scope changes, technical challenges
Data Scientists / ML Experts	[Umer, Haris]	Study ML algorithms for image conversion	Access to relevant data, collaboration on refining ML models, feedback on algorithm performance	Data availability, algorithm accuracy, computational resources
Maya Plugin Experts	[Umer, Haris]	Study and maintains the Maya plugin	Clear specifications, collaboration with the development team, feedback on plugin functionality	Maya compatibility, integration challenges, user feedback
Unreal Engine Learners	[Umer, Haris]	Integrates Meta-Human Plugin, enhances brightness	Detailed requirements, collaboration with other teams, access to Unreal Engine resources	Integration issues, resource constraints, Unreal Engine capabilities
Meta-Human Plugin Experts	[Umer, Haris]	Study and maintains the Meta-Human Plugin	Clear specifications, collaboration with the development team, feedback on plugin functionality	Plugin functionality, compatibility with other tools, user feedback
Project Manager	[Umer]	Oversees the project, ensures milestones	Regular updates, issue resolution, adherence to the project timeline	Project delays, scope changes, resource allocation
Quality Assurance (QA) Team	[Ahmed, Furqan]	Tests and ensures quality of the application	Access to test environments, clear test cases, collaboration for bug fixes	Bug identification, test coverage, compatibility testing
Legal and Compliance Team	[Ahmed, Furqan, Hadiqa]	Ensures project compliance with legal standards	Regular legal checks, adherence to data protection regulations, resolution of legal issues	Legal risks, data protection, compliance with regulations

Figure 4.2: Stakeholder Register

4.3 Use Case Diagram

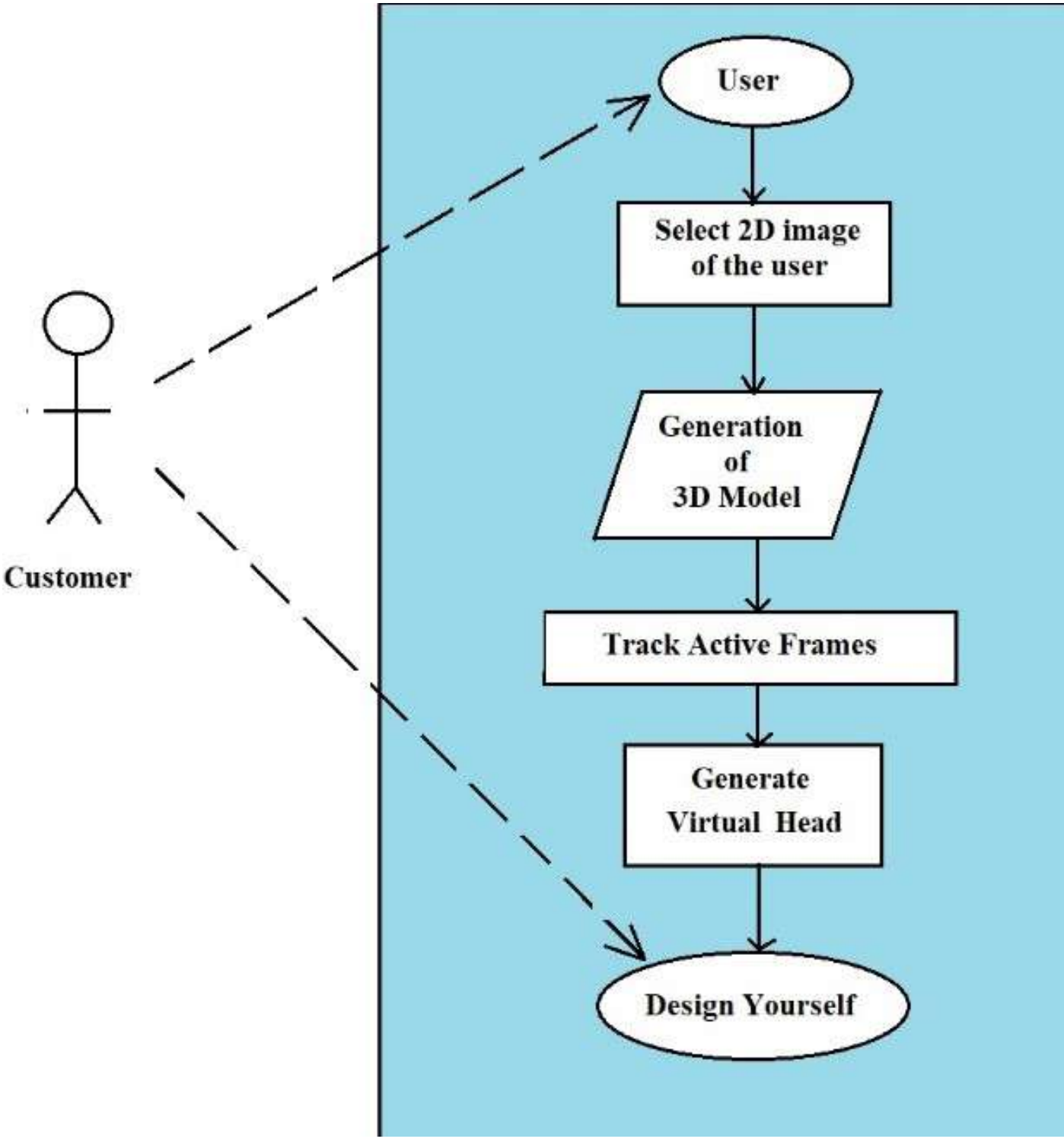


Figure 4.3: Use Case Diagram

4.4 Risk Register

Risk ID	Risk Description	Likelihood of the Risk Occuring	Impact If the Risk Occurs	Severity	Mitigating Action	Contingent Action	Progress On Action	Status
1	Integration Issues	Medium	High	High	Regularly test update plugins, have contingency plans	Identify alternative integration approaches.	In progress	On Track
2	Machine Learning Model Accuracy	High	High	High	Thoroughly validate machine learning algorithms.	Collaborate with machine learning experts for validation.	Not Started	Planned
3	Data security & Privacy	Medium	Medium	Medium	Implement robust data security protocols	Conduct regularly security audits	In progress	On Track
4	Timeline Delays	High	High	High	Maintain a flexible project timline, monitor progress	Identify critical path & priortize tasks	In progress	Some delays
5	Resource Constraints	Medium	Medium	Medium	Identify alternative resources & skill development plans	Cross-train team menbers for key tasks	In progress	On Track
6	User Acceptance	Medium	High	High	Conduct regular user testing and gather feedback	implement alternative design based on user feedback	In progress	On Track
7	Ethical Concerns	Low	High	Low	Ensure transparency in data usage, address ethical concerns	Establish a clear privacy policy and communicate it to users.	In progress	On Track
8	Third-Party Plugin Reliability	Medium	High	High	Keep plugins up-to-date, monitor for updates and support.	Have a backup plan for critical functionalities.	In progress	On Track
9	Legal Compliance	Low	High	Low	Obtain legal advice, ensure compliance with IP laws	Regularly review and update legal documentation	In progress	On Track

Figure 4.4: Risk Register

4.5 Gantt Chart

	Task Mode	Task Name	Duration	Start	Finish	Predecessors	Resource N
1		**Planning**	**3 days**	**Sun 1/1/23 8:00 AM**	**Wed 1/4/23 5:00 PM**		
2		Kick off meeting with the team	1 day	Sun 1/1/23 8:00 AM	Sun 1/1/23 5:00 PM		
3		Identify project scope and objectives	3 days	Mon 1/2/23 8:00 AM	Wed 1/4/23 5:00 PM	2	
4		**Analysis**	**5 days**	**Mon 1/2/23 8:00 AM**	**Fri 1/6/23 5:00 PM**		
5		Conduct market research	5 days	Mon 1/2/23 8:00 AM	Fri 1/6/23 5:00 PM	2	
6		**Planning**	**3 days**	**Mon 1/2/23 8:00 AM**	**Wed 1/4/23 5:00 PM**		
7		Create project plan and timeline	3 days	Mon 1/2/23 8:00 AM	Wed 1/4/23 5:00 PM	2	
8		**Designing**	**7 days**	**Thu 1/5/23 8:00 AM**	**Fri 1/13/23 5:00 PM**		
9		Design 3d models	7 days	Thu 1/5/23 8:00 AM	Fri 1/13/23 5:00 PM	3	
10		**Planning**	**5 days**	**Thu 1/12/23 8:00 AM**	**Wed 1/18/23 5:00 PM**		
11		Develop project charter and project management plan	5 days	Thu 1/12/23 8:00 AM	Wed 1/18/23 5:00 PM	5	
12		**Designing**	**3 days**	**Fri 1/13/23 8:00 AM**	**Tue 1/17/23 5:00 PM**		
13		Set up development environment and tools	3 days	Fri 1/13/23 8:00 AM	Tue 1/17/23 5:00 PM	7	
14		**Coding**	**21 days**	**Tue 1/24/23 8:00 AM**	**Tue 2/21/23 5:00 PM**		
15		Implement basic features and functionality	21 days	Tue 1/24/23 8:00 AM	Tue 2/21/23 5:00 PM	9	
16		**Testing**	**7 days**	**Wed 1/18/23 8:00 AM**	**Thu 1/26/23 5:00 PM**		
17		Test basic features	7 days	Wed 1/18/23 8:00 AM	Thu 1/26/23 5:00 PM	13	

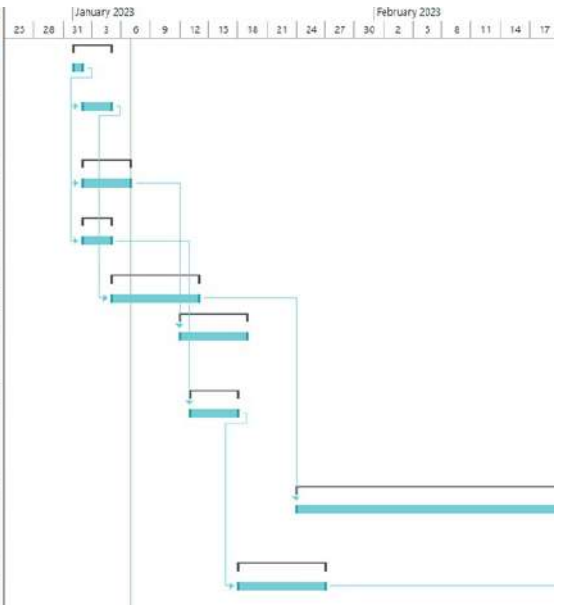
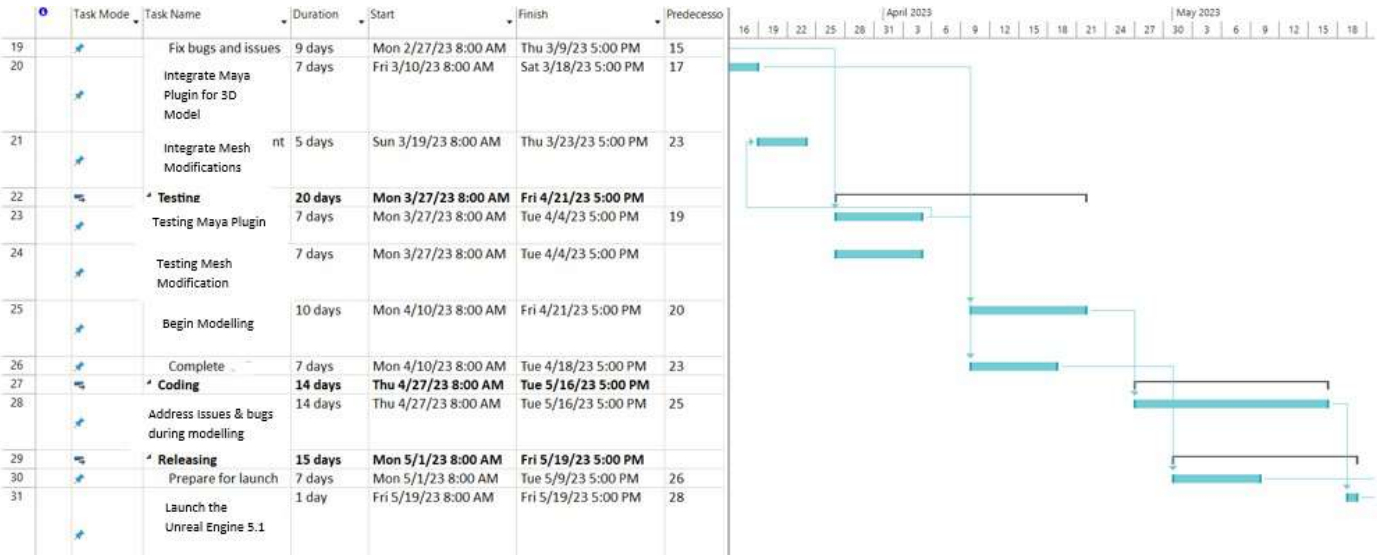
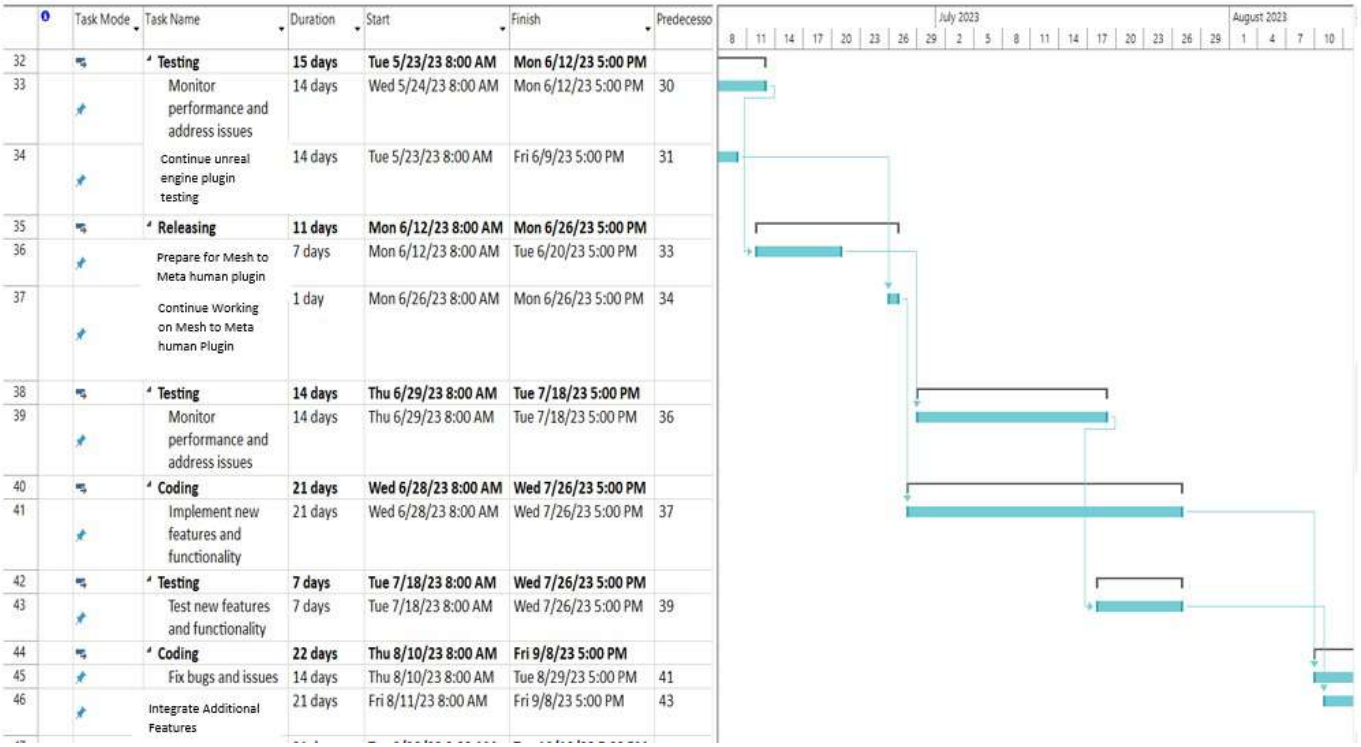


Figure 4.5: Table 1



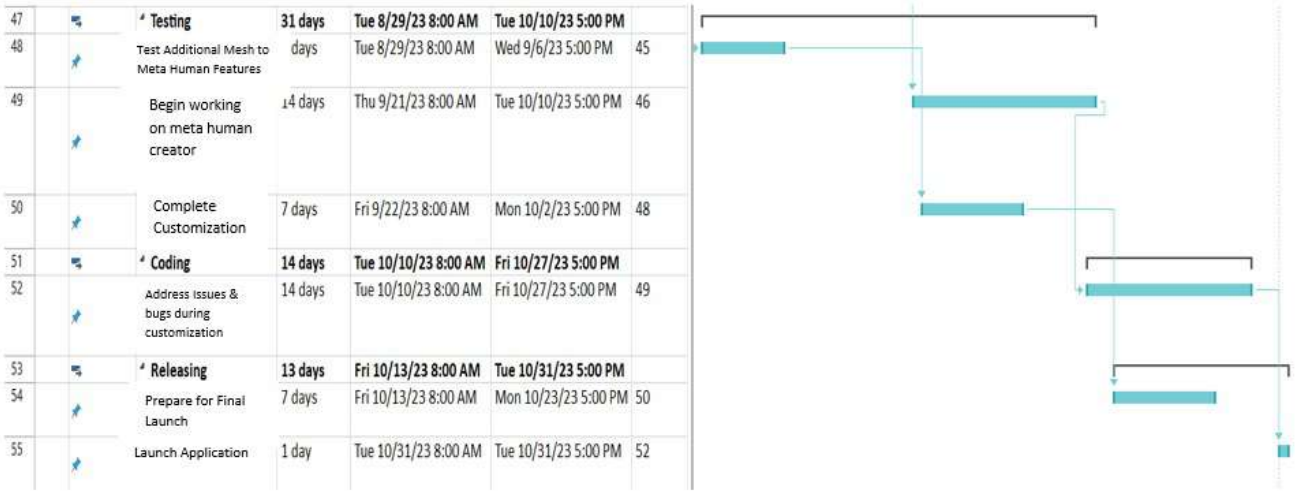
	Task Mode	Task Name	Duration	Start	Finish	Predecesso
19		Fix bugs and issues	9 days	Mon 2/27/23 8:00 AM	Thu 3/9/23 5:00 PM	15
20		Integrate Maya Plugin for 3D Model	7 days	Fri 3/10/23 8:00 AM	Sat 3/18/23 5:00 PM	17
21		Integrate Mesh nt Modifications	5 days	Sun 3/19/23 8:00 AM	Thu 3/23/23 5:00 PM	23
22		**Testing**	**20 days**	**Mon 3/27/23 8:00 AM**	**Fri 4/21/23 5:00 PM**	
23		Testing Maya Plugin	7 days	Mon 3/27/23 8:00 AM	Tue 4/4/23 5:00 PM	19
24		Testing Mesh Modification	7 days	Mon 3/27/23 8:00 AM	Tue 4/4/23 5:00 PM	
25		Begin Modelling	10 days	Mon 4/10/23 8:00 AM	Fri 4/21/23 5:00 PM	20
26		Complete	7 days	Mon 4/10/23 8:00 AM	Tue 4/18/23 5:00 PM	23
27		**Coding**	**14 days**	**Thu 4/27/23 8:00 AM**	**Tue 5/16/23 5:00 PM**	
28		Address issues & bugs during modelling	14 days	Thu 4/27/23 8:00 AM	Tue 5/16/23 5:00 PM	25
29		**Releasing**	**15 days**	**Mon 5/1/23 8:00 AM**	**Fri 5/19/23 5:00 PM**	
30		Prepare for launch	7 days	Mon 5/1/23 8:00 AM	Tue 5/9/23 5:00 PM	26
31		Launch the Unreal Engine 5.1	1 day	Fri 5/19/23 8:00 AM	Fri 5/19/23 5:00 PM	28

Figure 4.6: Gant Chart 2



	Task Mode	Task Name	Duration	Start	Finish	Predecesso
32		**Testing**	**15 days**	**Tue 5/23/23 8:00 AM**	**Mon 6/12/23 5:00 PM**	
33		Monitor performance and address issues	14 days	Wed 5/24/23 8:00 AM	Mon 6/12/23 5:00 PM	30
34		Continue unreal engine plugin testing	14 days	Tue 5/23/23 8:00 AM	Fri 6/9/23 5:00 PM	31
35		**Releasing**	**11 days**	**Mon 6/12/23 8:00 AM**	**Mon 6/26/23 5:00 PM**	
36		Prepare for Mesh to Meta human plugin	7 days	Mon 6/12/23 8:00 AM	Tue 6/20/23 5:00 PM	33
37		Continue Working on Mesh to Meta human Plugin	1 day	Mon 6/26/23 8:00 AM	Mon 6/26/23 5:00 PM	34
38		**Testing**	**14 days**	**Thu 6/29/23 8:00 AM**	**Tue 7/18/23 5:00 PM**	
39		Monitor performance and address issues	14 days	Thu 6/29/23 8:00 AM	Tue 7/18/23 5:00 PM	36
40		**Coding**	**21 days**	**Wed 6/28/23 8:00 AM**	**Wed 7/26/23 5:00 PM**	
41		Implement new features and functionality	21 days	Wed 6/28/23 8:00 AM	Wed 7/26/23 5:00 PM	37
42		**Testing**	**7 days**	**Tue 7/18/23 8:00 AM**	**Wed 7/26/23 5:00 PM**	
43		Test new features and functionality	7 days	Tue 7/18/23 8:00 AM	Wed 7/26/23 5:00 PM	39
44		**Coding**	**22 days**	**Thu 8/10/23 8:00 AM**	**Fri 9/8/23 5:00 PM**	
45		Fix bugs and issues	14 days	Thu 8/10/23 8:00 AM	Tue 8/29/23 5:00 PM	41
46		Integrate Additional Features	21 days	Fri 8/11/23 8:00 AM	Fri 9/8/23 5:00 PM	43

Figure 4.7: Gant Chart 3



47	Testing	31 days	Tue 8/29/23 8:00 AM	Tue 10/10/23 5:00 PM	
48	Test Additional Mesh to Meta Human Features	days	Tue 8/29/23 8:00 AM	Wed 9/6/23 5:00 PM	45
49	Begin working on meta human creator	14 days	Thu 9/21/23 8:00 AM	Tue 10/10/23 5:00 PM	46
50	Complete Customization	7 days	Fri 9/22/23 8:00 AM	Mon 10/2/23 5:00 PM	48
51	Coding	14 days	Tue 10/10/23 8:00 AM	Fri 10/27/23 5:00 PM	
52	Address issues & bugs during customization	14 days	Tue 10/10/23 8:00 AM	Fri 10/27/23 5:00 PM	49
53	Releasing	13 days	Fri 10/13/23 8:00 AM	Tue 10/31/23 5:00 PM	
54	Prepare for Final Launch	7 days	Fri 10/13/23 8:00 AM	Mon 10/23/23 5:00 PM	50
55	Launch Application	1 day	Tue 10/31/23 8:00 AM	Tue 10/31/23 5:00 PM	52

Figure 4.8: Gant Chart 4

4.6 Summary

In this chapter ,we have observed the development and working of HairStyle Modelling System with the help of different Tables, Diagrams and Charts which gives us a better understanding on how our system operates.

Chapter 5

Methodology

This methodology outlines the step-by-step process involved in the development and evaluation of the "Hairstyle Modelling System," ensuring transparency and rigor in the research process.

