KANTIPUR ENGINEERING COLLEGE

(Affiliated to Tribhuvan University)

Dhapakhel, Lalitpur

[Subject Code: CT755]

A MAJOR PROJECT FINAL REPORT ON

SKIN SEGMENTATION AND SKIN TONE EXTRACTION

Submitted by:

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A MAJOR PROJECT SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE DEGREE OF BACHELOR IN COMPUTER ENGINEERING

Submitted to:

Department of Computer and Electronics Engineering

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APPROVAL LETTER

The undersigned certify that they have read and recommended to the Institute of Engineering, Pulchowk Campus for acceptance, a project report entitled ”Skin Segmentation and Skin Tone Extraction” submitted by

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Last but not the least, we would appreciate all our teachers, seniors and friends for their support and constant inspiration which helped us to withstand in our dreams and make it come true.

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ABSTRACT

Skin Segmentation and Skin Tone Extraction is a desktop application. There is little research on the facial colour, for example: choice of cosmetics usually is focused on fashion or impulse purchasing. People are not able to make the right decision with facial colour,determining a persons skin colour is a large issue in the cosmetic industry. Facial colour extraction can also be used for health or disease prevention.This project presents a method for skin tone extraction under changing illumination conditions using Image Processing.User uploads image in our system which is read in RGB color space which is further processed to correct the brightness using gamma correction.And then,only the skin part is segmented by thresholding which is done by creating lower and upper threshold based on HSV. Then gaussian blur is applied on the segmented image to reduce the noise and to smooth out the edges and finally K-Means clustering is used to extract different shades of the skin.

Keywords – Keywords-Image Processing, RGB Color Space, Gamma Correction, Thresholding, Gaussian Blur, K-Means Clustering.

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LIST OF ABBREVIATIONS

1.	HSV	Hue Saturation Value.
2.	$OpenCV$	Open Computer Vision.
3.	RGB	Red Green Blue.

CHAPTER 1
INTRODUCTION

1.1 Background

Human skin color ranges from the darkest brown to the lightest hues. Differences in skin color among individuals is caused by variation in pigmentation, which is the result of genetics (inherited from one's biological parents), the exposure to the sun, or both. Differences across populations evolved through natural selection, because of differences in environment, and regulate the biochemical effects of ultraviolet radiation penetrating the skin. Your skin tone, also called undertone, is different from your complexion, which is the shade of your skin (light, medium, dark). Your undertone will remain the same no matter how much sun you get, even if youre pale in the winter and tan in the summer. Knowing your skin tone can be helpful in many ways–it can help you choose the right lipstick color, figure out which hair color is most flattering, and know which colors you should wear to really look like a knock-out.

The cosmetic market in today's time needs to assist people in finding the right cosmetic products according to the person's facial skin colour. However, determining a persons facial skin colour is also a large issue in cosmetic research.Our application makes it easier to determine or extract an individual's facial skin color and which helps to further find suitable cosmetic products according to the appropriate facial skin color.

Human skin detection is an essential phase in Skin segmentation and Skin tone extraction when using color images. Skin detection is very challenging because of the differences in illumination, differences in photos taken using an assortment of cameras with their own characteristics, range of skin colors due to different ethnicities, and other variations. Numerous methods have been used for human skin color detection, including the Gaussian model, rule-based methods, and k-means clustering. We introduce the technique of using the k-means clustering to enhance the capabilities of skin detection. Several different entities were used as inputs of a human image, and the pros and cons of different color spaces are discussed. Also, a vector was used as the input to the RGB color that contains information from three different color spaces. The comparison of the proposed technique with existing methods in this domain illustrates the effectiveness and accuracy of the proposed approach.

1.2 Problem Statement

Generally, people all around the world look for cosmetic or beauty products most suited to their facial skin color or tone. But it is difficult for people to find out their appropriate facial skin colour. Traditionally people go through a number of processes such as expert recommendation or self evaluation to determine the correct facial color. Despite the rise in the number of beauty experts,new technology, many consumers still struggle to find the right skin color. And yet, despite these new tools, significant research shows that 94Also,in the current situation the world is in the cosmetic industry has taken a push in sales. The general cosmetic or beauty product selection process is difficult and not advised in this new normal.

1.3 Objectives

The major objective of this project is:

I. To extract the appropriate facial skin color or skin tone.

1.4 Applications

The application of our project are as follows:

I. It can be used in the cosmetics industry, by various brands to suggest their customers appropriate products according to their facial skin color or tone.
II. It can also be used to group, determine people of different races or ethnicities based on their skin color.
III. It can be further used to identify types of facial skin diseases according to type of skin.

1.5 Features

The features of this project are:

I. Our application determines the appropriate facial skin shade of an individual.
II. Determines the dominant skin shade.
III. Shows various undertones in facial areas.

1.6 Feasibility

Feasibility is a measure of how beneficial or practical the development of a system will be to an organization. The process by which feasibility is measured and assessed is called feasibility analysis. The feasibility study is basically the test of the proposed system in the light of its work ability, meeting users requirement, effective use of resources and the cost effectiveness. The main goal of the feasibility study is not to solve the problem but to achieve the scope. It is carried out in terms of economic, technical and operational feasibility.

1.6.1 Economic Feasibility

Economic feasibility identifies the financial benefits and cost associated with the development of the project. It is the measure of the cost effectiveness of a project or solution. This is often called the cost benefit analysis. It is the evaluation to determine whether the system is economically acceptable. The financial aspect of the project is mainly focused by the evaluation. It determines whether the investment needed to implement the system will be recovered. Considering the economic feasibility,our system extracts the dominant skin tone and which helps in finding suitable cosmetics products according to the extracted skin color. The softwares we are using for the development of the project is available for free. Besides, we do not need any extra hardware equipment for the project. So, our project is economically feasible. Being a windows application it will have an associated hosting cost. Since the system only consist of jpeg or png multimedia data transfer, bandwidth required for the operation of this application is very low. The system will follow the freeware software standards. No cost will be charged from the potential customers. Bug fixes and maintaining tasks will have an associated cost. At the initial stage the potential market space will be the local companies and higher beauty industries. Beside the associated cost, there will be many benefits for the customers. since skin tone detection or generation is fully automated. From these its clear that the project is economically feasible.