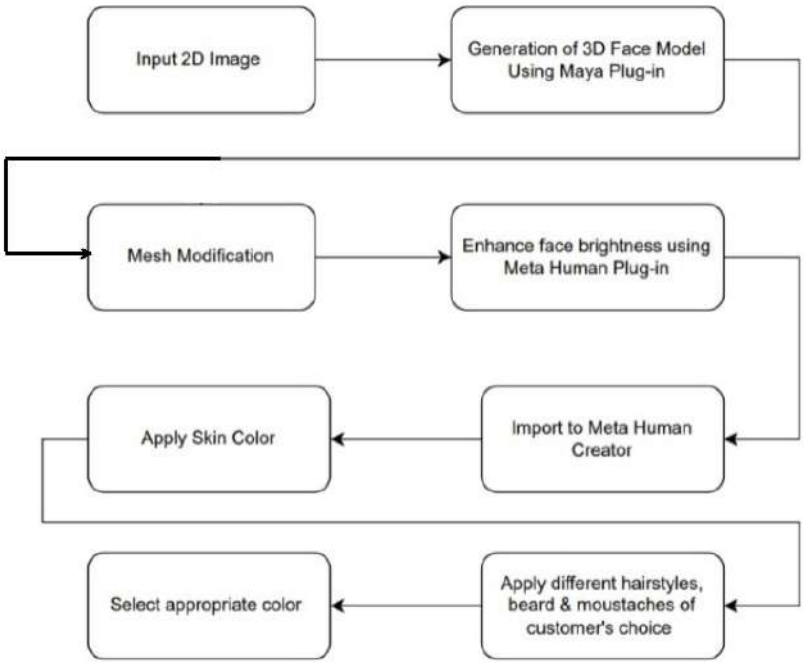


Figure 5.1: FlowChart

The methodology for the development of the 'Hairstyle Modelling System' is designed to seamlessly integrate user input, advanced 3D modeling techniques, and cutting-edge technologies. Commencing with the user interface, individuals provide a 2D image of their face and select their desired hairstyle, beard, or moustache. The journey then unfolds in Maya, where a dedicated plugin transforms the 2D image into a high-fidelity 3D model, subsequently subjected to meticulous mesh modifications for enhanced quality. The transition to Unreal Engine 5.1, leveraging the Meta-Human Plugin, adds a layer of brightness enhancement to the 3D model, ensuring optimal visualization within the Unreal Engine environment. Importing the model into Meta-Human Creator facilitates the application of diverse attributes, including skin colors and various grooming options. A pivotal aspect of the methodology involves the conversion from 2D to 3D through the Maya Script File, engaging sophisticated Machine Learning algorithms. This stage generates additional files, such as the Object File (OBJ), Material File (MTL), ISOMAP, Points File (pts), PCA Shape.text, and Text Files. Each file plays a specific role in augmenting the accuracy and realism of the 3D model, ranging from geometry and material information to non-linear dimension reduction and facial expression storage. The culmination of this process enables users to preview their chosen look interactively and make adjustments based on personal preferences. The methodology extends to thorough testing, validation, and documentation phases. Rigorous testing ensures the fidelity of the 3D models, and user feedback is collected to refine and enhance system performance. Comprehensive documentation, including code, algorithms, and system architecture, is compiled to articulate the intricate details of the development process. This holistic approach not only ensures the technical robustness of the 'Hairstyle Modelling System' but also lays the foundation for a user-centric and efficient virtual hairstyling experience.

5.1 Face Detection And 3D Model Generation:

5.1.1 Python

Python is a high-level, general-purpose,interpreted, dynamic programming language. It is easily understandable and codable, and its syntax allows programmers to express concepts in very few lines of code than possible in other languages like C or Java. Python language supports multiple programming paradigms, including objectoriented, imperative and functional programming or procedural styles. Python is used for the implementation of this project as it provides various utilities and modules and integrates with third party libraries such as OpenCV, NumPy and VPython for computer vision related functionalities.

5.1.2 Open CV

Open CV is an open-source computer vision and machine learning software library. It has a wide range of optimized algorithms like more than 2500, Using these algorithms we can detect a face, identify objects and classify human actions in videos. Open CV and its features are used for detection of input 2D image of the customer which is the main feature of our project and we made it possible using Facial Detail Synthesis.

5.1.3 ESO (Eigen-based Object and Scene reconstruction)

The EOS (Eigen-based Object and Scene reconstruction) library is an open-source software library for 3D object and scene reconstruction from 2D images. It provides a set of C++ and Python libraries and tools for developing applications that can perform tasks such as camera calibration, feature detection and matching, and 3D reconstruction.

Figure 5.1.3: 3D Model Generation

5.2 Mesh Modifications:

Mesh modifications are applied to the 3D model.

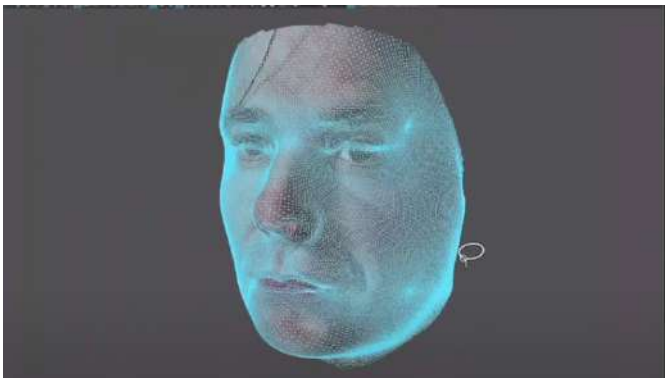


Figure 5.2: Mesh Modifications

5.3 Realism Enhancement:

The 3D model is imported into Unreal Engine 5.1 with Meta-Human plugins to enhance its visual realism.

Figure 5.3: Brightness Enhancement

5.4 Automatic Rigging

The Metahuman plugin features an "identity solve" function that enables the identification of the positioning of the eyes and mouth. This allows for the creation of a Metahuman model with a control rig face.

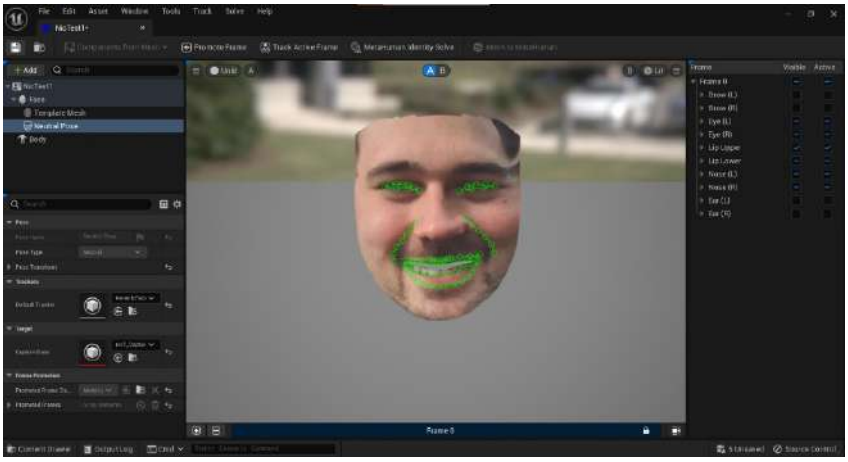


Figure 5.4: Auto-Rigging

5.5 Customization

Users can explore different skin colors, hairstyles, beards/mustaches other different features using Meta-Human Creator.

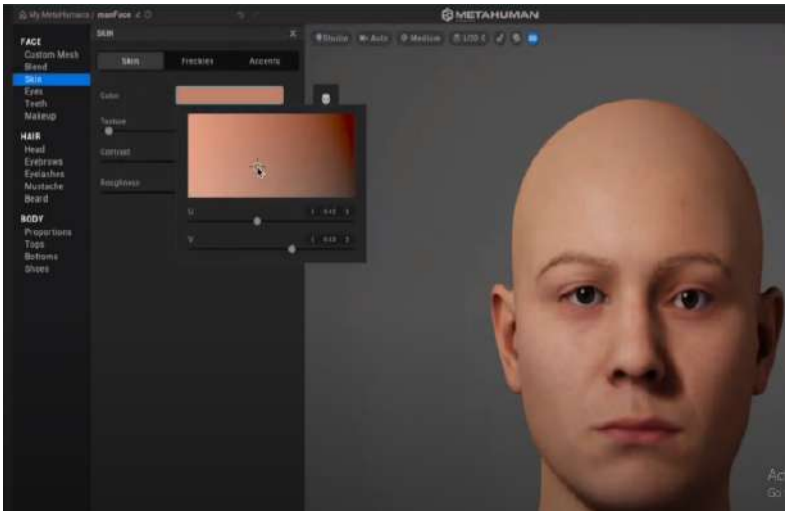
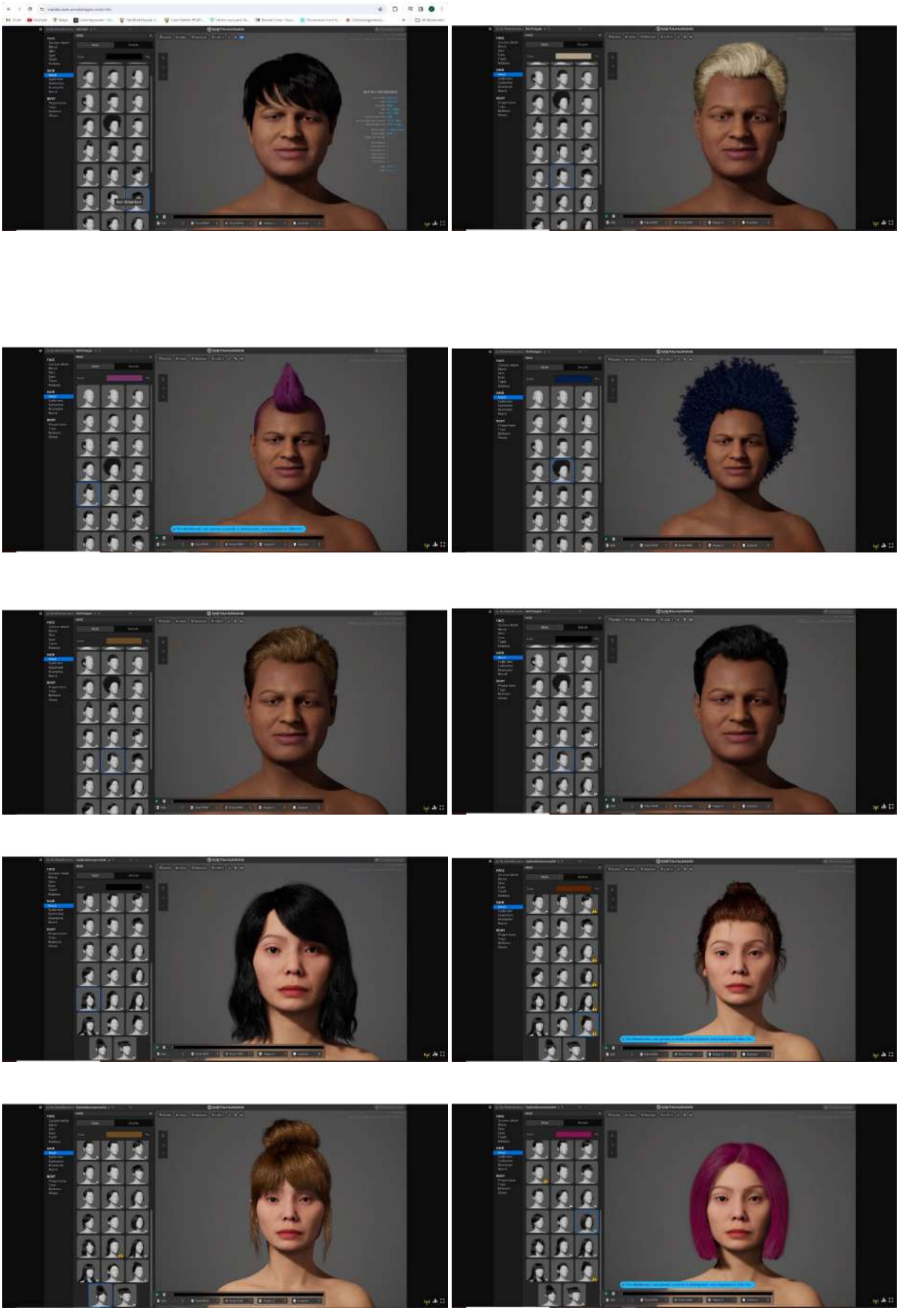
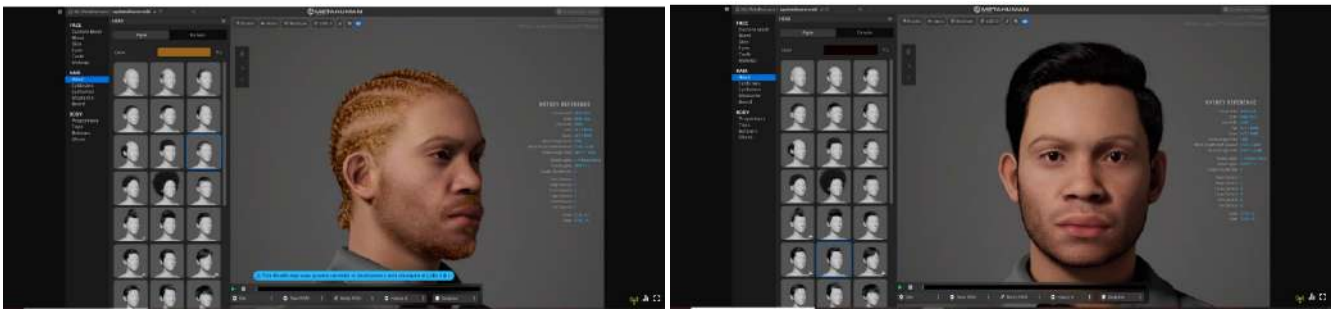


Figure 5.5: Apply Skin

APPLY HAIRSTYLE WITH DIFFERENT COLORS



APPLY BEARDS AND MUSTACHES WITH DIFFERENT COLORS



5.6 Preview And Selection

Users can preview their customized look and make informed grooming choices.

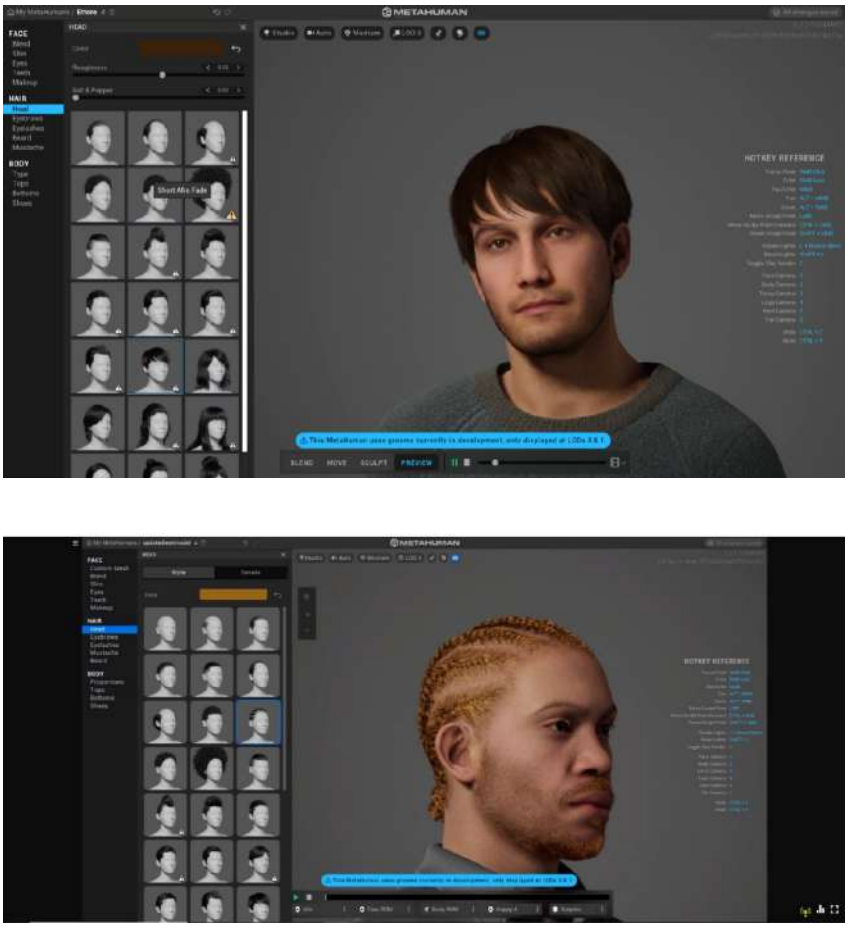


Figure 5.6: Preview and Selection

5.7 Face Expressions Analysis

5.7.1 Proposed Algorithms

Facial Detail Synthesis: The model is designed to generate high-resolution facial model that contain fine-grained details such as wrinkles, blemishes, and pores from a low-resolution input image. We chose this project as basic 3D face reconstruction algorithm. We present a single-image 3D face synthesis technique that can handle challenging facial expressions while recovering fine geometric details. Our technique employs expression analysis for proxy face geometry generation and combines supervised and unsupervised learning for facial detail synthesis. On proxy generation, we conduct emotion prediction to determine a new expression-informed proxy. On detail synthesis, we present a Deep Facial Detail Net (DFDN) based on Conditional Generative Adversarial Net (CGAN) that employs both geometry and appearance loss functions. For geometry, we capture 366 high-quality 3D scans from 122 different subjects under 3 facial expressions. For appearance, we use additional 163K in-the-wild face images and apply image-based rendering to accommodate lighting variations. Comprehensive experiments demonstrate that our framework can produce high-quality 3D faces with realistic details under challenging facial expressions.

5.8 Summary

The methodology involves user input through a 2D image, processed in Maya for 3D model creation and mesh modifications.Integration with Unreal Engine 5.1 enhances model brightness, followed by Meta-Human Creator for diverse attribute application.Pivotal 2D to 3D conversion employs Maya Script File and Machine Learning algorithms, generating essential files for accuracy.Rigorous testing and user feedback refine the system,while comprehensive documentation ensures technical transparency. This methodology ensures a seamless and user-centric experience,blending advanced 3D modeling with machine learning for accurate and interactive virtual hairstyling.

Chapter 6

Implementation and Testing

6.1 Tools and Development Environment

6.1.1 Data:

- **2D Images:** User provides an image for input.
- **Generated 3D Models:** Create a 3D model from that provided image.
- **Machine Learning Data:** Training data for ML algorithms, possibly facial feature datasets.

6.1.2 Coding Tools and Development:

- **Maya 2022:** Autodesk Maya is used for 3D modelling. Maya is 3D visual effects software with powerful character creation, rigging, animation, and simulation tools.
- **Unreal Engine 5.1:** For enhancing and customization the 3D model with the Meta-Human plugin. Unreal Engine is the world's most open and advanced real-time 3D creation tool for photoreal visuals and immersive experiences.
- **Meta-Human Creator:** To apply different hairstyles, beards, moustaches, and

apply various colors. MetaHuman Creator is a free, cloud-streamed tool you can use to create your own digital humans in an intuitive, easy-to-learn environment.

- **Python:** Python for scripting within Maya, handling machine learning, and general backend development. Python is a widely used, general-purpose, dynamically typed high-level programming language. We use Python in this project for its ability of allowing rapid prototyping of applications and for its wide support-base.
- **Machine Learning Frameworks:** PyTorch, Numpy, Scikit, cudatoolkit libraries for facial recognition and feature extraction.
- **Web Development:** HTML, CSS, JavaScript for building the frontend of your web application.
- **Backend Development:** Python, Django are used for backend connectivity and server-side logic.

6.1.3 IDE (Integrated Development Environment):

- **Visual Studio Code:** VSCode is used for frontend development, integration, and connectivity of frontend with the server side logic.
- **Python Editor in Autodesk Maya:** For scripting within Maya, Maya has its own Python Editor for Development purposes.
- **Anaconda:** Anaconda is used for creating Virtual Environment with required libraires and packages. Anaconda is a distribution of the Python programming language that is quite popular. It is designed specifically for machine learning and data science. There are more than 1,500 pre-installed packages that Anaconda comes with.

6.1.4 Libraries and APIs:

1. Maya Python API: API of Maya is used for creating and scripting within and outside of Maya for connecting Scripts with webpage.

2. Machine Learning Libraries: PyTorch, scikit-learn for implementing machine learning algorithms.

- **Scikit-Image:** Scikit-image is an open-source image processing library for the Python programming language. It includes algorithms for segmentation, geometric transformations, color space manipulation, analysis, filtering, morphology, and feature detection.
- **Numpy:** NumPy is a Python package designed to efficiently deal with large multi-dimensional arrays of arbitrary records without needing too much speed for small multi-dimensional arrays.
- **Pytorch:** PyTorch is a fully featured framework for building deep learning models, which is a type of machine learning that's commonly used in applications like image recognition.
- **Cudatoolkit:** CUDA is a parallel computing platform and programming model. It enables dramatic increases in computing performance by harnessing the power of the graphics processing unit (GPU).
- **Scikit:** Scikit is a machine learning library for the Python programming language.

3. Web Development Frameworks: Flask, Django web framework for building the backend of application.

6.1.5 External Resources:

- **Autodesk Maya and Maya Plugin:** Obtained from Autodesk's official website.
- **Unreal Engine 5.1 and Meta-Human Plugin:** Available through the Unreal Engine or Epic Games official website.
- **Machine Learning Datasets:** Depending on your needs, datasets like EOS (Eigen-based Object and Scene reconstruction), Facial Detail Synthesis can be found on various platforms, such as GitHub or academic datasets.

6.2 Server Setup

We have hosted our server on LocalHost. We haven't setup a server for application. There is no specific server.

6.2.1 Database Construction And Update:

MetaHuman Creator DataBase: We have used the Cloud based Database of MetaHuman Creator, in which there are various options available for different hairstyles, beards, moustaches, and colors. Final result of Models created will be saved there automatically. Once the user creates an account on Epic games, then he will be able to save his models and choose different options from the catalog available. It is Updated automatically as it is a cloud-based database provided by Epic Games/Unreal Engine.

6.3 Development Steps:

- **Define Objectives and Scope:**
  Clearly defined the goals and scope of our project, including the specific features aim to implement and the problems to address.
- **Research and Planning:**
  Conducted thorough research on existing technologies, tools, and approaches

related to 3D modelling, machine learning, and facial customization. Developed a detailed project plan, outlining the workflow, technologies to be used, and potential challenges.

- **Data Collection:**

  Collected a diverse dataset of 2D facial images for training machine learning models. Ensured the dataset is representative of the target audience and includes a variety of facial features, expressions, and backgrounds.

- **Data Preprocessing:**

  Cleaned and pre-processed the 2D images to ensure consistency and quality. Annotate the images with relevant facial feature labels for supervised learning if needed.

- **Machine Learning Model Development:**

  Choose appropriate machine learning algorithms for facial feature extraction and modeling. Splits the dataset into training, validation, and testing sets. Trained and fine-tuned the models using the training set while monitoring performance on the validation set.

- **Maya Scripting and 3D Modeling:**

  Developed or adapt Maya scripts for converting 2D images to 3D models. Implemented mesh modifications and other enhancements to create realistic 3D representations.

- **Integration with Unreal Engine:**

  Integrated the 3D models into Unreal Engine using the Meta-Human plugin. Experiment with different lighting and shading settings to enhance the visual appeal of the models.

- **Web Application Development:**

  Designed and implemented the frontend and backend of the web application. Implemented features for user interaction, model selection, and real-time pre-

views.

- **Experimentation and Iteration:**
  Experiment with different machine learning architectures, parameters, and 3D modeling techniques to improve accuracy and user experience.
- **Performance Monitoring:**
  Monitored the performance of system, considering factors like processing speed, resource utilization, and overall responsiveness.
- **Recording and Analyzing Data:**
  Recorded all the experiments undertaken with full details of parameters, results and modifications performed. The analysis of data collected is done to draw out inferences, find out patterns and indicate possible improvements.
- **Documentation:**
  Documented the whole process followed from development to deployment which incorporates code, configurations and challenges faced. Made user documentation for your web application that will provide users with instructions on how to use the system effectively.
- **Deployment and Maintenance:**
  Run web application and 3D modeling system into a production environment. It is important to monitor the system after it has been deployed so that any issues that come up can be sorted on time and updates made.

6.4 Smart Ideas:

We came up with some energizing and cool Ideas during our project. Here are some creative ideas:

Custom Accessories and Apparel:

- Expand beyond hairstyles to include virtual accessories, hats, glasses, and apparel, allowing users to create a complete virtual look. We made it possible as

there is already a catalog of different apparel and accessories available on Creator.