The softwares we are using for the development of project are availabe for free.Besides, we do not need any extra hardware equipment for the project. So, our project is technically feasible.

1.6.2 Technical Feasibility

It is a complete windows based application.The computing system existing today is adequate to run all the necessary software, no new hardware components are to be integrated. The main technologies and tools that are associated with our application are Python, Diagram drawing tools, Scikit learn, Visual studio Code. Each of the tools and programming languages used for application development are readily available over the internet and the technical skills required are manageable. The application introduced can easily adapt to the existing system. The possibilities of updating the application features with technological advancement can be huge as it is developed considering software engineering principles.

Initially the windows app will be hosted in a free web hosting space, but for later implementations it will be hosted in a paid web hosting space with a sufficient bandwidth. Bandwidth required in this application is very low, since it doesnt incorporate any multimedia aspect. From these its clear that the project is technically feasible.

1.6.3 Operational Feasibility

It is the measure of how well the solution works in the organization. It is also a measure of how people feel about the system. Obviously, the tedious and time consuming existing process , if replaced by the proposed computerized approach will help the people to find their appropriate skin color and in an easy way.

This project can be easily operated by the users, no special operators required.Our system has a very user friendly graphic user interface. So anyone with basic computing skills can run the system to generate the skin tone and find the correct shade for the given input image.

1.7 System Requirements

1.7.1 Hardware Requirements

Development Requirements

i. A well Functioning PC

Deployment Requirements

i. Processor: Pentium 4 or Higher.
ii. Memory (RAM): Minimum 1 GB.

1.7.2 Software Requirements

Development Requirements

i. Python
ii. Python Runtime Environment
iii. Scikit-learn
iv. Microsoft Visual Studio Code

Deployment Requirements

i. Windows OS as an Operating System

CHAPTER 2
LITERATURE REVIEW

2.1 Case Study

In today's fast paced life, where personal health care has taken a back seat and lowest priority due to ever growing hustle for earning more and staying ahead of the competition, the significance of beauty can hardly be overstated. At such crucial junctures, if technology can join hands with beauty sector, humanity will be blessed. In any developing country, ignorance towards personal beauty care is so rampant that their beauty often go unnoticed and overlooked. The uneducated masses wouldn't even know they have been using the wrong product until it reaches the last stage (or the most critical and dangerous phase which is often incurable).

Thus by logic, an intervention done by technology in the primitive or early stages may save valuable time and money which may help the diagnosis and avert the fatalities that is why we need accurate detection of human skin. Skin detection techniques can be broadly classified as pixel-based techniques or region-based techniques. In the pixel-based skin detection, each pixel is classified as either skin or non-skin pixel individually depending on certain conditions.This can be done using open CV. The skin detection based on color values is pixel-based. Then a set of area from the image is recognized as a skin image, using RGB (Red Green Blue), HSV (Hue Saturation Value) and YCbCr [1]. This paper uses a threshold based methodology to detect whether an image is a skin image or not. It formulates a range for RGB, HSV and YCbCr models which other papers have not ascertained. Most of the research work in this area highlights the different methodologies that can be used for image recognition; different color models. However after a comparative study of strengths and weaknesses of these models; combination of RGB, HSV and YCbCr seem to fit for the purpose of recognizing skin images[2].

2.2 Similar Works

Skin detection is an indication of the presence of a human skin in a digital image by converting the original image to a binary image in which 1 represents a skin pixel and 0 represents a non skin pixel. It is a very interesting problem as well as an important preprocessing step for further techniques like face detection, hand gestures detection, semantic filtering of web contents, etc.

So far, two major groups of methods have been developed for solving this problem using either color or texture features . In comparison to texture-based skin detection, color-based skin detection is usually studied more by researchers, and most of the state-of-the-art skin detection algorithms are color-based.

The main contribution of this method is to propose a new approach for skin detection using the Bayesian classifier and the connected component algorithm. First, the Bayesian classifier is used to compute the posterior probability that a pixel belongs to the skin class. Normally, the Bayesian classifier assigns a pixel to the skin class if its posterior probability is larger than 0.5. It leads to a high false positive rate because of the high overlapping degree between two regions. In this method, a high posterior probability threshold, e11, is utilized so that we can identify the true skin pixels and decrease the false positive rate as much as possible. The Bayesian classifier, in addition to finding the true skin pixels, also finds skin candidate pixels through another posterior probability threshold e2 . Next, the connected component algorithm is utilized to find all connected components containing the skin candidate pixels. With the idea that a skin pixel is believed to connect to another skin pixel, the connect components that contain the true skin pixels are classified as skin and vice versa. Obviously, the above condition requires a skin candidate pixel connected with at least one true skin pixel. The confusing background and the noise like skin pixels that do not match the condition will be, therefore, classified as non-skin, thereby improving the classification performance especially in terms of false positive rate.[3]

2.3 Existing System

Several works were done in the area of image segmentation by using different methods. Many are done based on different application of image segmentation. K-means algorithm is the one of the simplest clustering algorithm and there are many methods implemented so far with different method to initialize the center. Many researchers are also trying to produce new methods which are more efficient than the existing methods, and shows better segmented result.

Skin Detection Using K-Means Cluster model was applied on different color Images. Around 50 images are taken for consideration. The color images contained skin region of various parts like hand, face, leg and areas with color similar to that of skin. The tested image contains more than one skin regions also. From this, our proposed model has obtained a good result to segment a skin pixels in a given color images.[4] Skin color model can be used for detecting human skin in various computer vision applications such as face detection, filtering image.