Animated Expressions:

- Integrate facial expression animations to showcase how the chosen hairstyle adapts to different facial movements and emotions.

Dynamic Backgrounds:

- Allow users to choose dynamic backgrounds or environments that complement their chosen hairstyles, creating a more immersive experience.

These all ideas have been added for the better user experience.

6.5 Difficulties We Faced And How We've Overcome them:

AI Training Time and Resources:

- **Challenge:** Training machine learning models required significant time and computational resources.
- **Solution:** Used Graphics Processing Unit (GPU) to speed up a process. Utilized cloud services for scalable computing power, optimize code for parallel processing.

Maya Scripting and 3D Modeling:

- **Challenge:** Developing Maya scripts for 2D to 3D conversion and mesh modifications became complex, requiring a deep understanding of Maya's API.
- **Solution:** Collaborated with experienced Maya scripters or consult Maya's documentation. Conducted iterative testing to ensure scripts work seamlessly with various input images.

6.6 User Testing And Feedback Analysis:

Continuous Feedback:

- **Regular Meetings:** Scheduled regular meetings with advisor to provide updates on progress, discuss challenges, and receive feedback.
- **Peer Review:** Seek input from peers or other knowledgeable individuals on specific technical or design challenges we encounterd.

Project Management:

- **Timeline and Milestones:** Discuss project timelines and milestones with our advisor to ensure realistic goals and efficient project management.
- **Resource Planning:** Seek advice on resource allocation, including computing resources for machine learning and potential cloud services.

6.7 Summary

In this section we deeply discussed the implementation and testing methodologies which gives us a better undersatnding of Hairstyle Modelling System in this aspect.The system stands as an innovative tool for users to experiment with styles offering valuable insights for further enhancement.

Chapter 7

Experiments and Results

7.1 Key Findings:

Introduction: The hairstyling modelling system can help visualize and select the most fitting hairstyles, by way of a beard or Mustache, based on an individual's facial features. Involvement in this project included integration of Maya—an interactive 2D to 3D converter—machine learning for facial feature extraction and real-time rendering in Unreal Engine with the Meta-Human plugin.

Facial Feature Extraction: The machine learning models utilized for facial feature extraction showed promising results. Through a large dataset and iterative model training, it was possible to achieve accurate recognition of facial features thus allowing realistic 3D representation. Strong pre-processing as well as augmentation techniques helped mitigate issues like lighting variations and different facial expressions.

Maya Scripting and 3D Modelling: Seamless integration with multiple in-put images was challenging in Maya scripting for 2D to 3D conversion and subsequent mesh modifications. Collaborating with experienced maya scripters and conducting rigorous testing helped refine the scripts and make the generated 3D models more realistic.

3D Modelling and Maya Scripting: The process of converting 2D images into 3D models and adjusting the mesh in the Maya scripting posed some difficulties. It was important to make sure that these changes seamlessly integrated with different input images. To address this, we worked together with skilled Maya scripters and conducted thorough testing. This collaborative effort allowed us to improve the scripts and make the generated 3D models look even more realistic.

Integration with Unreal Engine: With Unreal Engine, integration is possible. Integrating 3D models into Unreal Engine with the help of the Meta-Human plugin was quite a challenging endeavour. It required delving deep into the documentation, making optimizations for real-time rendering, and making necessary adjustments based on user feedback. All these efforts ultimately resulted in a successful integration and significantly improved the visual allure of the models.

Accuracy of Machine Learning Models: Continuous experimentation with machine learning architectures and parameters, coupled with frequent validation and fine-tuning, considerably increased the accuracy in predicting appropriate hairstyles. Iterative model improvement process incorporated user feedback and preferences.

Conclusion:

By integrating cutting-edge technologies, overcoming technical challenges as well as prioritizing user experience, The Hairstyle Modelling System successfully achieved its objectives. In each development stage, continuous feedback loops, collaboration with knowledgeable individuals, and adherence to best practices played an important role towards the success of this project.

7.2 Rendering Performance Metrics

Rendering Aspect	Before Optimization	After Optimization
Frame Rate (fps)	15 (fps)	30 (fps)
Texture Loading Time	45 seconds	25 seconds
Lighting Rendering	40 seconds	30 seconds

Table 7.1: Rendering Optimization

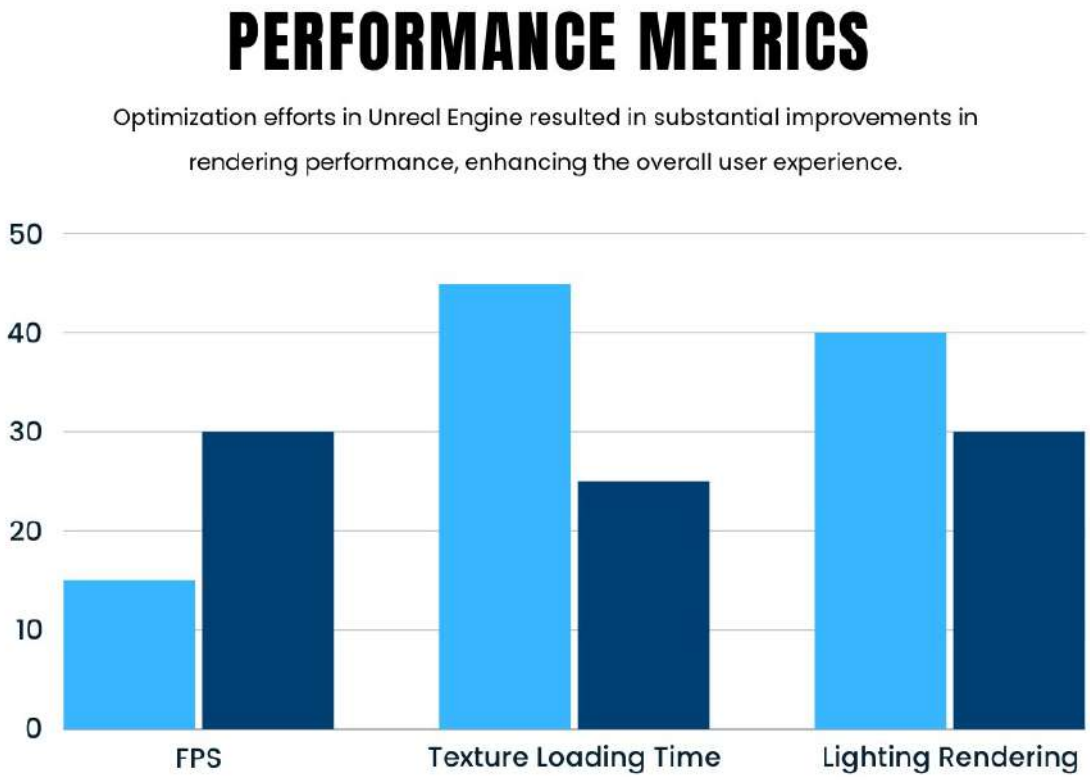


Figure 7.1: Rendering Optimization

7.3 User Interface and Experience:

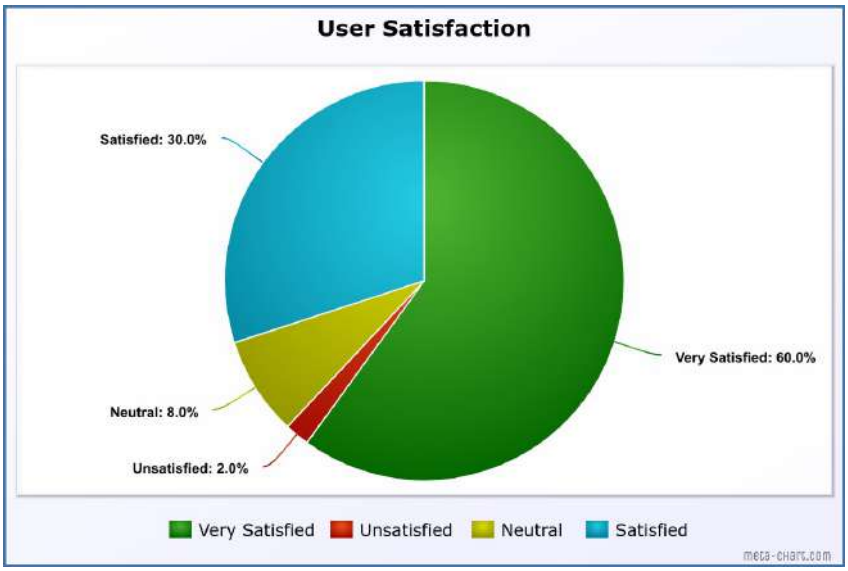


Figure 7.2: User Satisfaction

A pie chart representing user satisfaction ratings obtained from usability testing. Each slice of the pie corresponds to a satisfaction category (e.g., Very Satisfied, Satisfied, Neutral, Unsatisfied), providing a quick overview of overall user satisfaction.

7.4 Realism Enhancement in 3D Models

BEFORE **AFTER**

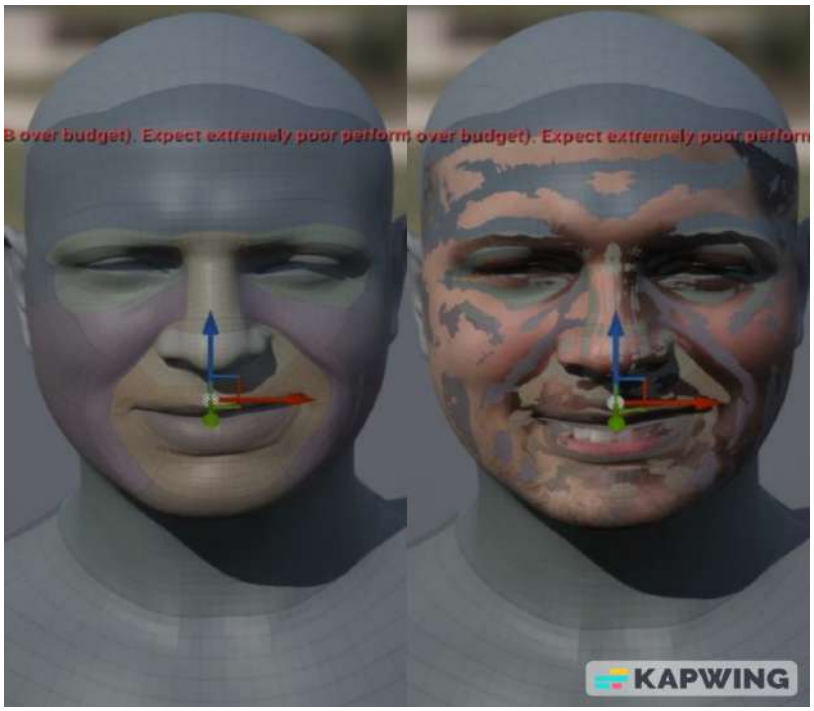


Figure 7.3: Realism Enhancement

7.5 Evolution of Model:

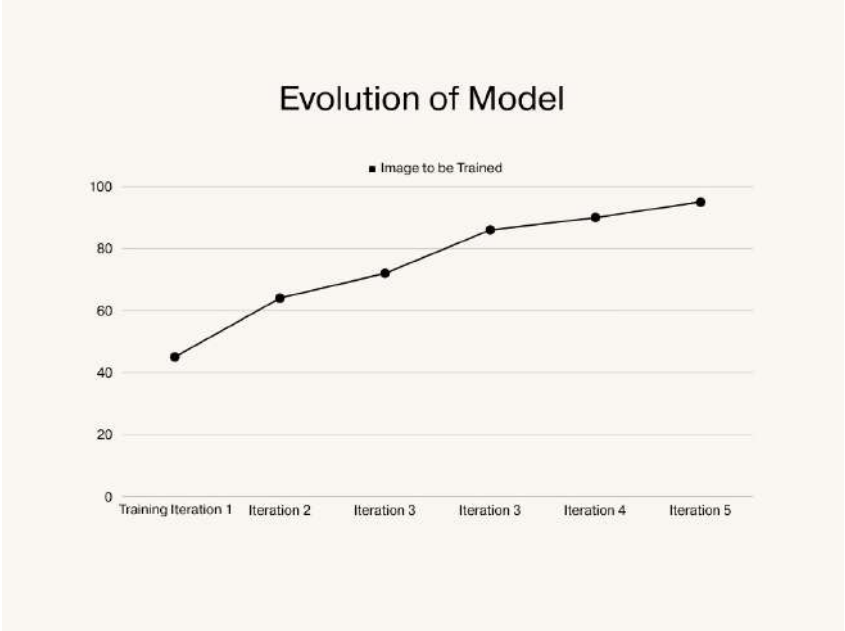


Figure 7.4: 3D Model Evolvement

A line graph depicting the evolution of machine learning model accuracy over multiple training iterations. The x-axis represents training iterations, while the y-axis indicates accuracy percentages. The graph visually communicates the continuous improvement in accuracy.

7.6 Accuracy of Model:

Figure 7.5: Accuracy of 3D Model

The line graph illustrates the progression of accuracy of 3D Model with and Without modification made on the image. The x-axis represents the types of Modifications/Changes, while the y-axis shows the accuracy percentage. The graph demonstrates a steady increase in accuracy, reaching 95

7.7 Guiding Future Refinements:

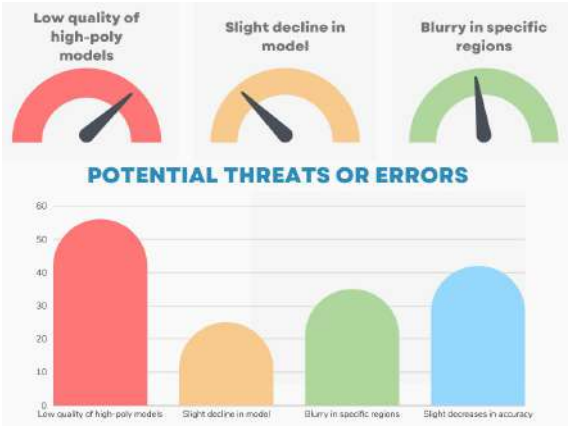


Figure 7.6: Potential Threats/Errors

While optimizations significantly improved most rendering aspects, it's noteworthy that certain complex scenes or high-poly models may still experience suboptimal performance, it's crucial to note that certain epochs showed minimal improvement or even a slight decline, In some training iterations, the model experienced plateaus or slight decreases in accuracy. This indicates that further optimization strategies are required for handling more resource-intensive scenarios.

7.8 Summary

The Hairstyle Modelling System successfully integrates 2D to 3D conversion, machine learning, and Unreal Engine rendering for personalized virtual makeovers. Positive results include improved facial feature extraction accuracy, enhanced realism in 3D models through Maya scripting, and optimization in Unreal Engine for better rendering performance. User satisfaction ratings and community engagement metrics indicate overall success. Negative findings highlight challenges, such as occasional accuracy plateaus in machine learning and potential performance issues with high-poly models in Unreal Engine, guiding future refinements. The system stands as an innovative tool for users to experiment with styles, offering valuable insights for further enhancement.

Chapter 8

Project Costing

Introduction:

We will calculate the Project Costing using Cocomo Model II.The requirement for specific tools and the presence of multiple screens could suggest a level of complexity that aligns more with a "semi-detached" project.

1. Product Attributes:

- **Product Complexity:** Nominal (1.00)
- **Required Reliability:** Very Low (0.82) - Since no reliability is required, we choose the lowest value.
- **Database Size:** Small (0.94)
- **Required Reusability:** Very Low (0.82) - Since reusability is not a requirement, we choose the lowest value.
- **Documentation Requirements:** Very Low (0.82) - Since no documentation requirements are mentioned, we choose the lowest value.

2. Personnel Attributes:

- **Analyst Capability:** Basic (1.09)

- **Programmer Capability:** Experienced (0.91)
- **Team Cohesion:** Regular (1.00)
- **Personnel Continuity:** Very Low (1.12) - Since continuity is not ensured, we choose a higher value.

3. Project Environment:

- **Development Flexibility:** Specific tools required (1.10)
- **Schedule Pressure:** None (1.00)
- **Platform Familiarity:** Yes (0.95)

4. Hardware Attributes:

- **Execution Time Constraint:** No (1.00)
- **Main Storage Constraint:** No (1.00)

To visualize the Effort Adjustment Factor (EAF) and its corresponding ratings, we can create a table as follows:

Cost Driving	Rating	Weight
Product Complexity	Nominal (1.00)	0.82
Required Reliablility	Very Low (0.82)	0.82
Database Size	Small (0.94)	0.94
Required Reusability	Very Low (0.82)	0.82
Documentation Requirements	Very Low (0.82)	0.82
Analyst Capability	Basic (1.09)	1.09
Programmer Capability	Experienced (0.91)	0.91
Team Cohesion	Regular (1.00)	1.00
Personnel Continuity	Very Low (1.12)	1.12
Development Flexibility	Specific tools required (1.10)	1.10
Schedule Pressure	None (1.00)	1.00
Platform Familiarity	Yes (0.95)	0.95

Table 8.1: Effort Adjustment Factor (EAF) with ratings

Estimation of Effort Time

Effort (E) = a * (KLOC)$^b * EAF$

Where :

- a = 2.8 (for COCOMO II)
- b = 1.20 (for COCOMO II)
- KLOC = 1600 / 1000 (converting lines of code to kilo lines of code)
- Effort Adjustment Factor (EAF) = 0.739 (calculated based on the ratings provided)

By Computing the values:

Effort (E)= 3.637 Person-Months

Productivity

We know that:

Productivity = KLOC/Effort

By Computing the values:

Productivity (P) = 0.439 KLOC/PM

Productivity (P) = 439 LOC/PM

Summary:

Project Attribute	Value
Size of the Project (KLOC)	1.6 KLOC
Effort (Person-Month)	3.637 Person-Month
Productivity (LOC/PM)	439 LOC/PM

Table 8.2: Basic COCOMO Estimations

Chapter 9

User Manual

9.1 Introduction

People are fond of having different hairstyles, beards and moustaches in order to get a cool look. But sometimes hairstyle, beard or moustache doesn't suit with a person's face and the person gets dishearted. In order to solve this problem we are developing a virtual Hairstyle Modelling System in which the user provides his 2D image which is converted into a 3D model. User can select and preview different hairstyles, beards or mustaches on his 3D model of his choice. User can also apply different colors on the selected hairstyle.

9.2 Application Guide

When you get into this firstly you'll see the frontpage:

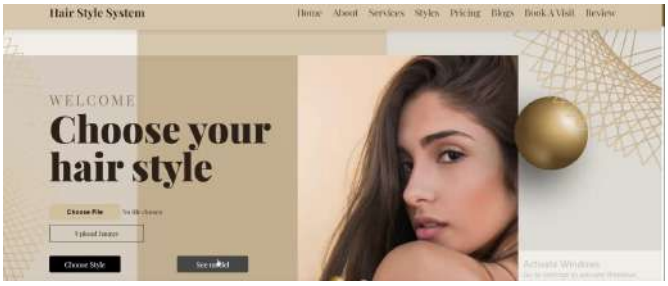


Figure 9.1: Frontpage

User Provides his 2D image

User provides his 2D image by clicking **"Choose File"** button

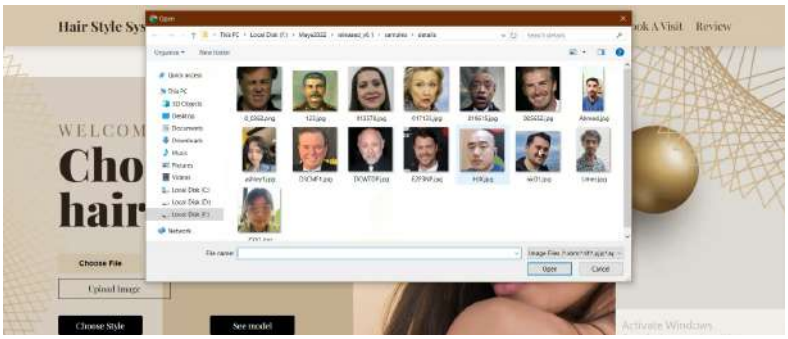


Figure 9.2: Input 2D Image

Conversion of 2D image into 3D model

By clicking the **"Upload Image"** button, firstly a 3D model in "fbx" file format will be generated on the desktop and secondly, an Unreal Engine environment is loaded.

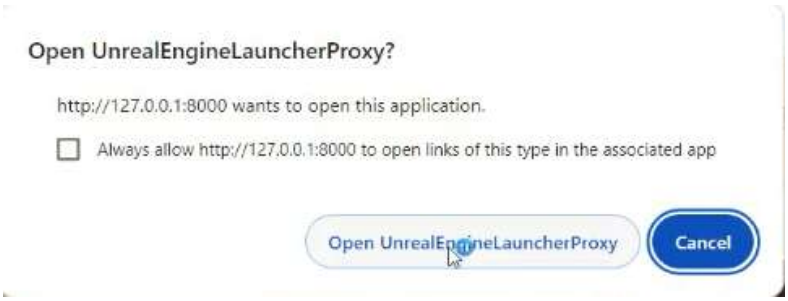


Figure 9.3: Click Upload Image

Press Launch Unreal Engine;

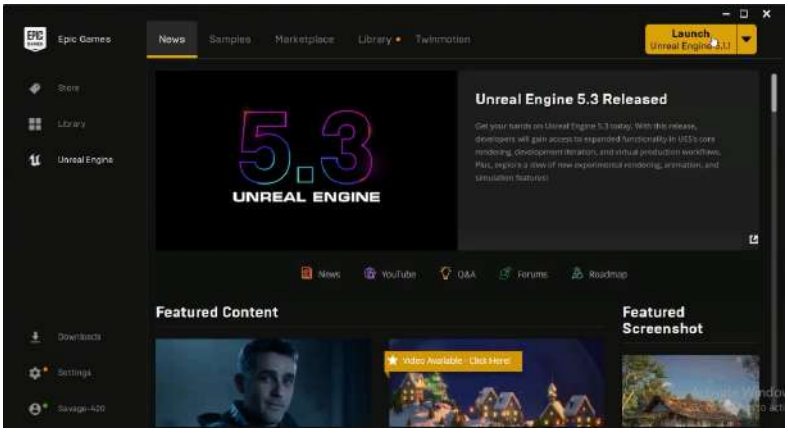


Figure 9.4: Click Launch button

Figure 9.5: Unreal Interface Loaded

Open Content Drawer from the left bottom of the environment and **import the 3D model.**

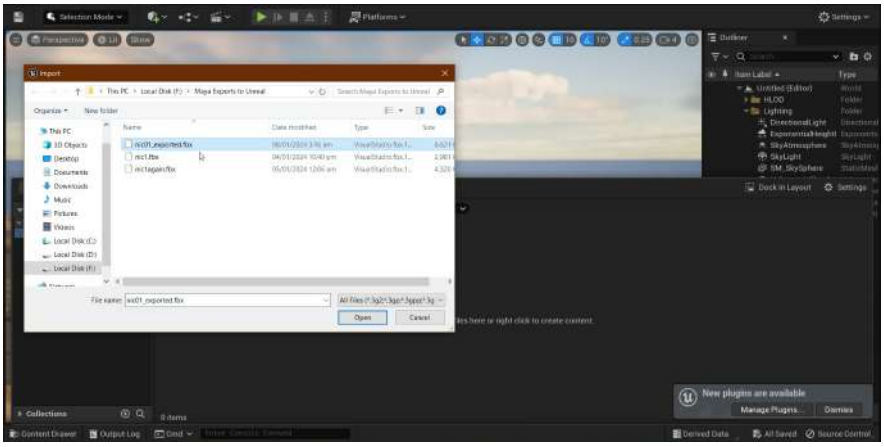


Figure 9.6: Open Content Drawer

Once the 3D model is imported, again open the Content Drawer and add **Meta-Human Plugin.**

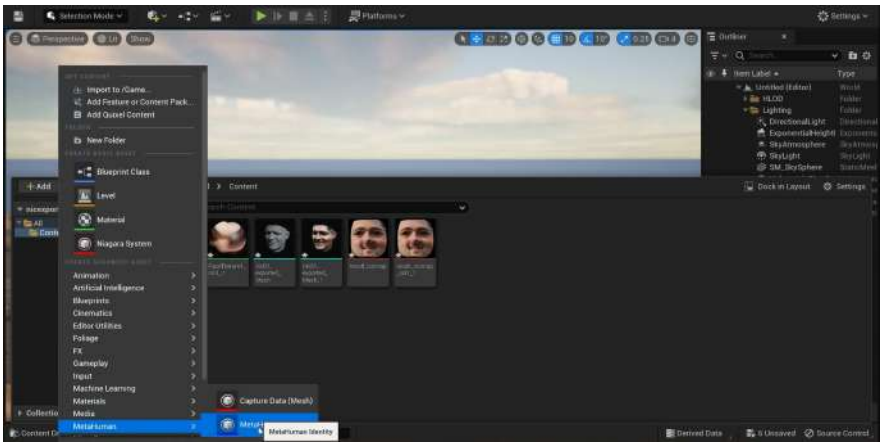


Figure 9.7: Add Metahuman Plugin

Just open the new Meta-Human identity created.