2.4 Comparative Analysis

A skin-color extraction algorithm is proposed to detect human faces in color images with varying illumination condition and presence of complex background. The approach is based on both a Gaussian mixture model of human skin-color distribution and image segmentation using all automatic and adaptive multi-thresholding technique. Experimental results on images presenting a wide range of variations in lighting condition, face orientation, scale, pose, facial expression and background, demonstrate the efficiency of our skin-segmentation algorithm. Using additional information about facial features, our method becomes an efficient step in localizing candidate faces for a face detection and suggesting the best product[5].

CHAPTER 3
METHODOLOGY

3.1 Overview

This system works in six phases for finding the skin tone from the picture. In the first phase, the user uploads the picture which is read using Open CV. In the second phase, lightness of the image is measured. And if the value of lightness is less than 130 then the brightness of the image is adjusted using gamma correction. In the third phase, only the skin part is extracted from the image by thresholding the image with a certain range of HSV value. Then in the fourth phase, a gaussian blur of radius 3 is applied to the segmented image which smoothen out the edges of the segmented skin and reduces the noise in the image. In fifth phase K-Means clustering is applied to make the cluster of the different shades of color in the image. Then dominant color is extracted by comparing the percentage of presence of the color shade in the image. Finally, in the sixth phase , after skin segmentation and dominant tone/color extraction, the most dominant color shade is compared to determine whether the skin tone of the user is Light, Medium or Dark.

3.2 System Mechanism

3.2.1 Phase 1: Read Image

This is done using OpenCV. OpenCV is a Computer Vision library that helps us extract/analyze data from images or video using image processing techniques.This system reads the images in RGB color space. Users will upload their picture which is read by the system in RGB format. The color space of the picture is converted to HSV Color Space in the next phases.

3.2.2 Phase 2: Gamma Correction

Gamma correction can be used to correct the brightness of an image by using a non linear transformation between the input values and the mapped output values:

$$O = \left(\frac{I}{255}\right)^{\gamma} * 255$$

As this relation is non linear, the effect will not be the same for all the pixels and will depend on their original value.

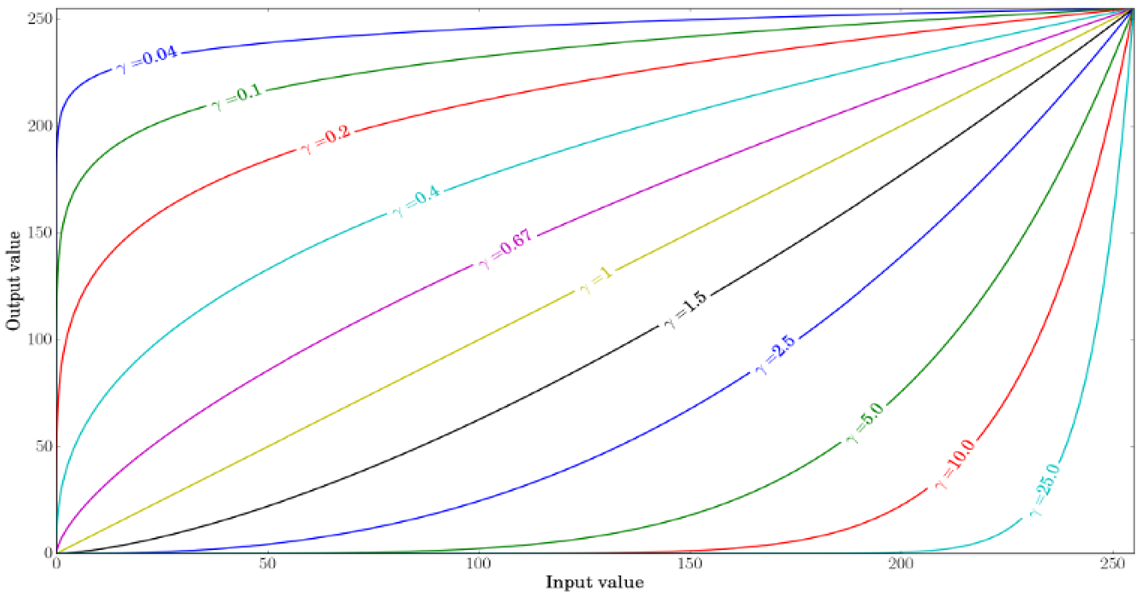

Figure 3.1: Plot for different values of gamma

In our project, gamma correction was done by comparing the lightness of the image. Lightness is measured by averaging the value constraint of every pixel of the image. As we know in HSV color space value gives the brightness of the color, so only the value of every pixel is measured. If the mean value of the image is less than certain value then the gamma correction is done in the image otherwise the image is not enhanced.

Figure 3.2: Gamma Correction

In Figure 3.2 the mean of the ”Value” constraint is 95.13 which is less than 130 so the Figure 3.2 has been corrected with: γ=0.4

3.2.3 Phase 3: Segment out the skin from the image

Skin Segmentation is done using Thresholding in the HSV Color space.The HSV (Hue, Saturation, Value) is the model used to represent the RGB color in alignment to the human perception. The Hue denotes the Dominance of the Wavelength for the particular color, Saturation denotes the amount of color used and Value indicates the intensity of the color (brightness of the color). Thresholding is the process of creating a binary image by filtering out pixels based on a defined threshold.

In simple terms we consider each pixel of an image, if that pixel is in the range of the threshold values ie HSV range then the pixel is coated white else it is coated black. In our context, the threshold values are set to lower threshold (0,10,60) and upper threshold (20,150,255).The HSV ranges was obtained by doing a bit of trial and error.

3.2.4 Phase 4: Apply Gaussian Blur

Image blurring is achieved by convolving the image with a low-pass filter kernel. It is useful for removing noise. It actually removes high frequency content (e.g: noise, edges) from the image resulting in edges being blurred when this filter is applied.