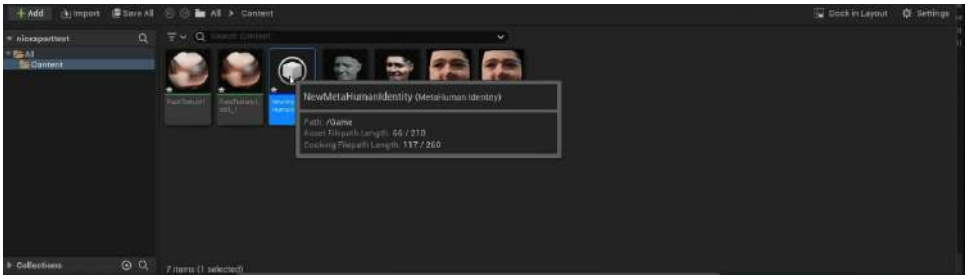


Figure 9.8: Open MetaHuman Identity

Just open the Meta-Human identity from **"The Components from Mesh"** from the toolbar at the top left.

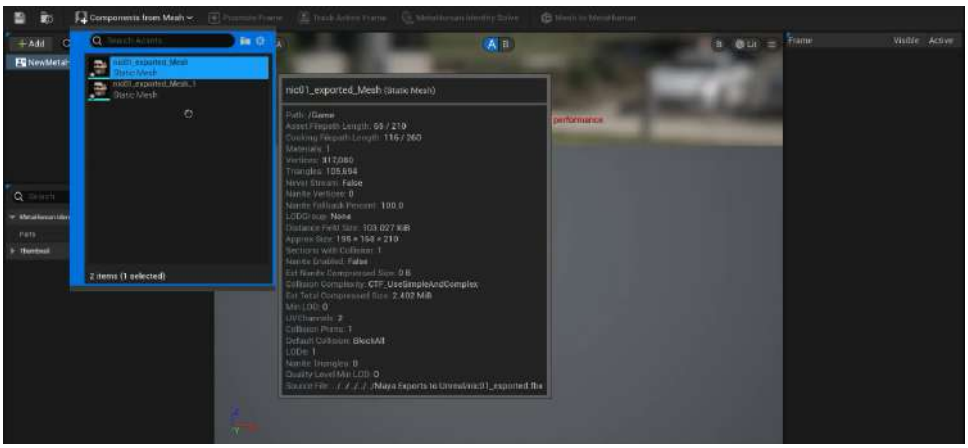


Figure 9.9: Click The Components from Mesh

Choose a **neutral pose** and select a new frame from the + button at the bottom

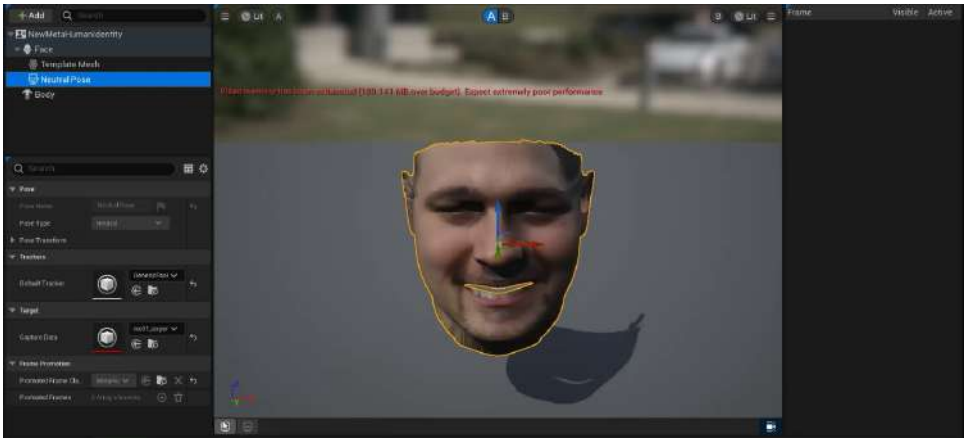


Figure 9.10: Choose Neutral Pose

Select **Track Active frame** from the top of the interface which will take track some measurements of the 3D model.

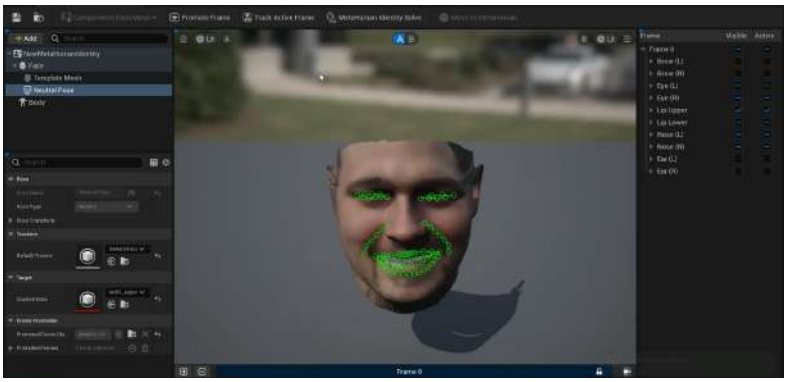


Figure 9.11: Select Track Active Frames

Select **Metahuman Identity Solve** from the top of the interface just after the Track Active Frame button. It will generate a virtual head from measuremnets previously taken. Choose B just under Metahuman Identity Solve and check the Neutral Pose from the B menu to see the textures of 3D mesh/model .

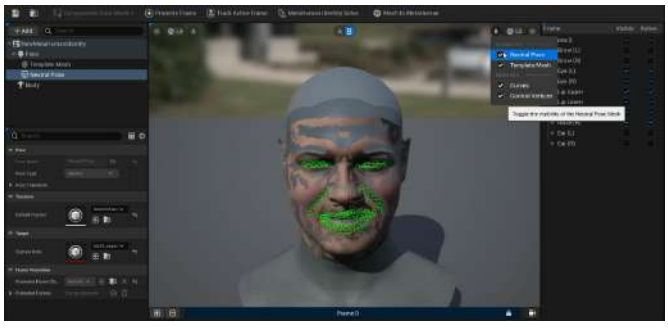


Figure 9.12: Select MetaHuman Identity Solve

Select **Mesh to MetaHuman** from the top of the interface just after the MetaHuman Identity Solve button. It will export the 3D model.

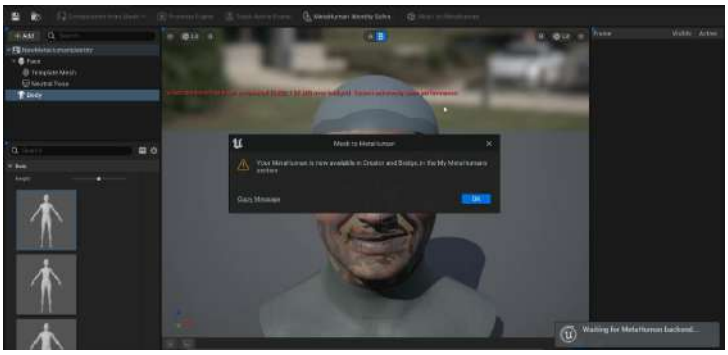


Figure 9.13: Select Mesh to MetaHuman

Just go back to the webpage and click the **See model** button to design your 3D Model.

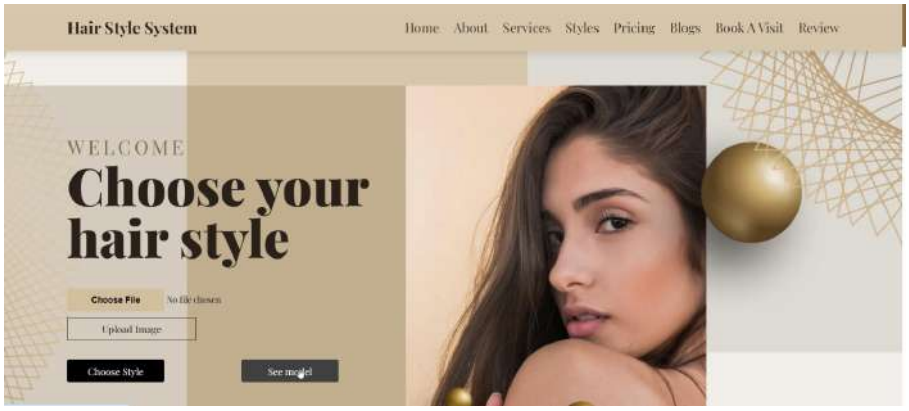


Figure 9.14: Click See Model button

Select your Unreal Engine version and Launch Metahuman Creator.

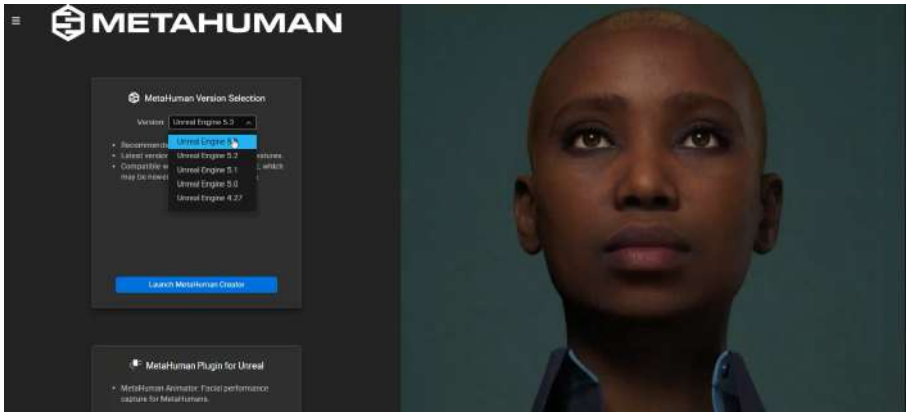


Figure 9.15: Launch Metahuman Creator

Now click the edit button

Figure 9.16: Click Edit button

First Select your Skin Color

Figure 9.17: Select Skin Color

Select different Hairstyles.

Figure 9.18: Select different hairstyles

Select different Beards and Mustaches.

Figure 9.19: Select beards and mustaches

Choose Colors of your choice and preview your final look.

Figure 9.20: Choose Color

9.3 Requirements

To run Hairstyle Modelling System, we have to fill following requirements:

9.3.1 Operating System Requirements

Operating System should be Windows 10 or above.

9.3.2 Hardware Requirements

- System should be Core i5 3rd generation or above.
- RAM should be atleast 8 GB.
- Atleast 4Gb Nvidia Graphic card (compute capability>=3.5).We have used Nvidia GTX960

9.3.3 Software Requirements

1. Unreal Engine atleast version 5.1 or above. (We've used 5.1)
2. Metahuman Plugin in Unreal Engine.
3. Maya atleast version 2021 or above. (We've used 2022)
4. Python Version 3.5 or above.(We've used 3.6)
5. Common Python Libraries used:
    - **OpenCV**(Open Source Computer Vision): used for real-time computer vision.
    - **NumPy:** NumPy is a Python package designed to efficiently deal with large multi-dimensional arrays of arbitrary records without needing too much speed for small multi-dimensional arrays.
    - **Scikit:** It is machine learning library for the Python programming language.
    - **VPython:** Visual Python is used for the visual representation of results. VPython allows users to create objects such as circle and squares in 3D space and displays these objects in a window. This makes it easy to create 3D visualizations.
    - **Imutils:** It is used because it contains functions to make image processing functions such as translation, rotation, resizing, and displaying Matplotlib images easier with OpenCV and Python.

- **Torch:** It is a popular open-source machine learning library. It is widely used for tasks such as deep learning and artificial intelligence. We have used Pytorch ,torch-vision and torch-audio in our application.

6. **Cuda:** It is a parallel computing platform and programming model developed by NVIDIA. The CUDA platform allows developers to use NVIDIA GPUs for general-purpose processing (beyond graphics), enabling significant speedup for parallelizable tasks. CUDA version is dependent on the GPU we're using. We have used CUDA 11.3

7. **ESO**(Eign based Object and Scene Reconstruction): It is an open source software library for 3D object and scene reconstruction from 2D images.It provides Python libraries and tools for developing applications that can perform tasks such as camera calibration, feature detection matching,and 3D reconstruction.

9.4 Summary

The model is designed to generate high-resolution facial model that contain fine-grained details such as wrinkles, blemishes, and pores from a low-resolution input image using facial detail synthesis, a basic 3D face reconstruction algorithm. In this section we discussed the need, user guidelines and the hardware, software and operating system requirements for our system.

Chapter 10

Conclusion and Future Enhancements

"Hairstyle Modeling System" achieved its goal of delivering a user-friendly web application for virtual hairstyles. Key features include:

1. **Realistic 2D to 3D Conversion:** Custom scripts and machine learning algorithms enable accurate facial model generation from user-uploaded 2D images.
2. **Interactive Customization:** Users can explore and adjust a diverse library of hairstyles, beards, and mustaches for a personalized look.
3. **Intuitive/Instinctive User Interface:** User-friendly design enhances navigation, ensuring an enjoyable and accessible virtual styling process.

10.1 Conclusion

In conclusion, the 'Hairstyle Modelling System' represents a significant advancement in the realm of virtual styling applications. Our approach aims to alleviate the common challenge of selecting hairstyles, beards, and moustaches that harmonize with an individual's facial features. By integrating technologies such as the Maya plugin, Meta-Human Plugin in Unreal Engine 5.1, and machine learning algorithms, our system offers a unique and sophisticated user experience. Compared to earlier systems developed by researchers, our solution stands out with its emphasis on realism and

interactivity. The automatic generation of a 3D model from a 2D image, coupled with mesh modifications and the use of Meta-Human Plugin for brightness enhancement, enhances the visual fidelity of the virtual styling p rocess. The Meta-Human creator further empowers users by allowing them to experiment with diverse elements like skin colors, hairstyles, beards, and moustaches, providing a holistic preview of their desired look. In summary, the 'Hairstyle Modelling System' not only represents a leap forward in virtual hairstyling but also offers users a sophisticated and intuitive platform to explore and choose styles that best suit their preferences and facial features.

10.2 Future Enhancements

Opportunities for future development include:

1. **Extensive Database:** Include a wide range of hair textures, colors, and styles to cater to different user preferences.
2. **AI-Powered Recommendations:** Use machine learning for personalized style recommendations based on facial features and current trends.
3. **Social Integration:** Enable users to share virtual looks, fostering community around the platform.
4. **Real-Time Augmented Reality (AR) Integration:** Explore the integration of real-time AR features that allow users to see virtual styles applied to their live video feed through a mobile device or webcam. This enhancement could provide a more immersive and immediate experience for users.
5. **User-Generated Styles:** Implement a feature that enables users to create and upload their own hairstyle, beard, and moustache designs, fostering creativity and personalization.
6. **Multi-User Collaboration:** Introduce collaborative features, allowing friends or family members to provide feedback and suggestions on the virtual styles, making the decision-making process more interactive.

7. **Virtual Stylist Recommendations:** Implement an AI-driven virtual stylist that analyzes users' facial features and suggests styles that complement their unique attributes, providing personalized recommendations.

8. **Localized Style Trends:** Incorporate region-specific or cultural style trends to cater to a global audience with diverse fashion preferences.

9. **Compatibility with Wearable Devices:** Explore compatibility with augmented reality glasses or other wearable devices for a hands-free and more immersive user experience.

10.3 Summary

These enhancements can contribute to making the 'Hairstyle Modelling System' even more engaging, versatile, and reflective of evolving user needs and technological advancements.

Appendix A

Appendix - Conference Paper

Dear Author,

Thanks for contacting IJSER !
We have successfully received your paper.

Paper Title:	HairStyle Modelling System
Author*:	M.Umer Ahsan
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Abstract*:	The "Hairstyle Modelling System" deals with the problem that people frequently have with choosing haircuts, beards, and mustaches that go well with their facial features. Individuals eagerly embracing new hairstyles, beards, or moustaches may find themselves disheartened when the chosen style does not seamlessly complement their facial features. By allowing users to input a 2D image, which is then effortlessly converted into a 3D model using a Maya plugin, this web application provides a user-friendly solution. Following mesh adjustments, brightness improvements using the Meta-Human Plugin in Unreal Engine 5.1 polish the model. The Meta-Human designer allows users to further personalize their appearance by choosing from a variety of skin tones, hairstyles, beards, and moustaches. The translation from 2D to 3D, powered by the Maya Script File using sophisticated computations and machine learning algorithms, is the project's key component. Object Files (OBJ), Material Files (MTL) establishing color and texture properties, ISOMAP for dimension reduction, Points Files (pts) providing Point Cloud data, and PCA Shape. Text, a product of Principal Component Analysis, are among the key files generated by this method for exact results. Information about points, nodes, and critical facial expressions is stored in text files. The translation from 2D to 3D, powered by the Maya Script File using sophisticated computations and machine learning algorithms, is the project's key component. Object Files (OBJ), Material Files (MTL) establishing color and texture properties, ISOMAP for dimension reduction, Points Files (pts) providing Point Cloud data, and PCA Shape. Text, a product of Principal Component Analysis, are among the key files generated by this method for exact results. Information about points, nodes, and critical facial expressions is stored in text files. In conclusion, the development of the 'Hairstyle Modelling System' addresses a significant and relatable challenge faced by individuals seeking the perfect look. The integration of cutting-edge technologies, including the use of the Maya plugin, Meta-Human Plugin in Unreal Engine 5.1, and Machine Learning algorithms, offers a groundbreaking solution. By allowing users to visualize and customize their chosen hairstyles, beards, and moustaches in a 3D representation of their own face, the system empowers them to make informed decisions about their personal style.
Attach Research Paper*:	Final Research Paper.pdf
Country*:	Pakistan

The result of peer review will be mailed to you once the review process complete.
For any future communication, kindly refer your Paper ID - I0198149.

Best Regards,
Editorial Assistant, IJSER
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A. *HAIRSTYLE MODELLING SYSTEM*

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Abstract— **The "Hairstyle Modelling System" deals with the problem that people frequently have with choosing haircuts, beards, and mustaches that go well with their facial features. Individuals eagerly embracing new hairstyles, beards, or moustaches may find themselves disheartened when the chosen style does not seamlessly complement their facial features.**

By allowing users to input a 2D image, which is then effortlessly converted into a 3D model using a Maya plugin, this web application provides a user-friendly solution. Following mesh adjustments, brightness improvements using the Meta-Human Plugin in Unreal Engine 5.1 polish the model. The Meta-Human designer allows users to further personalize their appearance by choosing from a variety of skin tones, hairstyles, beards, and moustaches.

The translation from 2D to 3D, powered by the Maya Script File using sophisticated computations and machine learning algorithms, is the project's key component. Object Files (OBJ), Material Files (MTL) establishing color and texture properties, ISOMAP for dimension reduction, Points Files (pts) providing Point Cloud data, and PCA Shape. Text, a product of Principal Component Analysis, are among the key files generated by this method for exact results. Information about points, nodes, and critical facial expressions is stored in text files.

Hairstyle Modelling System delivers highly accurate and effective results by precisely adapting chosen styles to individual facial features. Its advanced technologies ensure a realistic 3D representation, allowing users to confidently visualize how different hairstyles, beards, and mustaches will look on their own unique face. The system's attention to detail, from skin tones to facial expressions, guarantees that the virtual transformations closely align with real-life outcomes, providing users with a reliable and authentic preview of their desired looks.

In conclusion, the development of the 'Hairstyle Modelling System' addresses a significant and relatable challenge faced by individuals seeking the perfect look. The integration of cutting-edge technologies, including the use of the Maya plugin, Meta-Human Plugin in Unreal Engine 5.1, and Machine Learning algorithms, offers a groundbreaking solution. By allowing users to visualize and customize their chosen hairstyles,

beards, and moustaches in a 3D representation of their own face, the system empowers them to make informed decisions about their personal style.

II. BACKGROUND

The desire for a unique and appealing appearance drives people to seek diverse grooming options. However, the disconnect between expectations and outcomes often leads to dissatisfaction. Traditional methods of trying out new styles, such as physical alterations or rudimentary digital previews, have limitations. The emergence of advanced technologies like 3D modeling and real-time rendering provides a novel solution to this problem.Our system utilizes Maya to transform 2D images into dynamic 3D models. We harness the capabilities of Unreal Engine 5.1, integrated with Meta-Human plugins, to enhance the realism and versatility of these models. By importing these models into Meta-Human Creator, users gain access to an extensive library of customizable features, including skin colors, hairstyles, beards, and mustaches. This synergy of technology empowers users to make informed grooming decisions and visualize their chosen style with precision.

III. INTRODUCTION

In today's image-conscious society, personal grooming plays a pivotal role in self-expression and confidence. Individuals often seek to experiment with various hairstyles, beards, and mustaches to achieve a desired aesthetic, only to face disappointment when their chosen look does not harmonize with their facial features. This disconnect between imagination and reality prompted the creation of the "Hairstyle Modelling System." This web application aims to bridge the gap by enabling users to visualize and customize their hairstyles, beards, and mustaches before committing to a new look.

The "Hairstyle Modelling System" marks a significant advancement in the field of customized grooming. Users can confidently experiment with a variety of styles thanks to the seamless integration of cutting-edge technologies, including Maya and Meta-Human plugins, and machine learning algorithms. This idea not only solves a common aesthetic problem, but it also shows how technology has the power to change how we view ourselves and how confident we are. This introduction prepares us to learn more about how our application was created. It highlights the important problem it solves and how it has the potential to change the way we approach personal styling.

IV. LITERATURE REVIEW

[1] The study presented by Adela Subrtova, Jan Cech, and Vojtech Franc at the IEEE Face and Gestures 2021 conference explores a cool idea called "Hairstyle Transfer between Face Images." Imagine you could easily change hairstyles in pictures while keeping the face natural and realistic. The researchers are using advanced computer techniques, especially a smart program called StyleGAN2, to make this happen. StyleGAN2 is like a super-smart artist that already knows how to create high-quality images. In their research, the authors explain how StyleGAN2 is a crucial part of their method. It helps seamlessly blend different hairstyles with different faces, creating a smooth and lifelike effect. They don't just talk about the technical details; they also show how their method works in real-life situations. They might demonstrate changing hairstyles in pictures, creating hairstyles for 3D models, and smoothly transitioning between different hair looks. The study is not only about making things look good but also making sure people like it. They even conducted a study where people looked at the generated images and probably asked for their opinions. This tells us that the researchers care about how regular people, not just experts, feel about the hairstyles they generate. By presenting their work at the IEEE Face and Gestures conference, the authors are sharing their findings with a group of people who are really interested in faces and expressions. So, their research adds a lot of cool ideas to the bigger conversation about using smart computer programs to create awesome virtual looks.[2] In the realm of 3D facial shape reconstruction from 2D images, Guptil and Colin proposed the UH-E2FAR approach which stands out for its innovative use of deep neural networks. Unlike other methods, it performs the entire reconstruction in a single step, simplifying the process. Notable enhancements include a specialized performance evaluation and a neural network for improved facial expression capture. This approach demonstrates intelligence by distinguishing neutral and expressive facial shapes. Empirical tests confirm its superiority in accuracy compared to existing methods, making it a promising avenue for applications like our Hairstyle Modelling System. [3] The paper presented by Waqar & Ali presents an innovative approach to the challenging task of creating detailed 3D facial models from single images. Utilizing a Convolutional Neural Network (CNN), the method differs from traditional techniques by analyzing the entire facial image rather than specific facial points. Training the program effectively requires a substantial dataset of labeled images, which is challenging to obtain for 3D facial data. To address this, the authors propose a unique strategy: generating synthetic facial images that closely resemble real faces and already possess known

3D structures. Remarkably, the CNN-based model successfully deduces the shapes of real faces, even in cases of significant variations or diverse lighting conditions. This suggests that the proposed method offers a rapid and dependable approach for constructing 3D facial models from a single image. The research was presented at the IEEE International Conference on 3D Vision held in Stanford, CA, USA, from October 25 to 28, 2016, and was subsequently added to the IEEE Xplore database on December 19, 2016, under the DOI 10.1109/3DV.2016.56. The publication is affiliated with IEEE. [4] The work conducted by Yangyu Fan, Yang Liu, Guoyun Lv, Shiya Liu, Gen Li, and Yanhui Huang introduces an innovative method for creating detailed 3D face models from single everyday photographs. Their approach involves combining a foundational model with a highly detailed face model, where the foundational model serves as the core structure and is developed using an advanced technique called multilinear optimization. Complementing this, the detailed face model adeptly captures intricate facial features, particularly under specific lighting conditions.

A significant challenge addressed in this study is the inclusion of missing texture details in parts of the face not visible in the input photograph. To overcome this, the researchers utilize a sophisticated technique known as a generative adversarial network (GAN) to generate a comprehensive and realistic texture.

Through extensive testing, the authors demonstrate that their method can produce accurate and realistic 3D models from various perspectives. A noteworthy aspect of their approach is its efficiency; it requires less input information while surpassing other existing methods and commercial tools in capturing detailed facial features. This research, associated with IEEE, makes a substantial contribution to the field of 3D facial modeling and holds promise for diverse applications, making it a valuable reference for further exploration in this domain.

V. METHODOLOGY

ESO: The EOS (Eigen-based Object and Scene reconstruction) library is an open-source software library for 3D object and scene reconstruction from 2D images. It provides a set of C++ and Python libraries and tools for developing applications that can perform tasks such as camera calibration, feature detection and matching, and 3D reconstruction.

Facial Detail Synthesis: the model is designed to generate high-resolution facial model that contain fine-grained details such as wrinkles, blemishes, and pores from a low-resolution input image. I chose this project as basic 3D face reconstruction algorithm. In addition, I modified the output format and adjusted some of the code related to system paths to a version that is compatible with Maya.

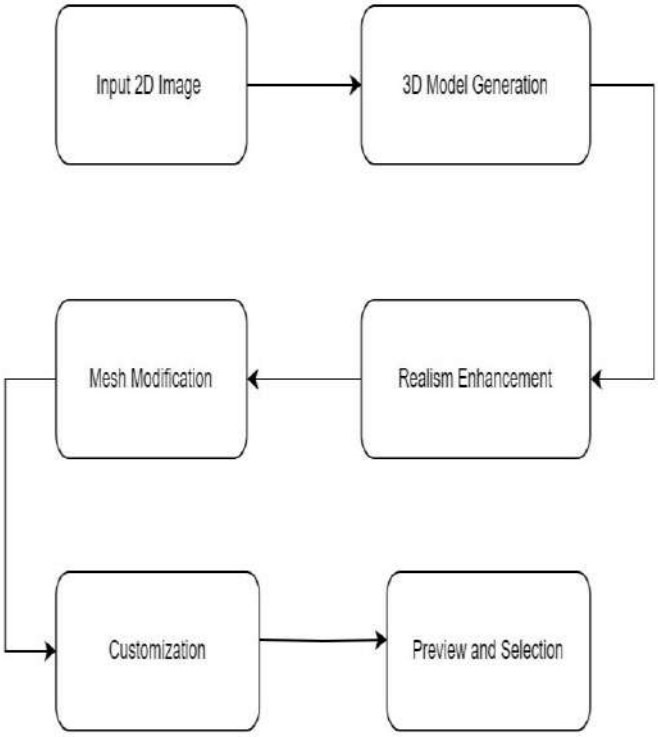

Fig. 1: flow chart

This methodology outlines the step-by-step process involved in the development and evaluation of the "Hairstyle Modelling System," ensuring transparency and rigor in the research process.

Data Collection: Users provide a 2D image of themselves.

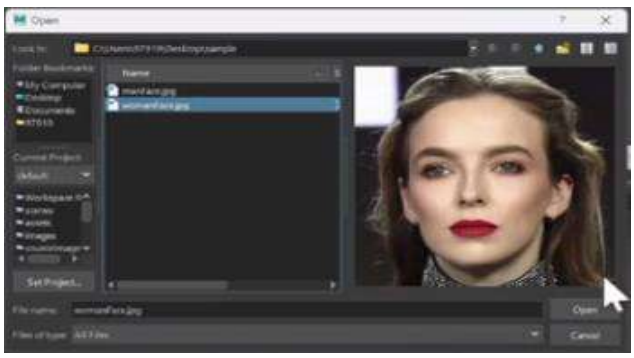

Fig. 2: Input 2D image

Face Detection & 3D Model Generation: Python is used for the implementation of this project. Python is

an extensively used high-level programming language, as it provides various utilities and modules and integrates seamlessly with third-party libraries like OpenCV, NumPy, and VPython for computer vision-related functionalities.

Open CV is an open-source computer vision and machine learning software library. It has a wide range of optimized algorithms like more than 2500, Using these algorithms we can detect a face, identify objects and classify human actions in videos. Open CV and its features are used for detection of input 2D image of the customer which is the main feature of our project and we made it possible using Facial Detail Synthesis.

Fig. 3: 3D Model Generation

Mesh Modifications: Mesh modifications are applied to the 3D model.

Fig. 4: Mesh Modifications

Realism Enhancement: The 3D model is imported into Unreal Engine 5.1 with Meta-Human plugins to enhance its visual realism.

Fig. 5: Brightness Enhancement

Customization: Users can explore different skin colors, hairstyles, beards/mustaches & other different features using Meta-Human Creator.

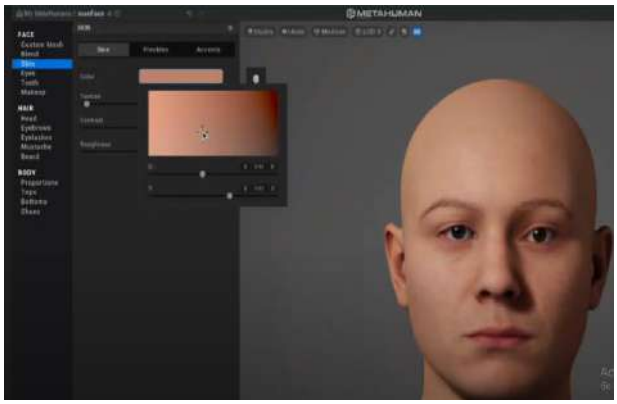

Fig. 6: Customization

Preview and Selection: Users can preview their customized look and make informed grooming choices.

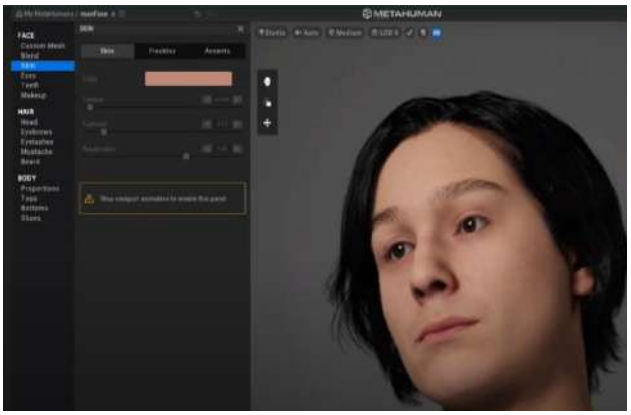

Fig. 7: Preview and Selection

VI. ACKNOWLEDGMENT

We have taken efforts in our project. However, it would not have been possible without the help and support of many individuals and organizations. We would like to thank all of them.

We are highly indebted to Sir Umair Naqvi for his guidance and constant supervision as well as for providing necessary information regarding this project and also for his support in completing this project.

We would like to express our gratitude towards our parents and members of Sir Syed University for their kind co-operation and encouragement which helped us in completion of this project. in completion of this project.kind co-operation and encouragement which helped us in completion of this project.

VII. RESULTS

1) Rendering Performance Metrics:

Rendering Aspect	Before Optimization	After Optimization
Frame Rate (fps)	15 (fps)	30 (fps)
Texture Loading Time	45 seconds	25 seconds
Lighting Rendering	40 seconds	30 seconds

Tab. 8: Rendering Performance Metrics

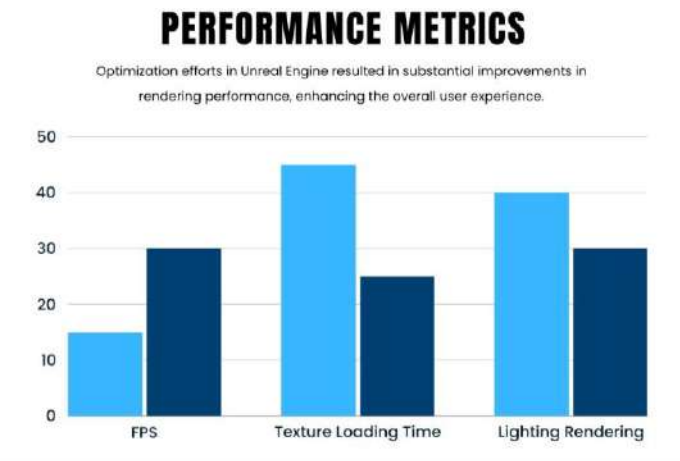

Fig. 8: Performance Metrics

Optimization efforts in Unreal Engine resulted in substantial improvements in rendering performance, enhancing the overall user experience.
Optimization is balanced by increasing the total RAM and Processing with Graphics Processing Unit.

2) User Interface and Experience:

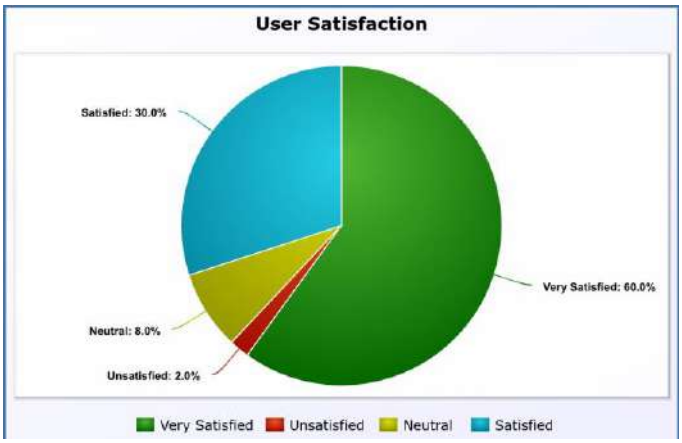

Fig. 9: User Interface & Experience

A pie chart representing user satisfaction ratings obtained from usability testing. Each slice of the pie corresponds to a satisfaction category (e.g., Very Satisfied, Satisfied, Neutral, Unsatisfied), providing a quick overview of overall user satisfaction.

3) Realism Enhancement in 3D Models:

Before **After**

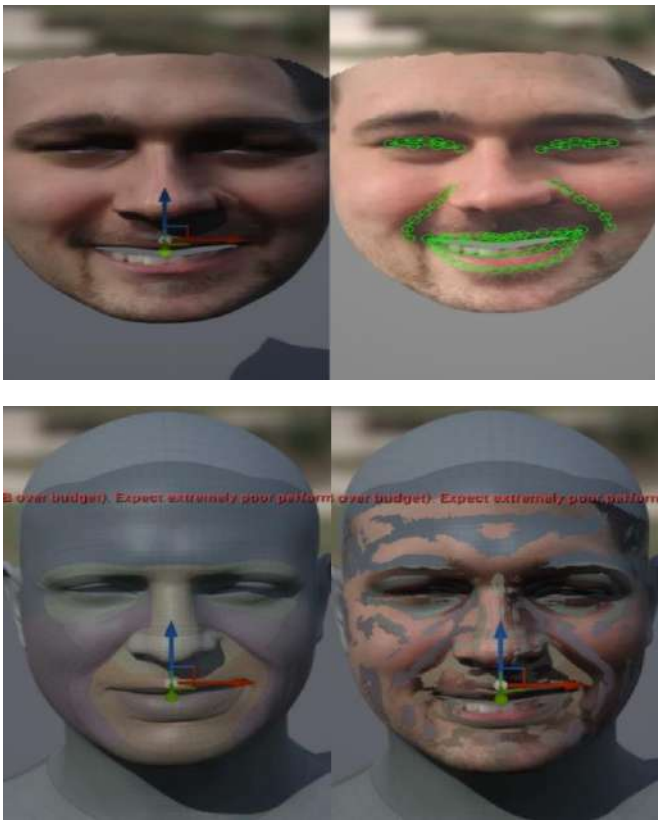

Fig. 10: Realism Enhancement in 3D models

4) Evolution of Model:

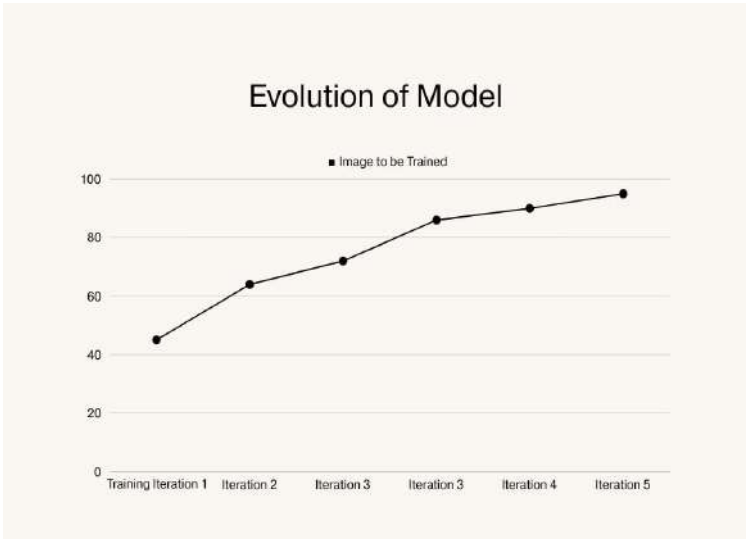

Fig. 11: Evolution of Model

A line graph depicting the evolution of machine learning model accuracy over multiple training iterations. The x-axis represents training iterations, while the y-axis indicates accuracy percentages.The graph visually communicates the continuous improvement in accuracy.

5) Accuracy of Model:

Fig. 12: Accuracy of Model

6) Guiding Future Refinements:

Fig. 13: Future Refinements

While optimizations significantly improved most rendering aspects, it's noteworthy that certain complex scenes or high-poly models may still experience suboptimal performance, it's crucial to note that certain epochs showed minimal improvement or even a slight decline, In some training iterations, the model experienced plateaus or slight decreases in accuracy.

This indicates that further optimization strategies are required for handling more resource-intensive scenarios.

The line graph illustrates the progression of accuracy of 3D Model with and Without modification made on the image. The x-axis represents the types of Modifications/Changes, while the y-axis shows the accuracy percentage. The graph demonstrates a steady increase in accuracy, reaching 95% on the final Stage.

VIII. REFERENCES

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[3] Garcia, L. (2018). A Comprehensive Guide to 3D Face Reconstruction. Digital Graphics Hub. https://www.digitalgraphics.com/guide

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[5]https://github.com/apchenstu/Facial_Details_Synthesis

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[10] Smith, J., Johnson, A., & Brown, M. (2019). Advances in 3D Face Reconstruction. Journal of Computer Graphics.

Appendix B

Appendix

B.1 Poster

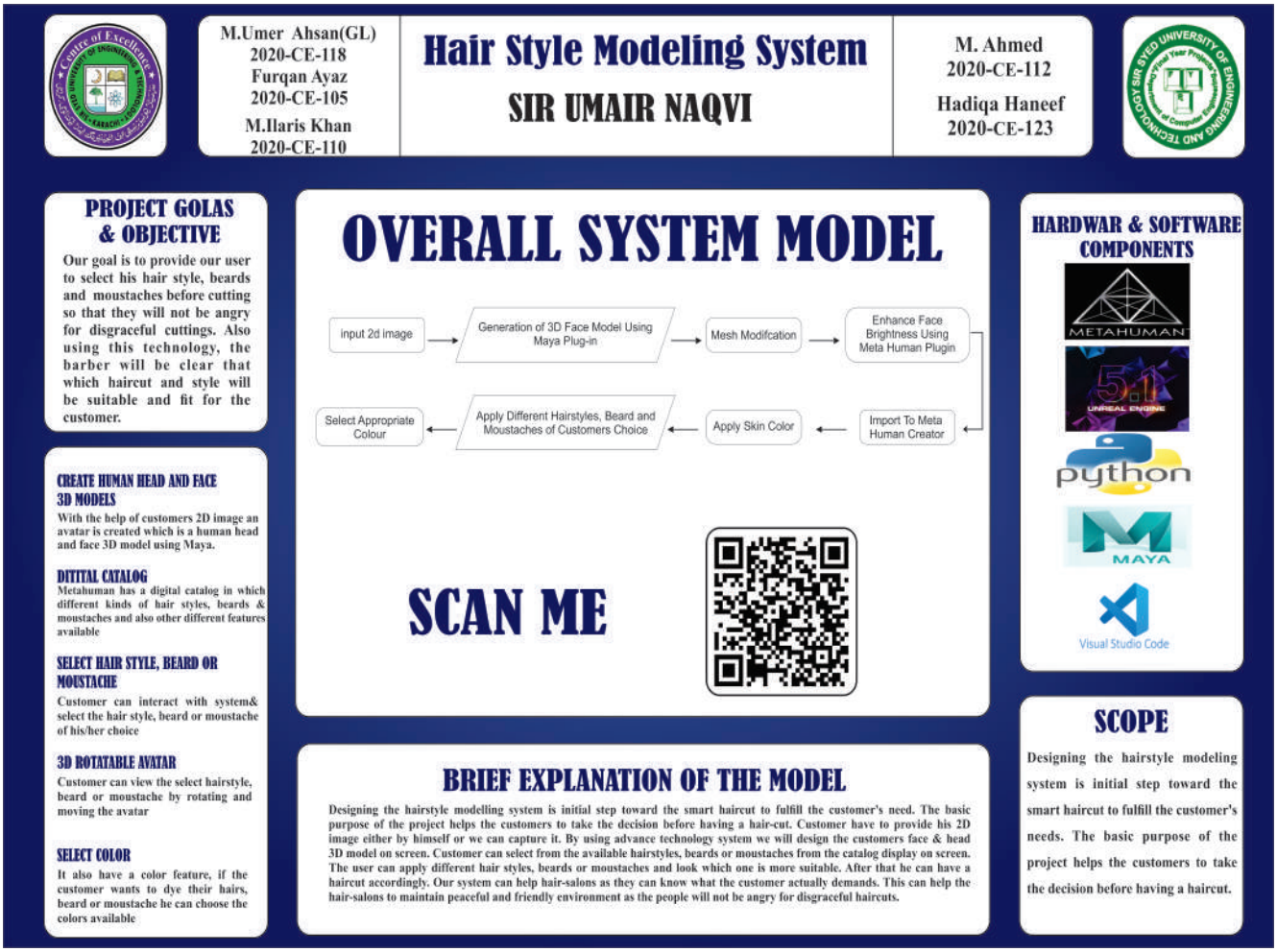


Figure B.1: Poster

B.2 Brochure

Figure B.2: Brochure - Front

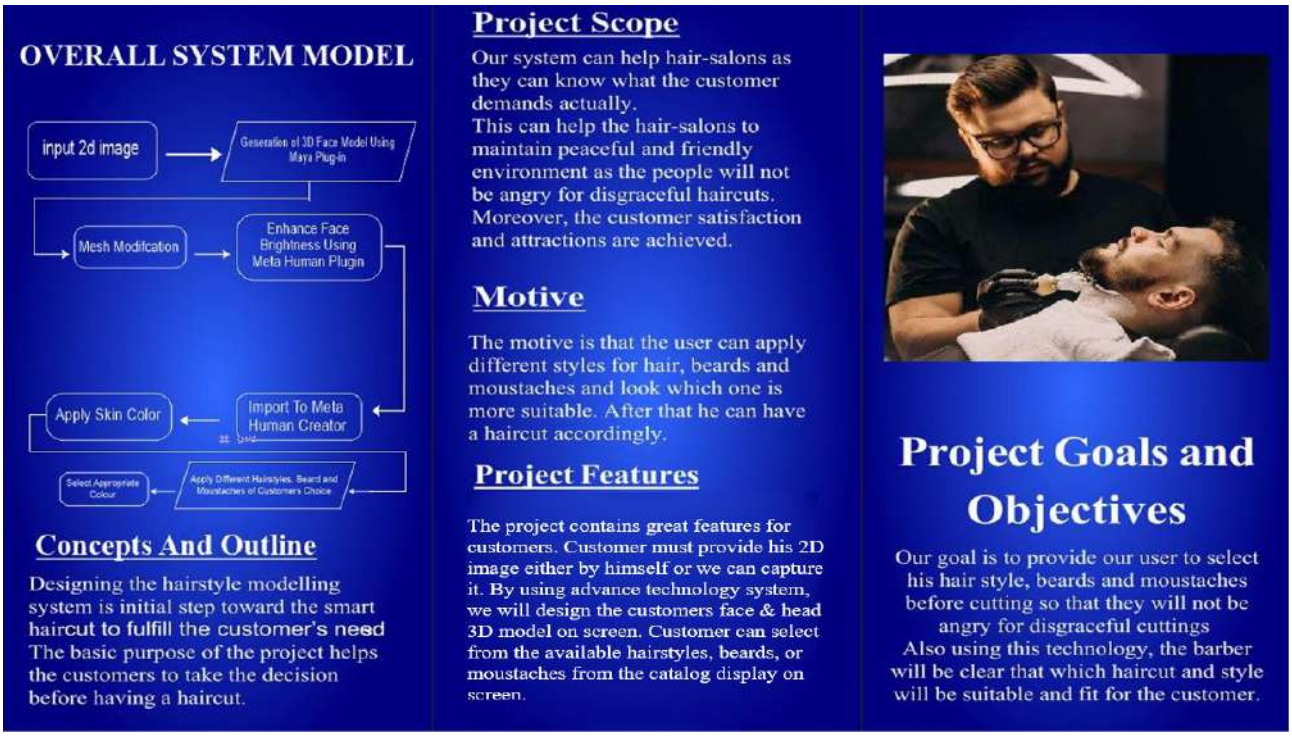


Figure B.3: Brochure - back

B.3 Standee

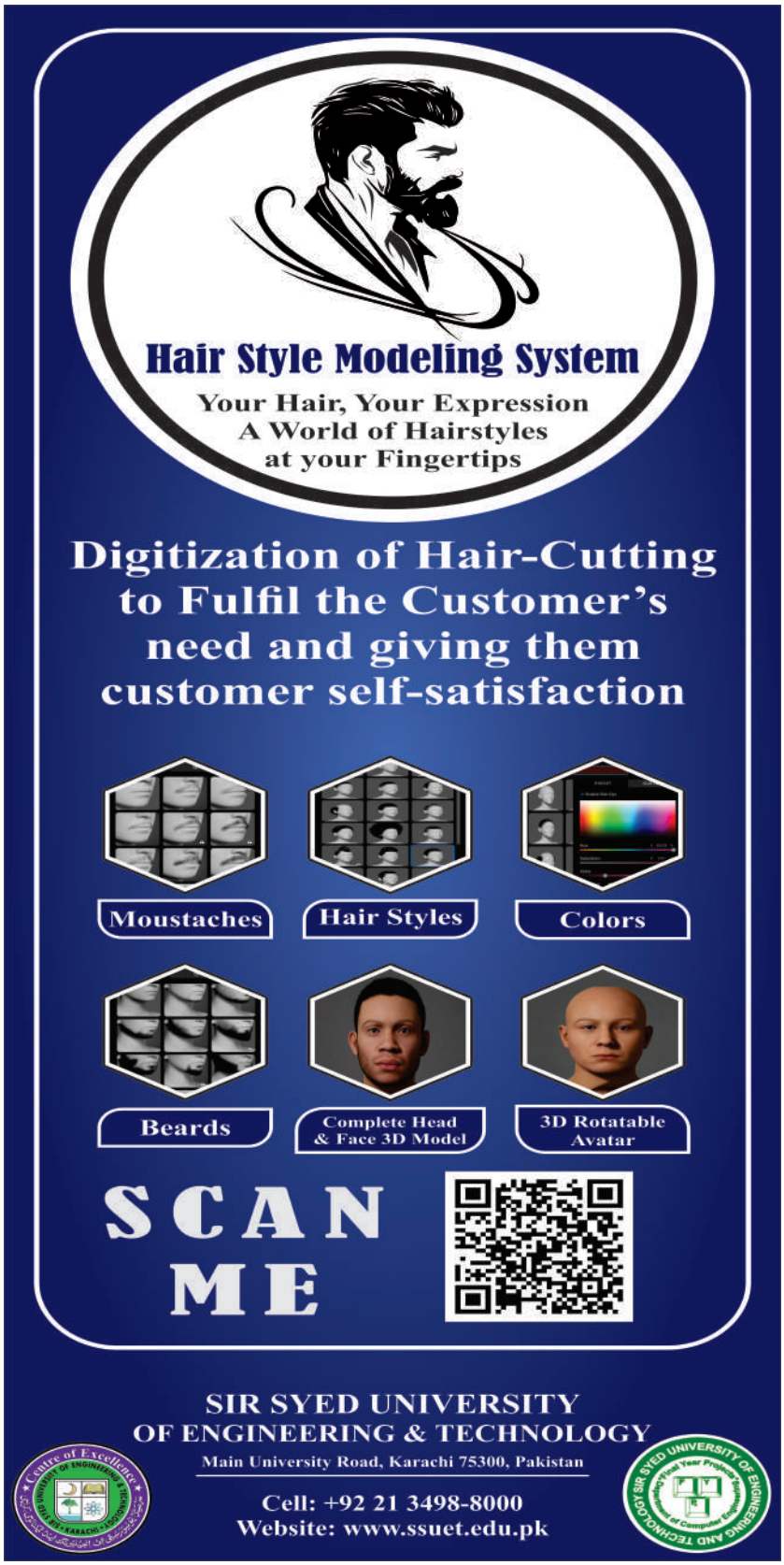


Figure B.4: Standee

Appendix C

Appendix- Software Requirement Specification

1 Introduction

The "Hairstyle Modelling System" deals with the problem that people frequently have with choosing haircuts, beards, and mustaches that go well with their facial features. Individuals eagerly embracing new hairstyles, beards, or moustaches may find themselves disheartened when the chosen style does not seamlessly complement their facial features.