To apply gaussian blur We specify the width and height of the kernel which is positive and odd. We also should specify the standard deviation in the X and Y directions, sigmaX and sigmaY respectively. If only sigmaX is specified, sigmaY is taken as equal to sigmaX. If both are given as zeros, they are calculated from the kernel size. Gaussian filtering is highly effective in removing Gaussian noise from the image.

Figure 3.3: Applying Gaussian Blur

The images uploaded by the users might include noise in the form of some scars and wrinkles, so applying gaussian blur helps to smoothen those scars and blends them with the rest of the skin. It also helps to smoothen out the rough edges created during the skin segmentation process.

3.2.5 Phase 5: Find the color shade

This is the main goal! We will be using the K-Mean Clustering Algorithm to find the color shades on the segmented image. Clustering is a way of grouping unlabeled data.K-Means Clustering is a type of unsupervised learning algorithm. The fundamentals of a clustering algorithm is that it finds groups of data points with similar features in a given data set. K-Means is one such clustering algorithm that groups data into K groups /clusters.

Working of K-Means Clustering :

1. Choose the number of clusters (K)
2. Randomly place the K number of data points (initial centroids)
3. Assign the points in the dataset to the closest centroid (This is normally done finding the Euclidean Distance of a point from the centroid)

$$d = \sqrt{(R1 - R2)^2 + (G1 - G2)^2 + (B1 - B2)^2}$$

4. Recompute the new centroid by taking the mean of the data points in each cluster.

$$m_i^{(t+1)} = \sum_{x_j \in S_i^{(t)}} x_j$$

5. Repeat 3 and 4 till the centroid doesnt move.

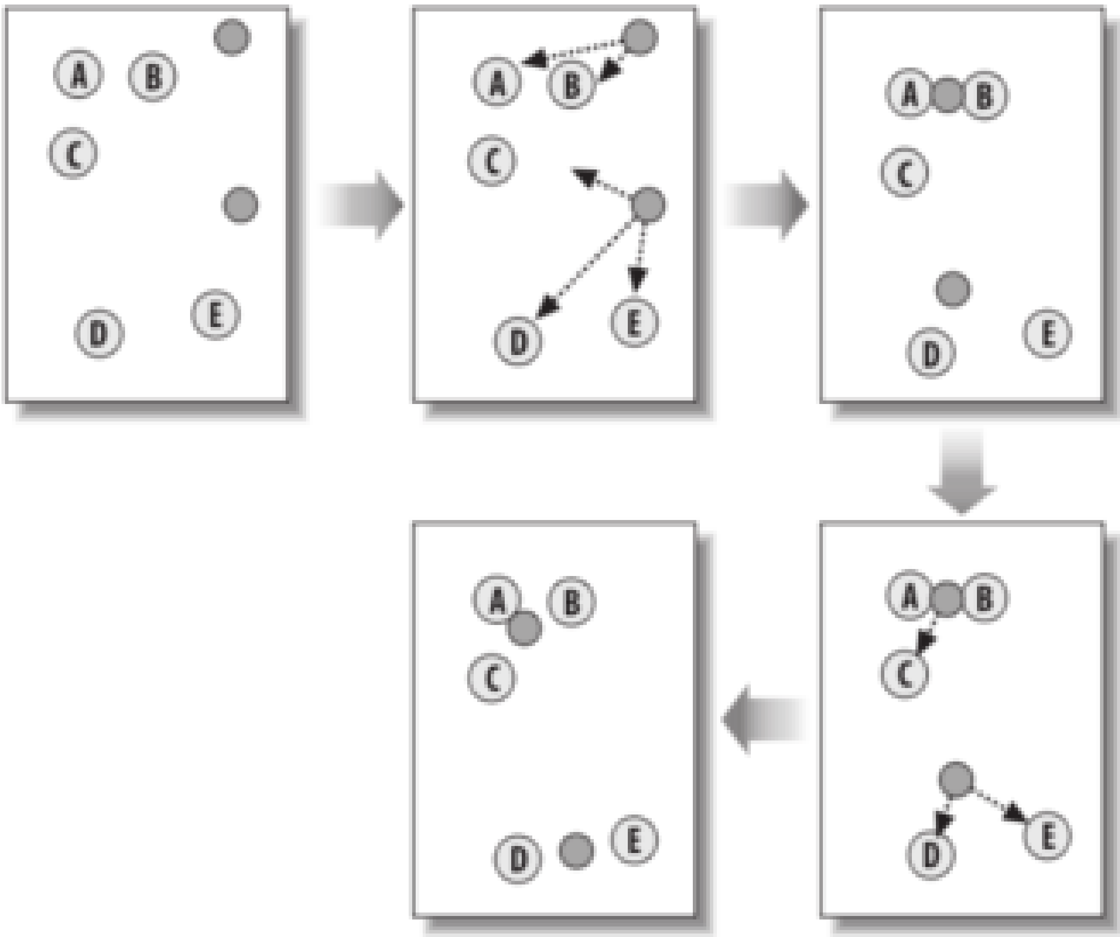

Figure 3.4: K-Means Clustering Algorithm

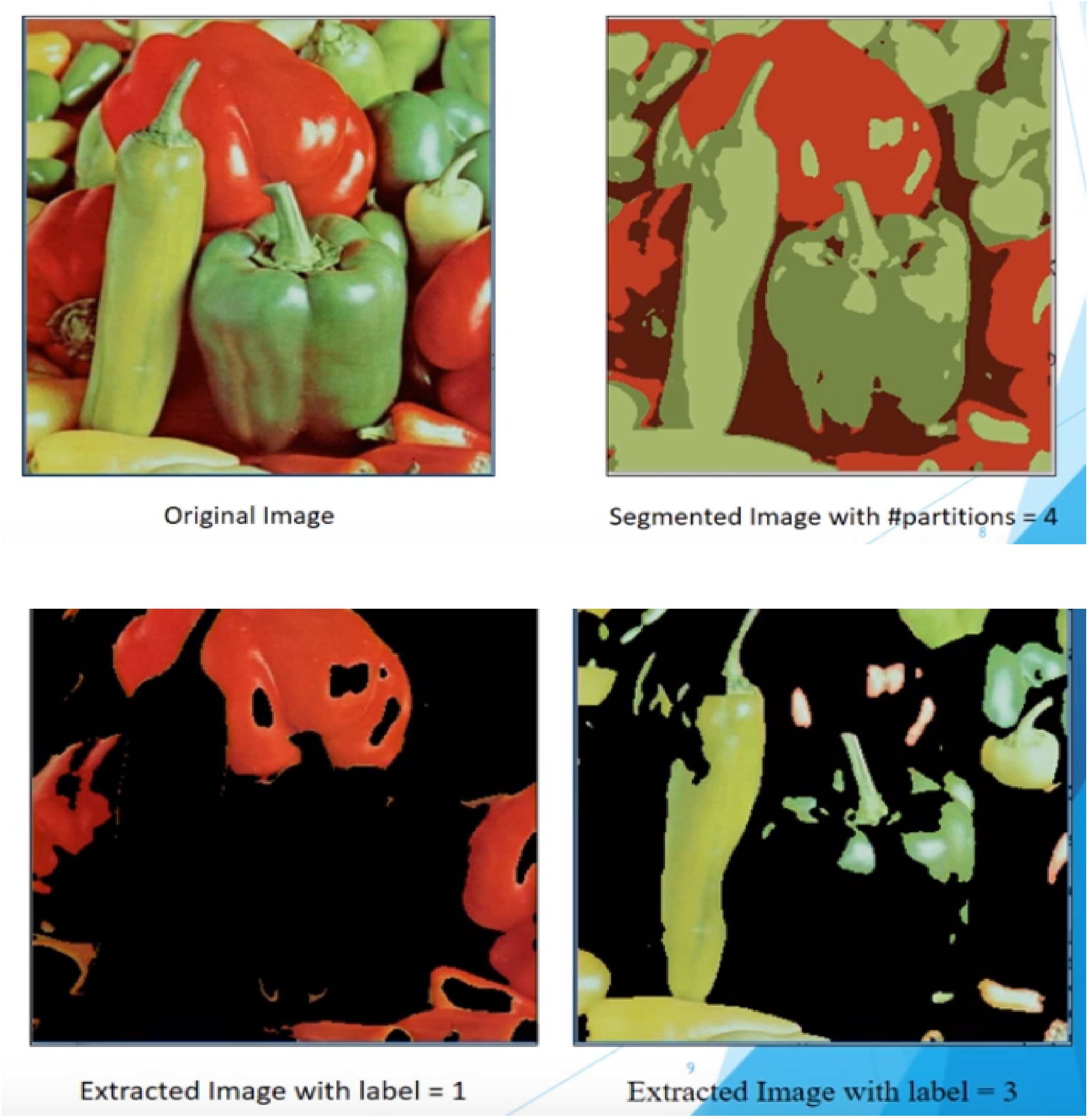

Figure 3.5: Extracted Images with different 'K' values.

In figure 3.5, we can see that no of shades in output display depend on the no of clusters(K) defined in K-Means algorithm. If k=1, then a single cluster is made and the system outputs a single shade. If k=2, then two clusters are made and the system outputs two shades and so on. For our convenience we have set k value to 5 considering the fact that a normal facial skin can have 5 variations of undertones.

3.3 Software Model

We will be using incremental model of software modeling for implementing our system.As incremental model involves development of the system where the system is put into production when the first increment is delivered some of the advantage of using this model are discussed as: Errors are easy to be identified.

System development is broken down into many mini development projects.

The software is generated quickly during the software life cycle.The software is generated quickly during the software life cycle.