1.1 Purpose

Hairstyle Modelling System (HMS) empowers users to experiment with different hairstyles, beards, and moustaches on their own 2D face images. Through this virtual try-on experience, users can make informed hair-related decisions before committing in real life, boosting confidence and fostering informed style exploration.

1.2 Product Scope

- **Input:** Capture a 2D face image through the web application's intuitive interface.
- **Processing:** Leverage a dedicated Maya plugin to convert the image into a personalized 3D model, utilizing machine learning for accuracy.
- **Enhancement:** Employ the Meta-Human Plugin within Unreal Engine 5.1 to refine the 3D model with brightness adjustments and realistic textures.
- **Customization:** Access a curated library of pre-defined hairstyles, beards, and moustaches categorized by hair type, length, style, and color.

- **Advanced Customization (Optional):** Fine-tune specific hairstyle attributes like curl intensity, beard density, and moustache shape for added user control.

- **Preview:** Generate hyper-realistic previews of the chosen hairstyles on the user's 3D model, enabling visualization from multiple angles.

- **Sharing:** Facilitate user interaction by allowing them to save and share hairstyle previews with friends, family, or hairstylists for feedback and collaboration.

- **Community Features (Optional):** Foster a social environment through user profile creation, commenting on others' previews, and creating public hairstyle galleries for inspiration and trend discovery.

- **Client-side:** User-friendly web application for image upload, hairstyle selection, real-time preview viewing, and sharing options.

- **Server-side:** Robust backend infrastructure for image processing, 3D model generation, hairstyle application, preview rendering, and data storage.

- **Maya Plugin:** Custom-developed plugin integrated with Maya, utilizing machine learning to analyze 2D images and construct accurate 3D facial models.

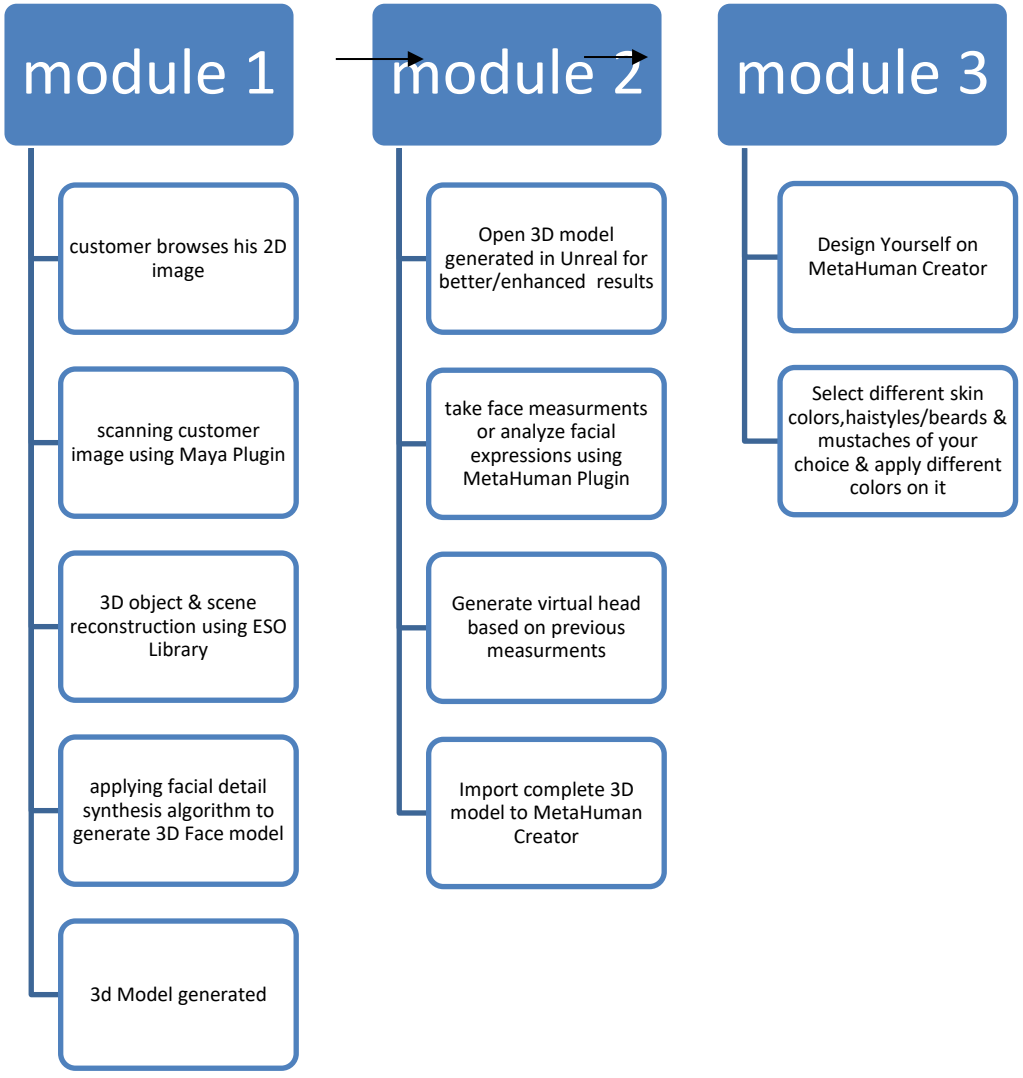
- **Unreal Engine 5.1:** Powerful game engine platform providing the framework for 3D model manipulation, incorporating the Meta-Human Plugin for texture enhancements and realistic rendering.

- **Meta-Human Creator:** State-of-the-art tool from Epic Games enabling seamless application of various hairstyles to the user's 3D model with incredible detail and precision.

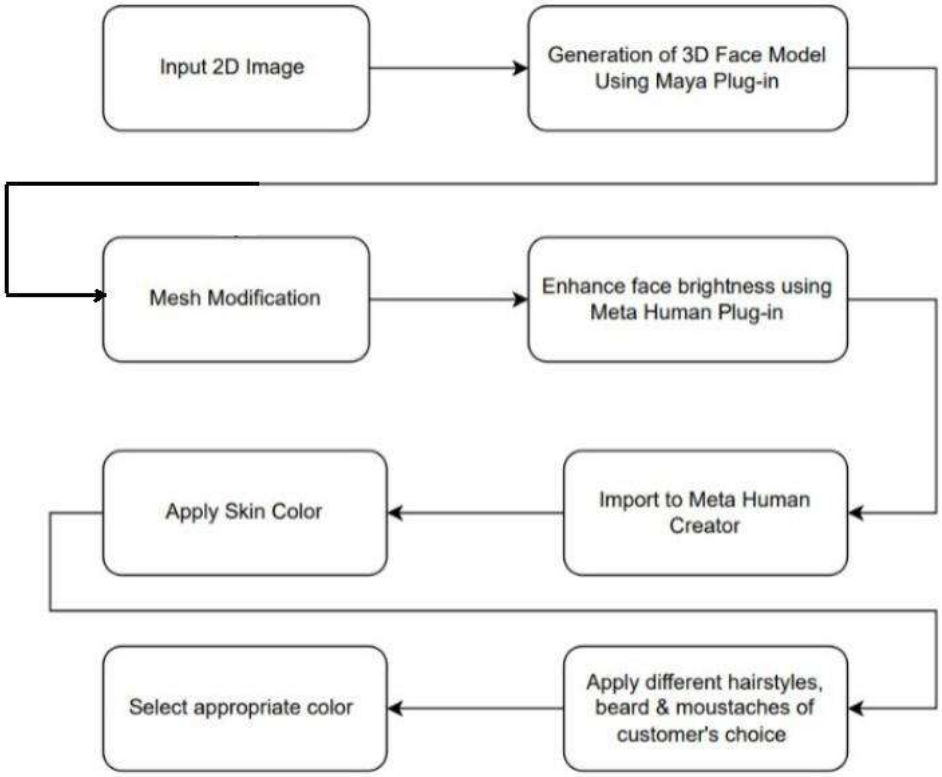
- **Database:** Secure and scalable database housing user data, uploaded images, generated 3D models, chosen hairstyle combinations, and other relevant information.

1.3 System Diagram

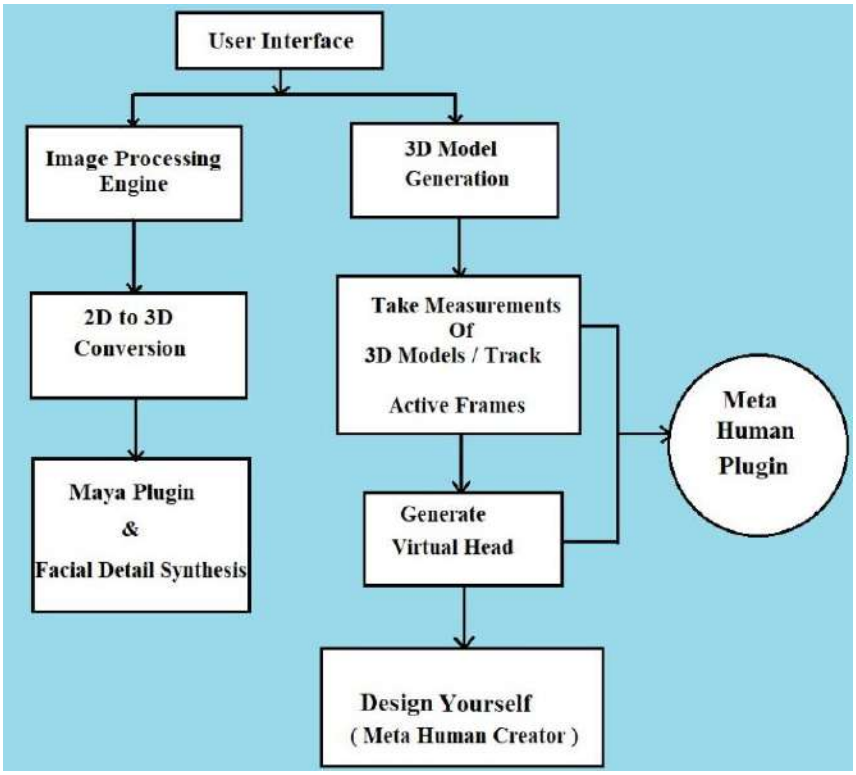
MODULAR PROGRAM STRUCTURE:



Process flow/Representation



Data Flow Diagram



1.4 Stake Holders

Table 1: Project Stakeholders for Proposed Project

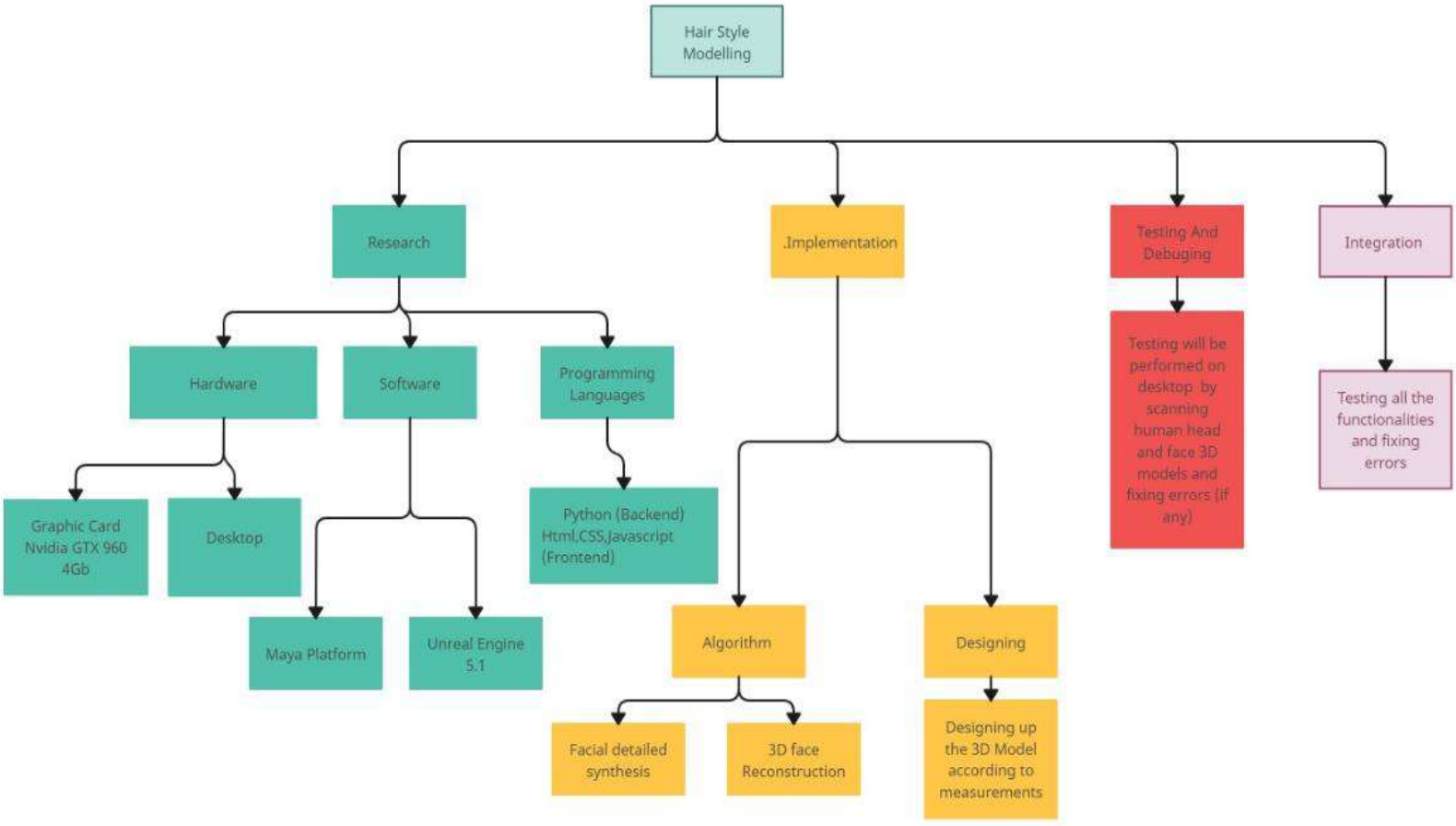
PROJECT Sponsor	Sir Syed University of Engineering and Technology
Stakeholder	**STUDENT NAMES & ROLES:** Muhammad Umer Ahsan : Working on 3D face reconstruction algorithms. Muhammad Haris Khan : Creating a 3d model with the help of facial detail algorithm. Mohammad Ahmed : Exploring MetHuman Plugin to generate a virtual 3D head model. Furqan Ayaz: Providing a front end interface from which user can interact with the model. Hadiqa: Apply different hairstyles,beards & mustaches with other features. **PROJECT SUPERVISOR NAME:** Sir Umair Naqvi

1.4.1 Stake Holder Register

Stakeholder Name	Title	Role	Requirements	Concerns
End Users (Customers)	[User Representative]	Utilizes the application for customization	User-friendly interface, accurate 3D modeling, a variety of customization options	User satisfaction, ease of use, diversity in available styles
Development Team	[Umer, Haris]	Designs & implement the application	Clear requirements, effective communication, timely feedback on changes	Resource availability, scope changes, technical challenges
Data Scientists / ML Experts	[Umer, Haris]	Study ML algorithms for image conversion	Access to relevant data, collaboration on refining ML models, feedback on algorithm performance	Data availability, algorithm accuracy, computational resources
Maya Plugin Experts	[Umer, Haris]	Study and maintains the Maya plugin	Clear specifications, collaboration with the development team, feedback on plugin functionality	Maya compatibility, integration challenges, user feedback
Unreal Engine Learners	[Umer, Haris]	Integrates Meta-Human Plugin, enhances brightness	Detailed requirements, collaboration with other teams, access to Unreal Engine resources	Integration issues, resource constraints, Unreal Engine capabilities
Meta-Human Plugin Experts	[Umer, Haris]	Study and maintains the Meta-Human Plugin	Clear specifications, collaboration with the development team, feedback on plugin functionality	Plugin functionality, compatibility with other tools, user feedback
Project Manager	[Umer]	Oversees the project, ensures milestones	Regular updates, issue resolution, adherence to the project timeline	Project delays, scope changes, resource allocation
Quality Assurance (QA) Team	[Ahmed, Furqan]	Tests and ensures quality of the application	Access to test environments, clear test cases, collaboration for bug fixes	Bug identification, test coverage, compatibility testing
Legal and Compliance Team	[Ahmed, Furqan, Hadiqa]	Ensures project compliance with legal standards	Regular legal checks, adherence to data protection regulations, resolution of legal issues	Legal risks, data protection, compliance with regulations

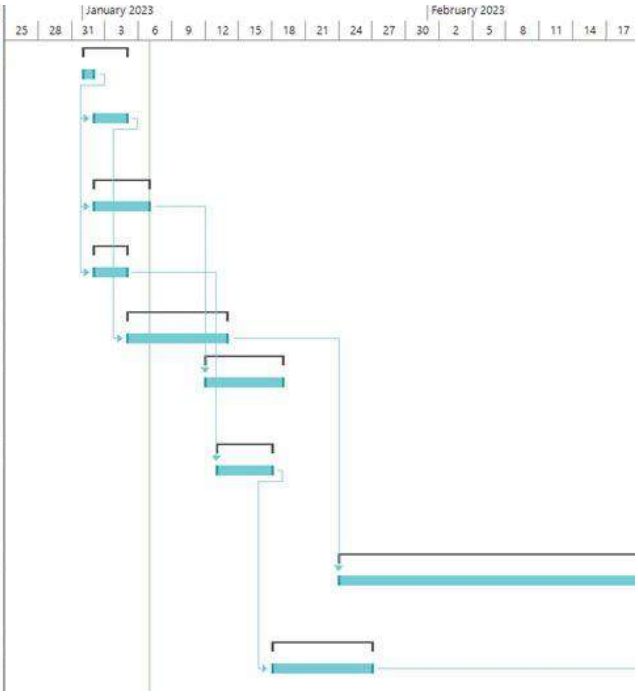
1.5 Project WBS and Gantt Chart

WBS

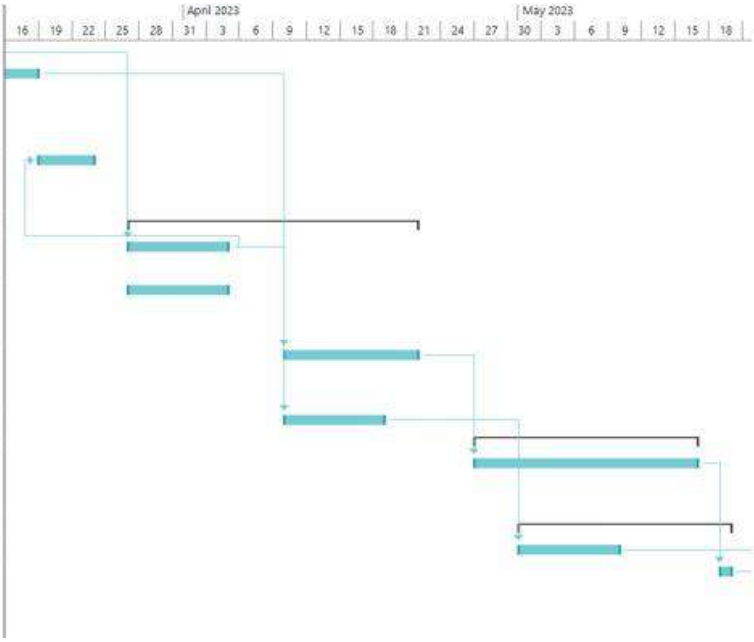


GANTT CHART

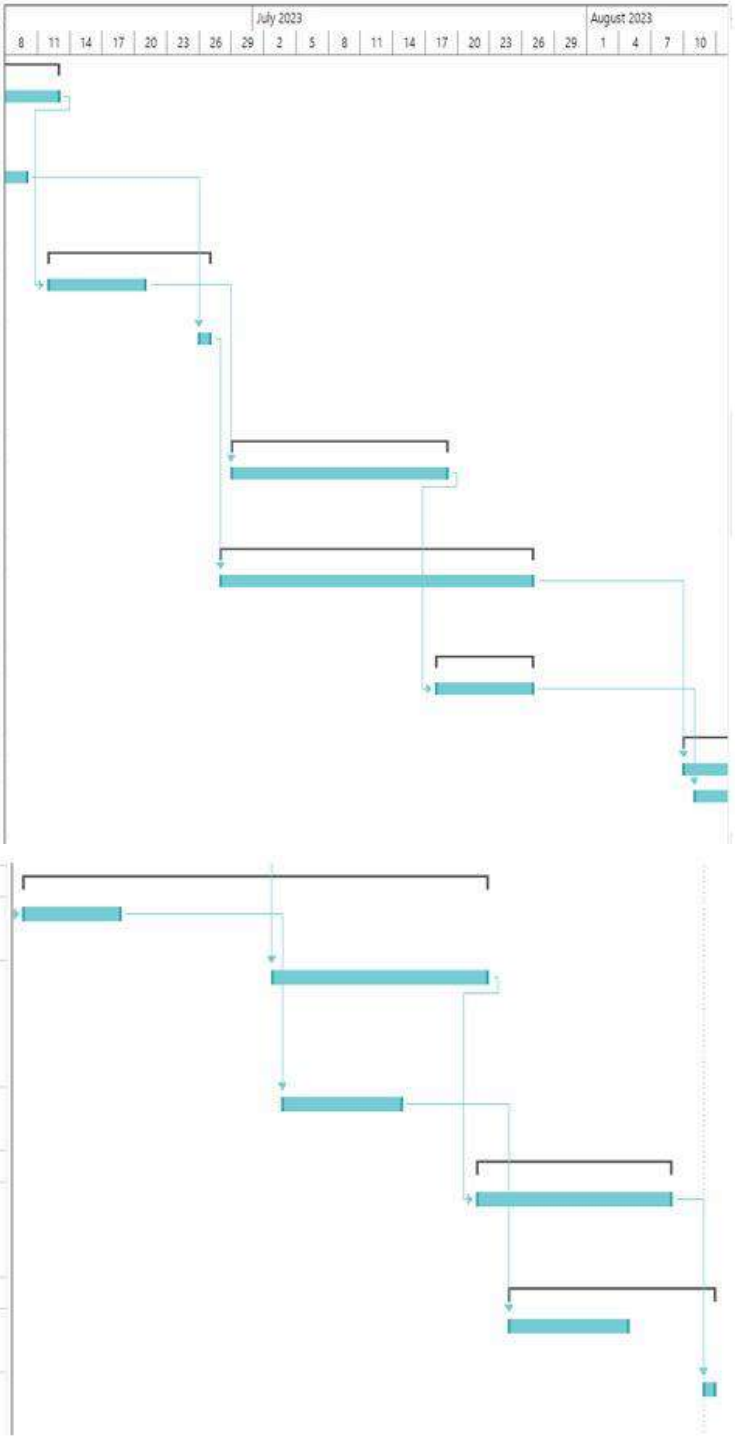
	Task Mode	Task Name	Duration	Start	Finish	Predecessors	Resource N
1		**Planning**	**3 days**	**Sun 1/1/23 8:00 AM**	**Wed 1/4/23 5:00 PM**		
2		Kick off meeting with the team	1 day	Sun 1/1/23 8:00 AM	Sun 1/1/23 5:00 PM		
3		Identify project scope and objectives	3 days	Mon 1/2/23 8:00 AM	Wed 1/4/23 5:00 PM	2	
4		**Analysis**	**5 days**	**Mon 1/2/23 8:00 AM**	**Fri 1/6/23 5:00 PM**		
5		Conduct market research	5 days	Mon 1/2/23 8:00 AM	Fri 1/6/23 5:00 PM	2	
6		**Planning**	**3 days**	**Mon 1/2/23 8:00 AM**	**Wed 1/4/23 5:00 PM**		
7		Create project plan and timeline	3 days	Mon 1/2/23 8:00 AM	Wed 1/4/23 5:00 PM	2	
8		**Designing**	**7 days**	**Thu 1/5/23 8:00 AM**	**Fri 1/13/23 5:00 PM**		
9		Design 3d models	7 days	Thu 1/5/23 8:00 AM	Fri 1/13/23 5:00 PM	3	
10		**Planning**	**5 days**	**Thu 1/12/23 8:00 AM**	**Wed 1/18/23 5:00 PM**		
11		Develop project charter and project management plan	5 days	Thu 1/12/23 8:00 AM	Wed 1/18/23 5:00 PM	5	
12		**Designing**	**3 days**	**Fri 1/13/23 8:00 AM**	**Tue 1/17/23 5:00 PM**		
13		Set up development environment and tools	3 days	Fri 1/13/23 8:00 AM	Tue 1/17/23 5:00 PM	7	
14		**Coding**	**21 days**	**Tue 1/24/23 8:00 AM**	**Tue 2/21/23 5:00 PM**		
15		Implement basic features and functionality	21 days	Tue 1/24/23 8:00 AM	Tue 2/21/23 5:00 PM	9	
16		**Testing**	**7 days**	**Wed 1/18/23 8:00 AM**	**Thu 1/26/23 5:00 PM**		
17		Test basic features and functionality	7 days	Wed 1/18/23 8:00 AM	Thu 1/26/23 5:00 PM	13	



	Task Mode	Task Name	Duration	Start	Finish	Predecesso
19		Fix bugs and issues	9 days	Mon 2/27/23 8:00 AM	Thu 3/9/23 5:00 PM	15
20		Integrate Maya Plugin for 3D Model	7 days	Fri 3/10/23 8:00 AM	Sat 3/18/23 5:00 PM	17
21		Integrate Mesh Modifications	5 days	Sun 3/19/23 8:00 AM	Thu 3/23/23 5:00 PM	23
22		**Testing**	**20 days**	**Mon 3/27/23 8:00 AM**	**Fri 4/21/23 5:00 PM**	
23		Testing Maya Plugin	7 days	Mon 3/27/23 8:00 AM	Tue 4/4/23 5:00 PM	19
24		Testing Mesh Modification	7 days	Mon 3/27/23 8:00 AM	Tue 4/4/23 5:00 PM	
25		Begin Modelling	10 days	Mon 4/10/23 8:00 AM	Fri 4/21/23 5:00 PM	20
26		Complete	7 days	Mon 4/10/23 8:00 AM	Tue 4/18/23 5:00 PM	23
27		**Coding**	**14 days**	**Thu 4/27/23 8:00 AM**	**Tue 5/16/23 5:00 PM**	
28		Address issues & bugs during modelling	14 days	Thu 4/27/23 8:00 AM	Tue 5/16/23 5:00 PM	25
29		**Releasing**	**15 days**	**Mon 5/1/23 8:00 AM**	**Fri 5/19/23 5:00 PM**	
30		Prepare for launch	7 days	Mon 5/1/23 8:00 AM	Tue 5/9/23 5:00 PM	26
31		Launch the Unreal Engine 5.1	1 day	Fri 5/19/23 8:00 AM	Fri 5/19/23 5:00 PM	28



	Task Mode	Task Name	Duration	Start	Finish	Predecesso
32		**Testing**	**15 days**	**Tue 5/23/23 8:00 AM**	**Mon 6/12/23 5:00 PM**	
33		Monitor performance and address issues	14 days	Wed 5/24/23 8:00 AM	Mon 6/12/23 5:00 PM	30
34		Continue unreal engine plugin testing	14 days	Tue 5/23/23 8:00 AM	Fri 6/9/23 5:00 PM	31
35		**Releasing**	**11 days**	**Mon 6/12/23 8:00 AM**	**Mon 6/26/23 5:00 PM**	
36		Prepare for Mesh to Meta human plugin	7 days	Mon 6/12/23 8:00 AM	Tue 6/20/23 5:00 PM	33
37		Continue Working on Mesh to Meta human Plugin	1 day	Mon 6/26/23 8:00 AM	Mon 6/26/23 5:00 PM	34
38		**Testing**	**14 days**	**Thu 6/29/23 8:00 AM**	**Tue 7/18/23 5:00 PM**	
39		Monitor performance and address issues	14 days	Thu 6/29/23 8:00 AM	Tue 7/18/23 5:00 PM	36
40		**Coding**	**21 days**	**Wed 6/28/23 8:00 AM**	**Wed 7/26/23 5:00 PM**	
41		Implement new features and functionality	21 days	Wed 6/28/23 8:00 AM	Wed 7/26/23 5:00 PM	37
42		**Testing**	**7 days**	**Tue 7/18/23 8:00 AM**	**Wed 7/26/23 5:00 PM**	
43		Test new features and functionality	7 days	Tue 7/18/23 8:00 AM	Wed 7/26/23 5:00 PM	39
44		**Coding**	**22 days**	**Thu 8/10/23 8:00 AM**	**Fri 9/8/23 5:00 PM**	
45		Fix bugs and issues	14 days	Thu 8/10/23 8:00 AM	Tue 8/29/23 5:00 PM	41
46		Integrate Additional Features	21 days	Fri 8/11/23 8:00 AM	Fri 9/8/23 5:00 PM	43
47		**Testing**	**31 days**	**Tue 8/29/23 8:00 AM**	**Tue 10/10/23 5:00 PM**	
48		Test Additional Mesh to Meta Human Features	days	Tue 8/29/23 8:00 AM	Wed 9/6/23 5:00 PM	45
49		Begin working on meta human creator	14 days	Thu 9/21/23 8:00 AM	Tue 10/10/23 5:00 PM	46
50		Complete Customization	7 days	Fri 9/22/23 8:00 AM	Mon 10/2/23 5:00 PM	48
51		**Coding**	**14 days**	**Tue 10/10/23 8:00 AM**	**Fri 10/27/23 5:00 PM**	
52		Address Issues & bugs during customization	14 days	Tue 10/10/23 8:00 AM	Fri 10/27/23 5:00 PM	49
53		**Releasing**	**13 days**	**Fri 10/13/23 8:00 AM**	**Tue 10/31/23 5:00 PM**	
54		Prepare for Final Launch	7 days	Fri 10/13/23 8:00 AM	Mon 10/23/23 5:00 PM	50
55		Launch Application	1 day	Tue 10/31/23 8:00 AM	Tue 10/31/23 5:00 PM	52



2 Functional Requirements

2.1 Functional Feature

1. **Product Context and Origin:**
   The Hairstyle Modelling System is a web application designed to revolutionize virtual hairstyling experience. Originating from the need to provide users with a platform for exploring and previewing personalized hairstyles, beards, and moustaches, the system aims to blend 2D to 3D conversions, machine learning, and real-time rendering for an immersive user experience.
2. **Product Classification:**
   The system represents an entirely new product in the virtual styling world. It introduces cutting edge technologies to offer users a unique and engaging way to visualize and experiment with various hairstyles, facial hair, and features in a three-dimensional space.
3. **Functional Features:**
   User Interface Functional Features:

   2D to 3D Conversion:

   - Allows users to upload 2D images for automatic conversion to realistic 3D models.
   - Provides an intuitive and user-friendly interface for initiating the conversion process.

   Virtual Styling:

   - Offers a wide range of hairstyles, beards, and moustaches for users to explore.
   - Enables users to select, customize, preview different styles on their 3D avatars.

   Realtime Rendering:

   - Integrates with Unreal Engine for real-time rendering of 3D models.
   - Enhances visual realism through the Meta-Human plugin and dynamic lighting features.

Server-Side Functional Features:

Machine Learning for Facial Features Extraction:

- Utilizes machine learning algorithms to extract accurate facial features from 2D images.
- Implements data preprocessing and augmentation techniques for robust model training.

Maya Scripting and 3D modelling:

- Develops Maya Scripts for seamless 2D to 3D conversion and mesh modifications.
- Ensures compatibility and integration with the Unreal Engine for rendering.

Optimization and Performance:

- Optimizes rendering performance withing Unreal Engine for smooth user experience.
- Handles resource intensive scenarios through effective server-side optimizations.

2.2 Operating environment

1. **Hardware Platform:**

The Hairstyle Modelling System is designed to operate on a range of hardware platforms, ensuring accessibility and optimal performance across devices. The recommended hardware specifications include:

Desktop/Laptop:

- Dual-core processor or higher
- 8 GB RAM or higher
- Nvidia 4 GB Graphics Card or higher

2. **Operating Systems and Versions:**

The software will be compatible with widely used operating systems to cater to a diverse user base. The supported operating systems include:

Windows:

- Windows 10 and above

Linux:

- Ubuntu 18.04 LTS and above

3. **Geographical Locations:**

The Hairstyle Modelling System is accessible globally. Users, servers, and databases can be in various geographical locations. The system architecture is designed to ensure responsiveness and reliability for users irrespective of their geographical location.

4. **Organizations Hosting Infrastructure:**

The system's infrastructure, including servers and databases, may be hosted by reputable cloud service providers to ensure scalability, reliability, and efficient resource management. The organizations hosting the infrastructure adhere to industry standards for data security and privacy.

Database Hosting:

Meta-Human own database service is provided and used for users to save their models in their respective accounts.

Server Hosting:

Virtual servers could be hosted on the selected infrastructure.

5. **Networking Requirements:**

The system relies on stable internet connectivity for seamless user interaction and data processing. The minimum network bandwidth requirements for an optimal user experience are:

Download Speed:

5 Mbps or higher

Upload Speed:

2 Mbps or higher

Compatibility Matrix:

Platform	Operating System	Browser
Desktop/Laptop	Windows 10 and above	Chrome, Firefox, Edge
	Ubuntu 18.04 LTS	Chrome, Firefox

2.3 Design and Implementation Constraints

1. **Programming Language:**

The development of the Hairstyle Modelling System is constrained by the requirement to use specific programming languages for compatibility, integration, and efficient execution. The primary languages are:

Backend:

- Python for server-side logic and Maya Scripting/Machine learning integration
- JavaScript and Django for backend server scripting

Frontend:

- HTML5, CSS3, and JavaScript for web interface development
- Unreal Engine scripting and plugins for 3D model rendering

Rationale:

The chosen languages align with industry standards, support seamless integration with Unreal Engine, and offer robust libraries and frameworks for web development and machine learning.

2. **Machine Learning Libraries:**

The implementation of facial feature extraction relies on established machine learning libraries and frameworks. The libraries primarily include:

Pytorch:

- Used for developing and building deep learning models and image recognition.

Scikit-image:

- Employed to implement algorithms like geometric transformations, filtering, and feature detection of machine learning models.

Numpy:

- Used to perform variety of mathematical operations and calculations on data with efficient accuracy.

Torchvision:

- Provides additional functionalities to manipulate and process images with image processing algorithms.

Pillow:

- Used to process basic image processing functionalities primarily transformation and other transpose functions.

Rationale:

These libraries are widely adopted in the machine learning community, offering extensive functionalities, community support, and proven reliability for image-based application.

3. **Unreal Engine and Maya:**

The system constraint developers to use Unreal Engine for realtime rendering and Maya scripting for 2D to 3D conversion.

Unreal Engine:

- Utilized for enhancing image quality and rendering realistic 3D models in real-time.

Maya:

- Employed for creating scripts to facilitate the conversion process.

Rationale:

Both Unreal Engine and Maya are industry-standard tools with powerful features for 3D modelling, rendering, and scripting, ensuring the creation of high-quality virtual hairstyles.

4. **Browser Compatibility:**

   the system is designed to be compatible with modern web browsers, limiting support to the latest versions of Chrome, Firefox, Safari, and Edge.

Rationale:

Restricting browser support to recent versions ensures compatibility with advanced web features and reduces the complexity of cross-browser testing.

2.4 Functional Requirement Identification Technique

Feature: 2D to 3D Conversion

User Image Upload:

- Allow users to upload 2D images of themselves.

Automatic Conversion:

- Implement an algorithm to automatically convert 2D images into realistic 3D models.

Conversion Settings:

- Provide users with customizable settings for adjusting the conversion process, such as facial feature emphasis and model resolution.

Feature: Virtual Styling

Hairstyle Selection:

- Enable users to choose from a variety of hairstyles, beards, and moustaches.

Customization Options:

- Allow users to customize selected styles, adjusting parameters like length, colour, and density.

Real-time Preview:

- Provide a real-time preview of the selected styles on the 3D avatar.

Feature: Real-time Rendering

Integration with Unreal Engine:

- Integrate 3D models into Unreal Engine for realistic and dynamic rendering.

Meta-Human Plugin:

- Utilize the Meta-Human plugin to enhance the brightness and realism of rendered models.

Feature: Machine Learning for Facial Feature Extraction

Accurate Feature Extraction:

- Develop machine learning algorithms to accurately extract facial features from 2D images.

Data Augmentation:

- Implement data augmentation techniques to enhance the model's ability to handle variations in facial expressions and lighting conditions.

Feature: Maya Scripting and 3D Modelling

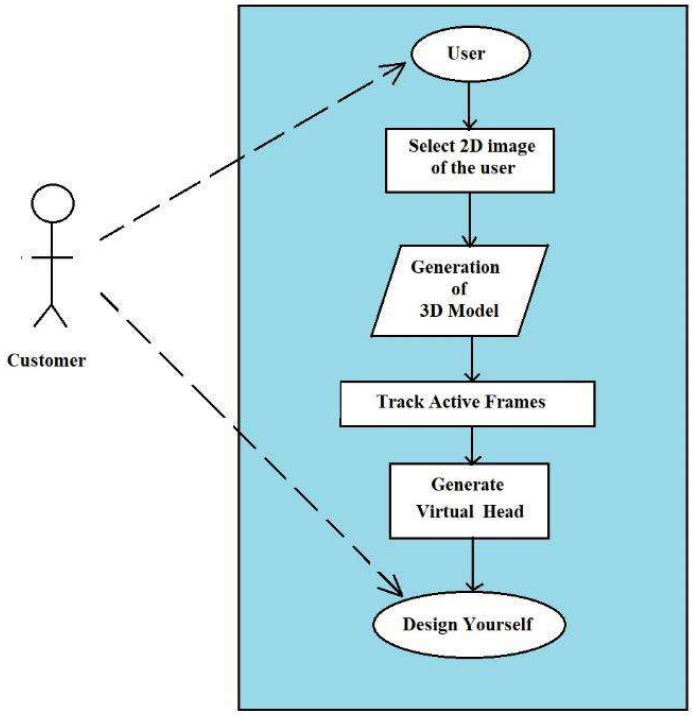
Maya Script Development:

- Develop Maya scripts for efficient 2D to 3D conversion and mesh modifications.

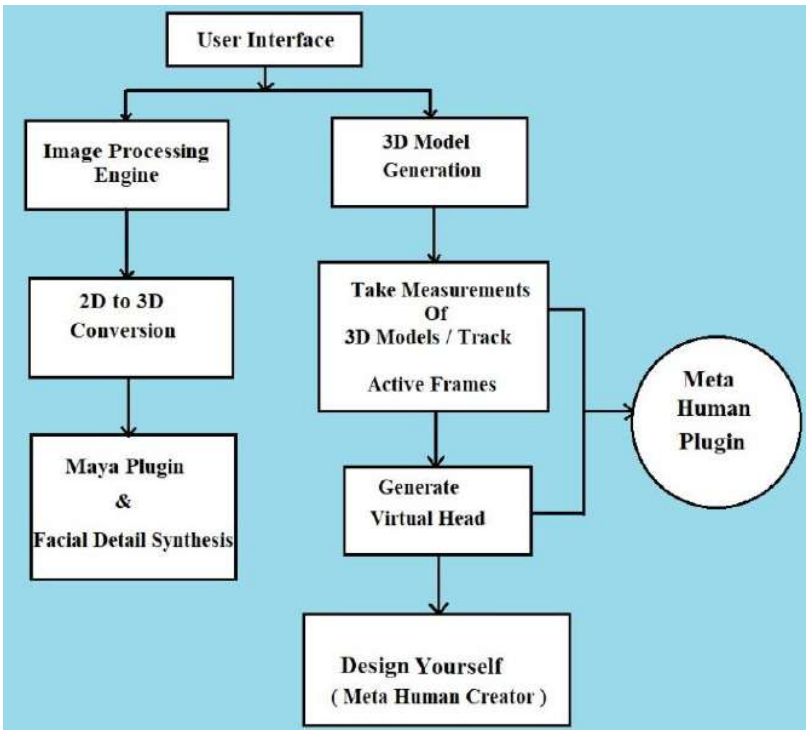
Integration with Unreal Engine:

- Ensure seamless integration with Unreal Engine for consistent rendering and realistic representation.

2.4.1 Use Case

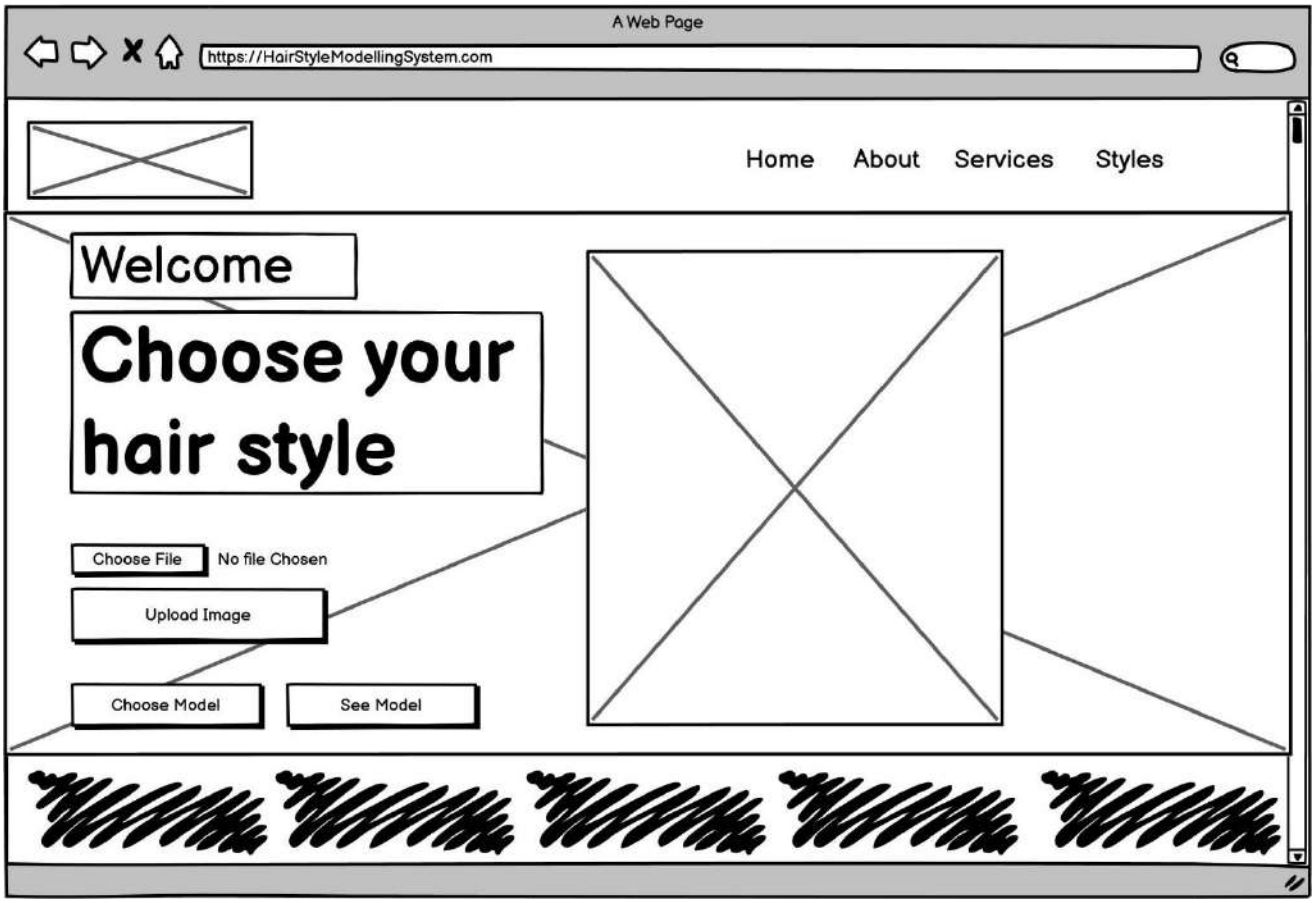


2.4.2 Data Flow Diagram



2.4.3 UX Prototype

WIREFRAME:



3 Non Functional Requirements

3.1 Performance Evaluation

1. **User Image Upload Performance:**
    - The system should support concurrent image uploads by users with a response time of 5 seconds.

    Rationale: Ensures efficient handling of multiple users uploading images simultaneously.

    - Image processing for conversion should be completed within 10-15 seconds.

    Rationale: Provides a responsive and timely conversion experience for users.

2. **Virtual Styling Performance**
    - Real-time preview rendering of selected styles should achieve a frame rate of 30 frames per second (fps).

    Rationale: Ensures smooth and visually pleasing style preview interactions.

    - Customization adjustments should be reflected in real-time with a latency of 200 milliseconds.

    Rationale: Enhances the interactive and responsive nature of the styling process.

3. **Real-time Rendering Performance**
    - Rendering of 3D models in Unreal Engine should achieve a minimum frame rate of 20 fps.