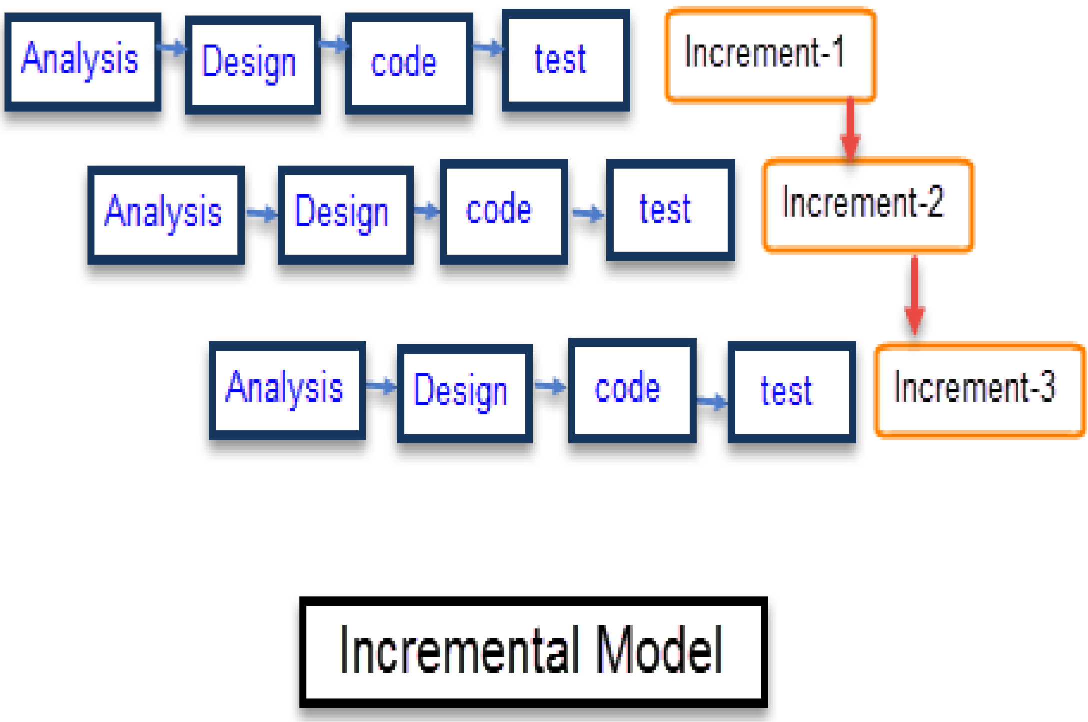

Figure 3.6: Incremental Model

3.4 UseCase Diagram

Use Case Diagram of our system is shown in Figure 3.7

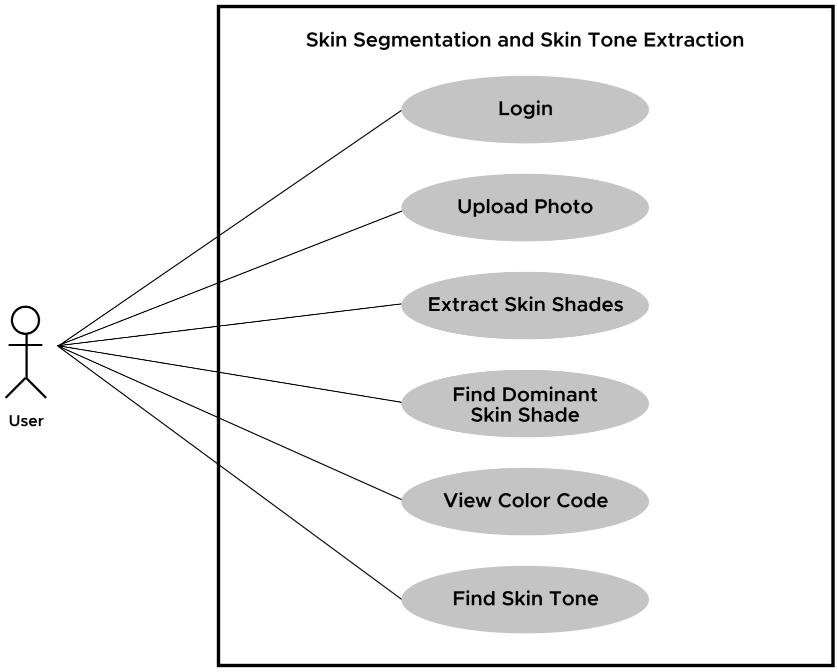

Figure 3.7: Use Case Diagram

The Figure 3.7 contains the use case diagram which represents our system, there is one actor named user.There are a total of six use cases that represent the specific functionality of our system. User interacts with a particular use case. A user actor can login,upload photos,extract skin shade,find dominant skin tone,view color code and find the kind of skin tone. This actor can perform all of these interactions with the system though our use cases don't have multiple actors.These interactions of the user and the use cases sums up the entire skin tone detection application.

3.5 System Block Diagram

System Block Diagram of our system is shown in Figure 3.8

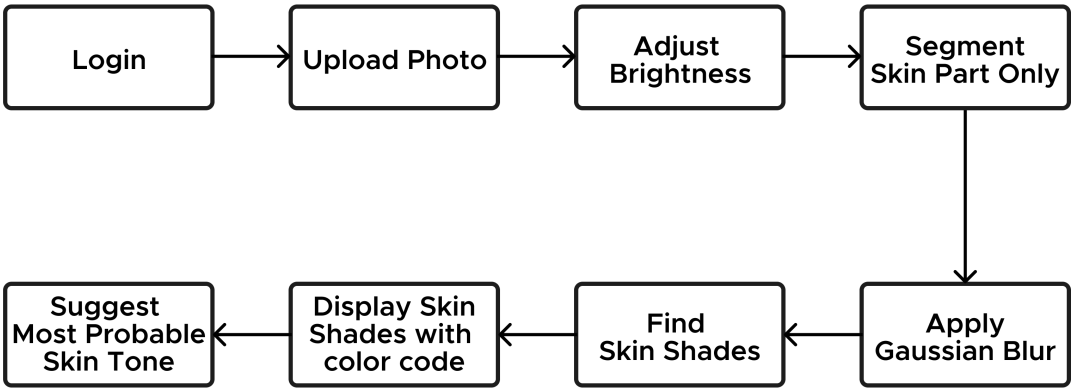

Figure 3.8: System Block Diagram

- **Login :** At first user logins to the system using credential.
- **Upload Photo :** Users upload their desired picture to the system.
- **Adjust Brightness :** System determines whether the brightness of the image needs to be adjusted or not.
- **Skin Segmentation :** Our system segments out the skin parts only from the image using thresholding value.
- **Gaussian Blur :** Now the gaussian blur of radius 3 is applied on the segmented image to smoothen out scars and the edges on the image.
- **Find Skin Shades :** Now K-means clustering is applied on the image to find the different shades of color of the skin.
- **Display Color Bar :** Then the extracted skin shades are plotted according to their percentage.
- **Display Skin Tone :** Finally the dominant color shade is compared to identify whether the skin tone is light,medium or dark.

CHAPTER 4
RESULT AND ANALYSIS

4.1 Result

Screenshots of output screen of our program is shown in Figure 4.1 and 4.2.

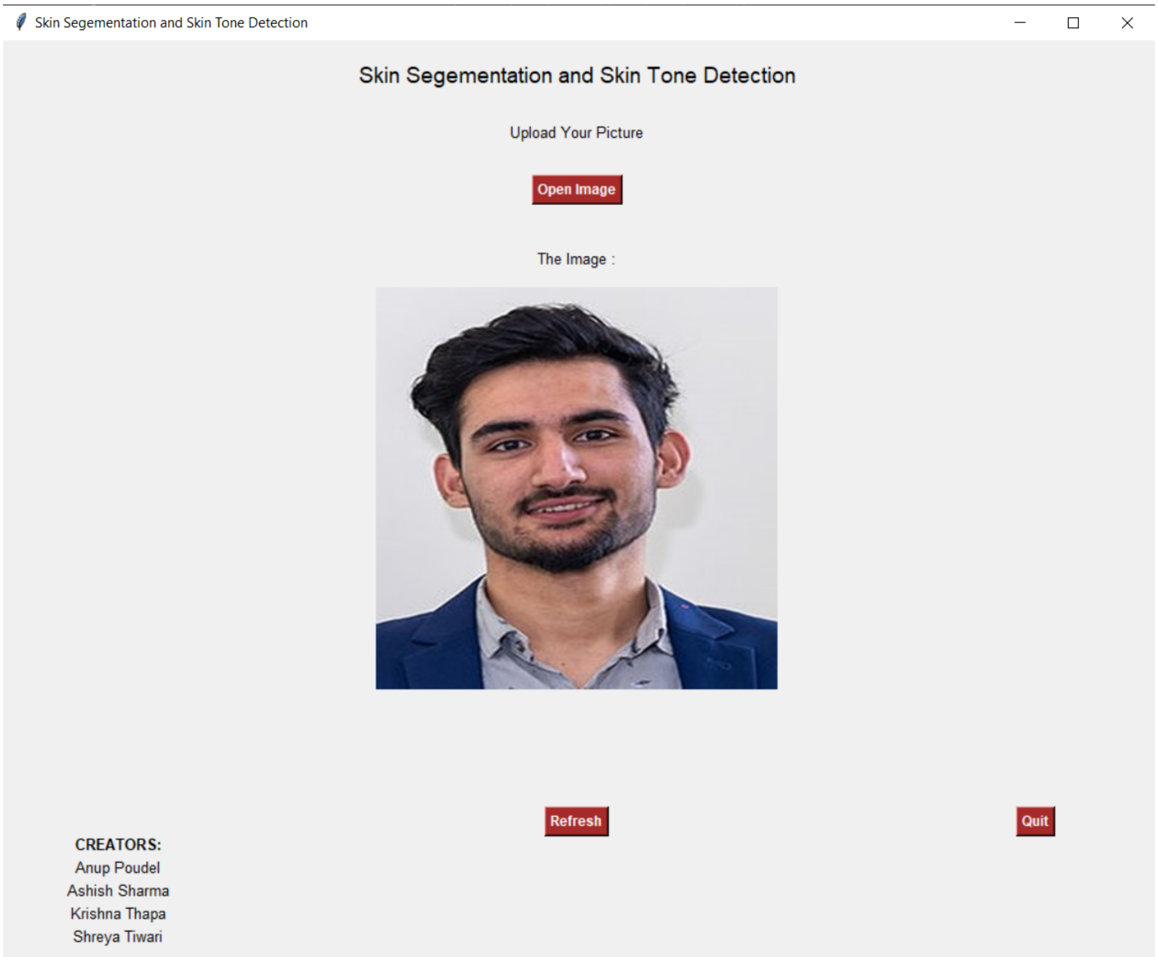

Figure 4.1: Image Uploading Window

This is first User Interface window where user can upload their image to find their skin tone.