    Rationale: Provides a visually immersive experience with realistic and smooth rendering.

    - Dynamic lighting adjustments through the Meta-Human plugin should occur within 5 seconds.

    Rationale: Ensures dynamic and responsive adaptation to different lighting conditions.

4. **Machine Learning Model Performance**
    - Facial feature extraction from 2D images should achieve an accuracy rate of 90%.

    Rationale: Ensures the accuracy and reliability of facial features in the generated 3D models.

    - Data augmentation processes should not introduce distortions, maintaining a distortion rate below 10%.

    Rationale: Guarantees data augmentation contributes positively to model training without compromising quality.

5. **Maya Scripting and 3D Modeling Performance**
    - Maya scripts for 2D to 3D conversion should be completed within 10 seconds.

    Rationale: Ensures efficiency in the conversion process.

    - Integration with Unreal Engine for rendering should have a latency of 300-400 milliseconds.

    Rationale: Minimizes delays in rendering and enhances the overall system responsiveness.

3.2 Safety Requirements

1. **User Image Upload Safety:**

Safety Requirement 1.1: The system must perform thorough validation checks on uploaded images to prevent malicious content or inappropriate material.

Safeguard: Implement image content analysis algorithms to detect and filter inappropriate or harmful content.

Safety Requirement 1.2: The system should not store or retain any personal or sensitive information from user-uploaded images after the conversion process is completed.

Safeguard: Implement a secure data disposal mechanism to ensure the removal of sensitive information.

2. **Virtual Styling Safety:**

Safety Requirement 2.1: Styles and customizations presented to users should comply with industry standards for cultural sensitivity, avoiding content that may be offensive or inappropriate.

Safeguard: Implement content filtering algorithms to screen and exclude styles that may be culturally sensitive or offensive.

Safety Requirement 2.2: User customization options should adhere to realistic and safe representations, preventing extreme or potentially harmful alterations.

Safeguard: Implement bounds and limitations on customization parameters to avoid unrealistic or potentially unsafe representations.

3. **Real-time Rendering Safety:**

Safety Requirement 3.1: Rendering features should not induce discomfort or adverse reactions in users (e.g., motion sickness).

Safeguard: Implement user-friendly rendering techniques and provide options for users sensitive to certain visual effects.

Safety Requirement 3.2: Dynamic lighting adjustments should not cause discomfort or pose risks to individuals with photosensitivity.

Safeguard: Include options for users to customize or disable dynamic lighting effects if needed.

Secure Storage of API Keys:

- Any keys used for the REST API (e.g., authentication tokens, API keys) must be securely stored.

3.3 Business Perspective/Requirements

1. **Target Industry/Market:**
   - The system should target the beauty and personal grooming industry, catering to individuals seeking virtual hairstyling and facial customization services.
   - The system should integrate seamlessly with beauty and salon businesses, providing a platform for them to showcase their styling services.

2. **Competitors Analysis:**
   - Conduct a comprehensive analysis of competitors in the virtual styling domain, focusing on their marketing strategies, user engagement, and unique selling propositions.

3. **Scalability/Extensibility:**
   - The system should be scalable and extensible, allowing for growth to meet increasing demand and incorporating new features to adapt to evolving industry trends.

3.4 Licensing Requirements

Regulatory Compliance:

1. **Authority to Operate:**

Licensing Requirement 1: The system must adhere to all provisions of relevant laws, rules, regulations, or formal orders applicable to facilities concerning the initial or continued authority to operate.

Compliance Measure: Regularly monitor and update the system to align with any changes in legal requirements related to operations.

Legal Copyrights & Notices:

1. **Copyright Protection:**

Licensing Requirement 2: The system must display a copyright notice indicating that the work is protected by copyright law and is not to be copied.

Implementation: Include a visible copyright notice on all user interfaces and documentation, following legal guidelines for format and content.

2. **Intellectual Property Notices:**

Licensing Requirement 3: Include intellectual property notices, such as trademark symbols or patent identifiers, where applicable, to communicate the protected status of relevant elements within the system.

Implementation: Embed intellectual property notices in appropriate locations, adhering to legal standards and conventions.

3.5 Software Quality Attributes

Availability:

- **Quality Attribute 1:** The system should maintain a high level of availability, defined as the ratio of the available system time to the total working time it is required or expected to function.

  Measurement: Calculate and monitor the system's uptime and downtime, aiming for a high availability percentage.

Correctness:

- **Quality Attribute 2:** The application should demonstrate correctness in terms of its functionality, internal calculations, and navigation.

  Evaluation Criteria:

  - **Functional Correctness:** Ensure that the application adheres to all specified functional requirements.
  - **Calculation Accuracy:** Verify that internal calculations produce accurate results.
  - **Navigation Precision:** Confirm that the navigation within the application follows the intended paths accurately.

Maintainability:

- **Quality Attribute 1:** Different versions of the product should be easy to maintain.

Evaluation Criteria:

- **Modularity:** Ensure that the system is modular, allowing for easy updates or modifications to specific components.
- **Documentation:** Maintain comprehensive documentation to facilitate understanding and modification by development teams.

❖ **Quality Attribute 2:** For development, it should be easy to add code to the existing system, and it should be easy to upgrade for new features and new technologies from time to time.

Evaluation Criteria:

- **Code Extensibility:** Develop code in a way that allows for easy addition of new features or components.
- **Technology Upgradability:** Ensure that the system architecture allows for seamless integration with new technologies.

❖ **Quality Attribute 3:** Maintenance should be cost-effective and easy.

Evaluation Criteria:

- **Efficiency of Updates:** Assess the efficiency and ease of applying updates or patches to the system.
- **Cost of Maintenance:** Evaluate the overall cost-effectiveness of maintenance activities.

Usability:

❖ **Quality Attribute 4:** Usability can be measured in terms of ease of use.

Evaluation Criteria:

- **User-Friendly Interface:** Design and maintain an interface that is intuitive and easy for users to navigate.
- **Learning Curve:** Ensure that the application is easy to learn for both new and existing users.

❖ **Quality Attribute 5:** The application should be user-friendly.

Evaluation Criteria:

- **Navigation Simplicity:** Confirm that the navigation within the application is straightforward and logical.

- **User Support:** Provide adequate support features to assist users in using the application.

4 Software Design Methodology

4.1 Data dictionary / Data set

MetaHuman Creator DataBase: We have used the Cloud based Database of MetaHuman Creator, in which there are various options available for different hairstyles, beards, moustaches, and colors. Final result of Models created will be saved there automatically.

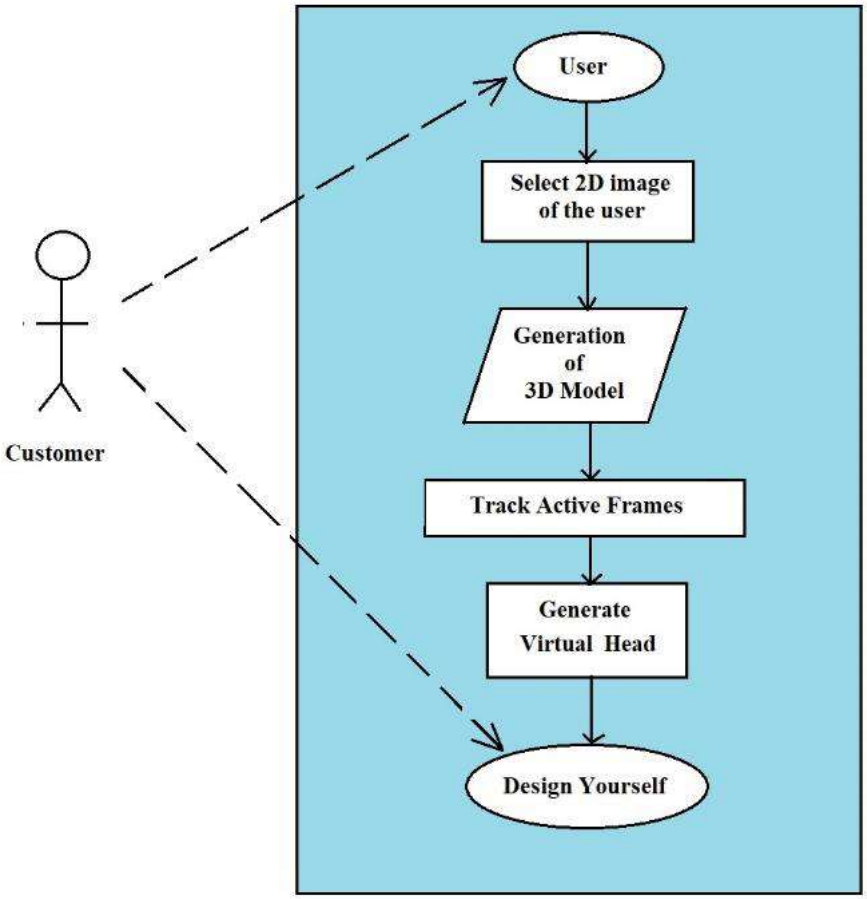
Once the user creates an account on Epic games, then he will be able to save his models and choose different options from the catalog available.

It is Updated automatically as it is a cloud-based database provided by Epic Games/Unreal Engine.

4.2 Design Models

4.2.1 The applicable models may include:

- Use Case Diagram



- Entity Relationship Diagram

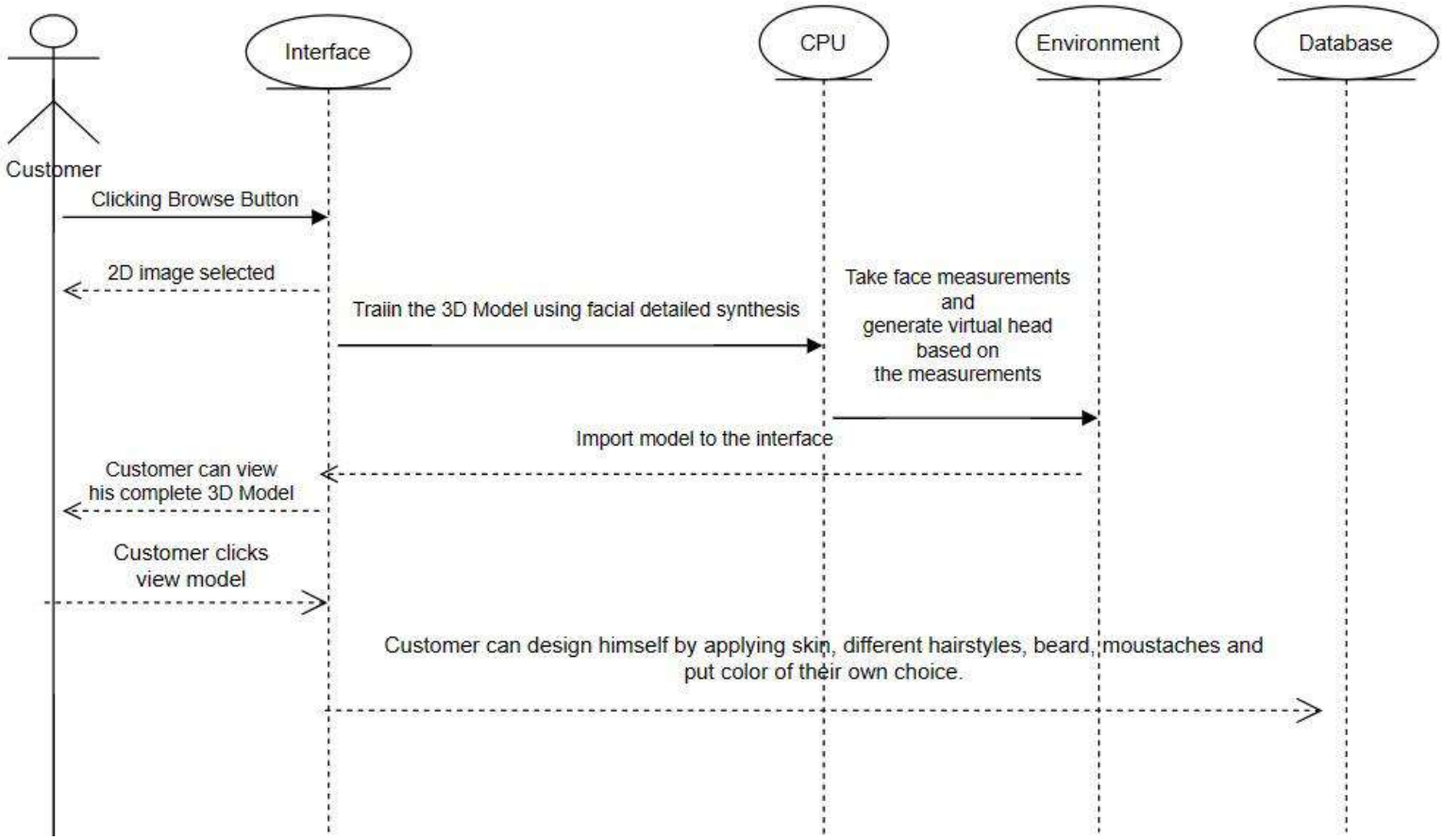
Entity Relationship Diagram does not exist as we have not created our own database.We have basically used MetaHuman Creator DataBase.

It is basically a Cloud based Database of MetaHuman Creator, in which there are various options available for different hairstyles, beards, moustaches, and colors. Final result of Models created will be saved there automatically.

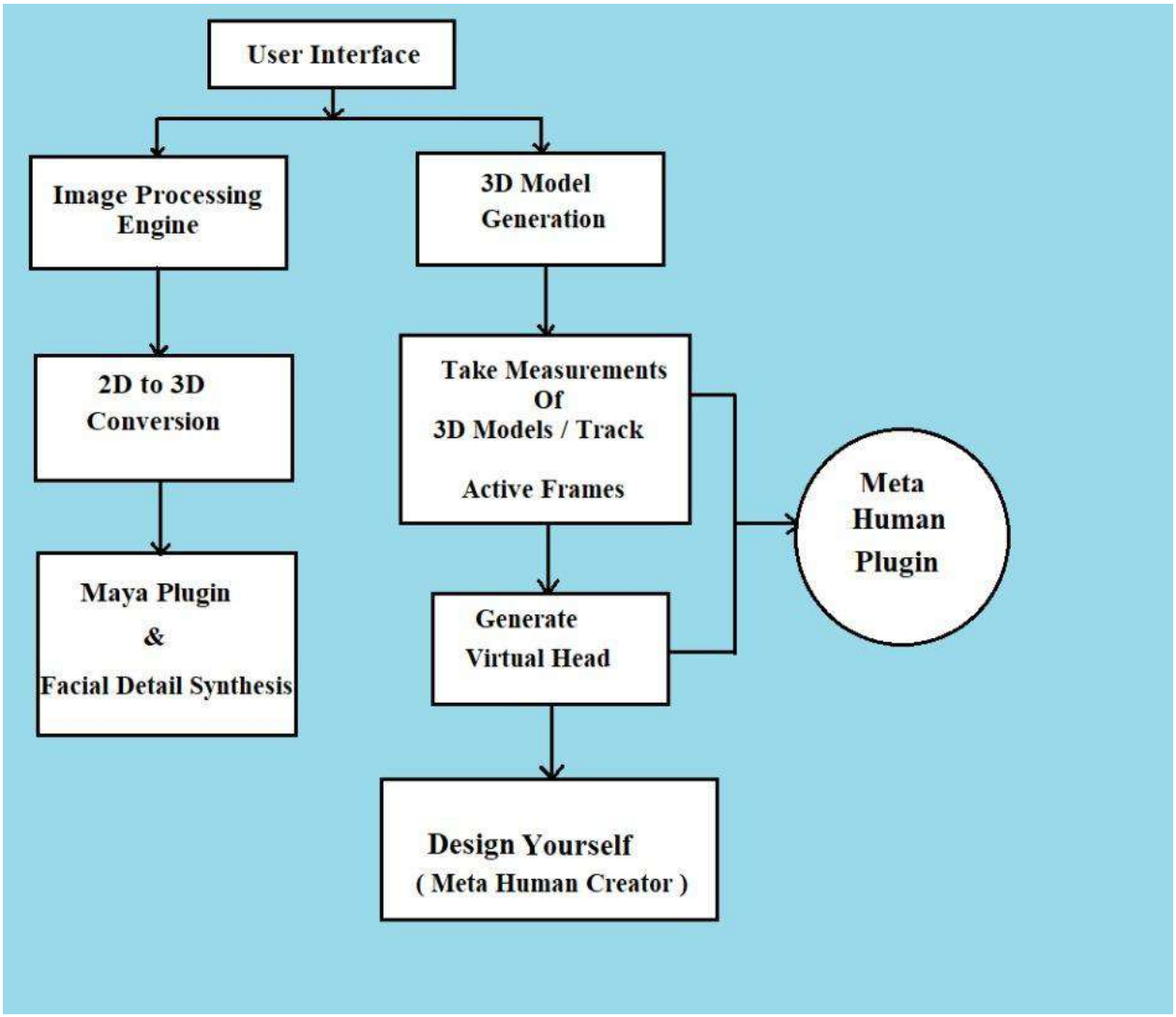
Once the user creates an account on Epic games, then he will be able to save his models and choose different options from the catalog available.

It is Updated automatically as it is a cloud-based database provided by Epic Games/Unreal Engine.

- Sequence Diagram



- Data Flow Diagram



4.3 Specialized Algorithms

Following algorithm is used;

FACIAL DETAIL SYNTHESIS:

The model is designed to generate high-resolution facial model that contain fine-grained details such as wrinkles, blemishes, and pores from a low-resolution input image. We chose this project as basic 3D face reconstruction algorithm.
We present a single-image 3D face synthesis technique that can handle challenging facial expressions while recovering fine geometric details. Our technique employs expression analysis for proxy face geometry generation and combines supervised and unsupervised

learning for facial detail synthesis. On proxy generation, we conduct emotion prediction to determine a new expression-informed proxy. On detail synthesis, we present a Deep Facial Detail Net (DFDN) based on Conditional Generative Adversarial Net (CGAN) that employs both geometry and appearance loss functions. For geometry, we capture 366 high-quality 3D scans from 122 different subjects under 3 facial expressions.

For appearance, we use additional 163K in-the-wild face images and apply image-based rendering to accommodate lighting variations. Comprehensive experiments demonstrate that our framework can produce high-quality 3D faces with realistic details under challenging facial expressions.

4.4 Software requirements traceability matrix

4.4.1 Tools and Development Environment

1. **Data:**

2D Images: User provides an image for input.

Generated 3D Models: Create a 3D model from that provided image.

Machine Learning Data: Training data for ML algorithms, possibly facial feature datasets.

2. **Coding Tools and Development:**

Maya 2022: Autodesk Maya is used for 3D modelling. Maya is 3D visual effects software with powerful character creation, rigging, animation, and simulation tools.

Unreal Engine 5.1: For enhancing and customization the 3D model with the Meta-Human plugin. Unreal Engine is the world's most open and advanced real-time 3D creation tool for photoreal visuals and immersive experiences.

Meta-Human Creator: To apply different hairstyles, beards, moustaches, and apply various colors. MetaHuman Creator is a free, cloud-streamed tool you can use to create your own digital humans in an intuitive, easy-to-learn environment.

Python: Python for scripting within Maya, handling machine learning, and general backend development. Python is a widely used, general-purpose, dynamically typed high-level programming language. We use Python in this project for its ability of allowing rapid prototyping of applications and for its wide support-base.

Machine Learning Frameworks: PyTorch, Numpy, Scikit, cudatoolkit libraries for facial recognition and feature extraction.

Web Development: HTML, CSS, JavaScript for building the frontend of your web application.

Backend Development: Python, Django are used for backend connectivity and server-side logic.

3. **IDE (Integrated Development Environment):**
    - **Visual Studio Code:** VSCode is used for frontend development, integration, and connectivity of frontend with the server side logic.
    - **Python Editor in Autodesk Maya:** For scripting within Maya, Maya has its own Python Editor for Development purposes.
    - **Ananconda:** Anaconda is used for creating Virtual Environment with required libraires and packages. Anaconda is a distribution of the Python programming language that is quite popular. It is designed specifically for machine learning and data science. There are more than 1,500 pre-installed packages that Anaconda comes with.
4. **Libraries and APIs:**
    - **Maya Python API:** API of Maya is used for creating and scripting within and outside of Maya for connecting Scripts with webpage.
    - **Machine Learning Libraries:** PyTorch, scikit-learn for implementing machine learning algorithms.
        - **Scikit-Image:** scikit-image is an open-source image processing library for the Python programming language. It includes algorithms for segmentation, geometric transformations, color space manipulation, analysis, filtering, morphology, and feature detection.
        - **Numpy:** NumPy is a Python package designed to efficiently deal with large multi-dimensional arrays of arbitrary records without needing too much speed for small multi-dimensional arrays.
        - **Pytorch**: PyTorch is a fully featured framework for building deep learning models, which is a type of machine learning that's commonly used in applications like image recognition.

- ❖ **Cudatoolkit:** CUDA is a parallel computing platform and programming model. It enables dramatic increases in computing performance by harnessing the power of the graphics processing unit (GPU).
- ❖ **Scikit:** Scikit is a machine learning library for the Python programming language.

- **Web Development Frameworks:** Flask, Django web framework for building the backend of application.

5. **External Resources:**

- **Autodesk Maya and Maya Plugin:** Obtained from Autodesk's official website.
- **Unreal Engine 5.1 and Meta-Human Plugin:** Available through the Unreal Engine or Epic Games official website.
- **Machine Learning Datasets:** Depending on your needs, datasets like EOS (Eigen-based Object and Scene reconstruction), Facial Detail Synthesis can be found on various platforms, such as GitHub or academic datasets.

4.4.2 Server Setup

We have hosted our server on LocalHost.

We haven’t setup a server for application. There is no specific server.

4.4.3 Database Construction & Update

MetaHuman Creator DataBase: We have used the Cloud based Database of MetaHuman Creator, in which there are various options available for different hairstyles, beards, moustaches, and colors. Final result of Models created will be saved there automatically.

Once the user creates an account on Epic games, then he will be able to save his models and choose different options from the catalog available.

It is Updated automatically as it is a cloud-based database provided by Epic Games/Unreal Engine.

4.4.4 Operating System Requirements

Operating System should be Windows 10 or above.

4.4.5 Hardware Requirements

1. System should be Core i5 3rd generation or above.
2. RAM should be atleast 8 GB.
3. Atleast 4Gb Nvidia Graphic card (compute capability>=3.5).We have used Nvidia GTX960

5 External Interface Requirements

5.1 User Interfaces

User interface reads '2D Image' selected by customer & enables your customer to visualize their 3D face models by launching Unreal Engine (MetaHuman Plugin). Your Customer can visualize complete 3D face & head model with the help of MetaHuman Identity Solver based on the previous measurements of the 3D Face. Your Customer can finally design yourself with the help of MetaHuman Creator where he can apply different skin colors, different hairstyles/beards & mustaches. Finally he can apply different colors of his choice on the selected look.

A unique experience of customer engagement, the innovative user interface of this virtual hairstyle system captures the real-time motion of your customers through the LED. The virtual hairstyle system, thereby gives an opportunity to make better haircutting decisions.

5.2 Hardware Interfaces

Vertical LED screen will use to show the customer 3D model generated with the help of Maya Plugin, MetaHuman Plugin & finally MetaHuman Creator. System will generate the 3D model of human face by scanning the the 2D image provided by the user (using Maya Plugin). By using the MetaHuman Plugin user can view his 3D model in an enhanced way & will take some measurements & analyze facial expressions of the 3D face to generate a virtual head .User can design himself in MetaHuman Creator where he can apply different skin colors, different hairstyles/beards & mustaches. Finally he can apply different colors of his choice on the selected look.

5.3 Software Interfaces

5.3.1 Visual Studio

To use for development application

5.3.2 Maya Plugin

To make a human 3D face model

5.3.3 Unreal Engine

To make 3D human head

5.3.4 Python

Using algorithm for facial detail synthesis

5.3.5 Operating system

Window 10

5.4 Communications Interfaces

There is no requirements associated with any communications functions required. All working in real time.

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[12] https://github.com/apchenstu/Facial$_{D}etails_{S}ynthesis$

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