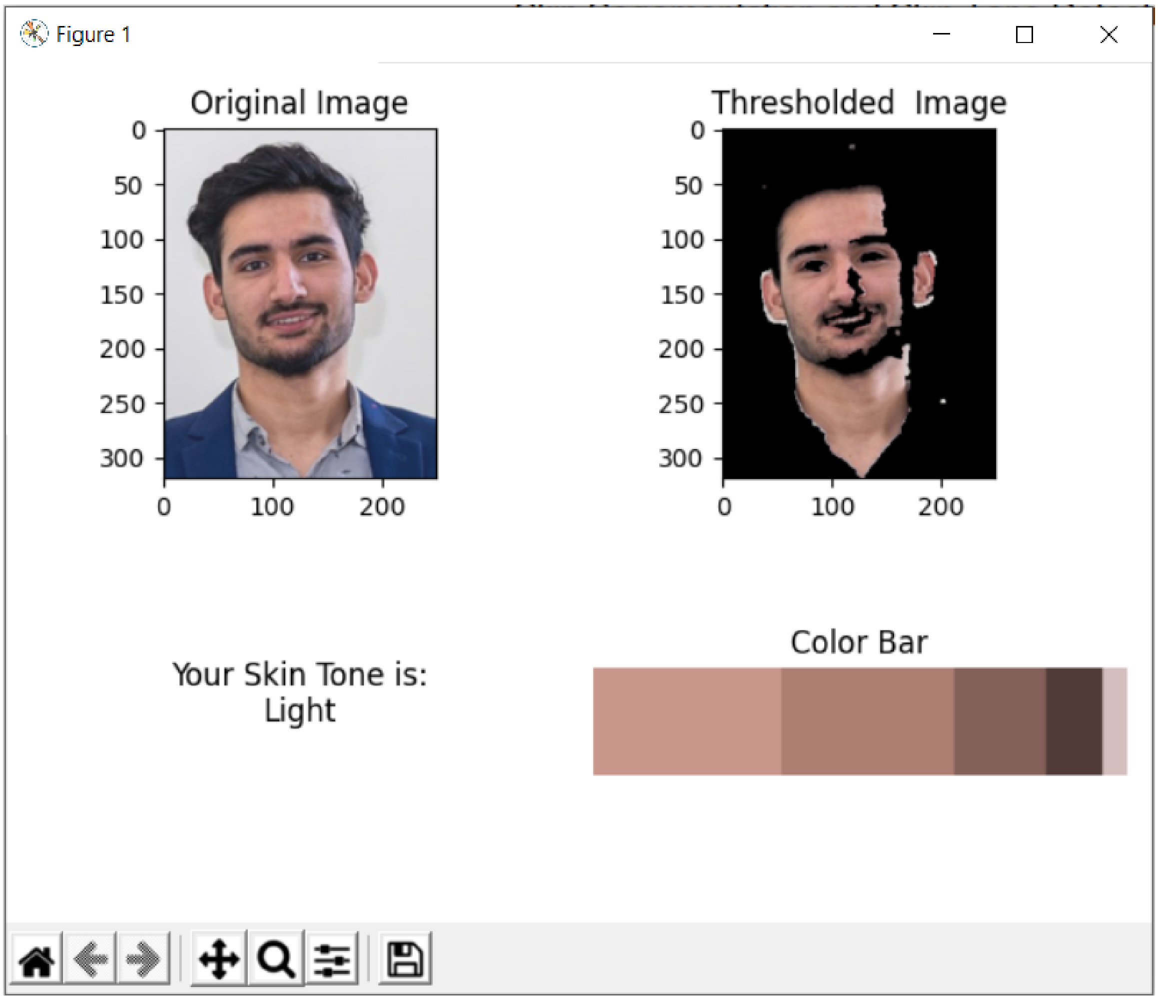

Figure 4.2: Output Window

This output window shows the thresholded image, users skin tone and the extracted color bar.

```
The brightness of the picture is sufficient, no enhancement
Color Information
{'cluster_index': 4,
 'color': [189.11983054266642, 160.3106717772845, 112.68579786161001],
 'color_percentage': 0.28222310938747575}

{'cluster_index': 2,
 'color': [208.7788247750106, 181.5011116993117, 139.5988353626241],
 'color_percentage': 0.27041747462073684}

{'cluster_index': 0,
 'color': [84.57858296792091, 61.394876528963664, 47.22986383567966],
 'color_percentage': 0.19676057944564845}

{'cluster_index': 3,
 'color': [125.81324354657714, 99.67946127946114, 70.70347923681214],
 'color_percentage': 0.12672521957340024}

{'cluster_index': 0,
 'color': [84.57858296792091, 61.394876528963664, 47.22986383567966],
 'color_percentage': 0.12387361697273867}

Light
Color Bar
```

Figure 4.3: Color Code Information Window

This window displays the color code information and their percentage of occurrence.

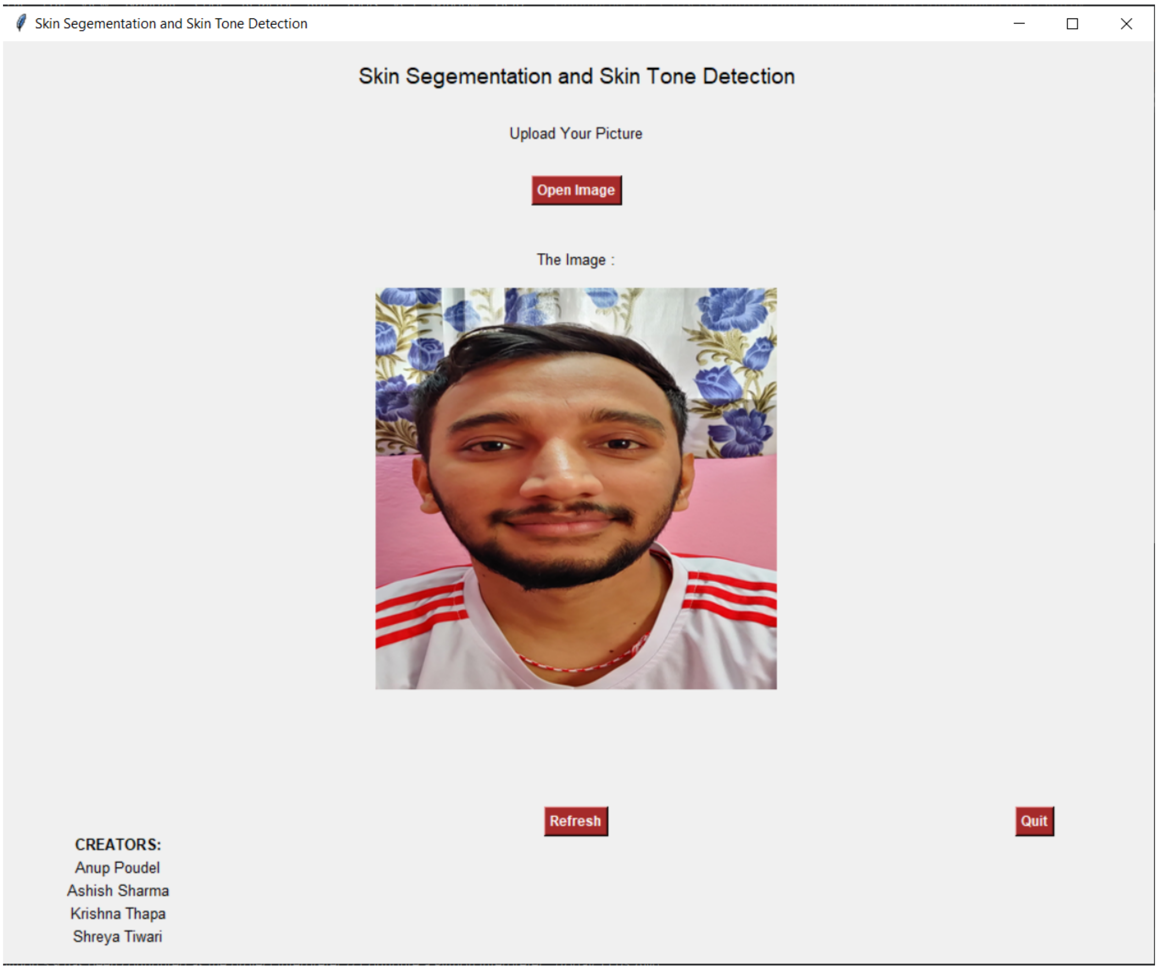

Figure 4.4: Image Uploading Window

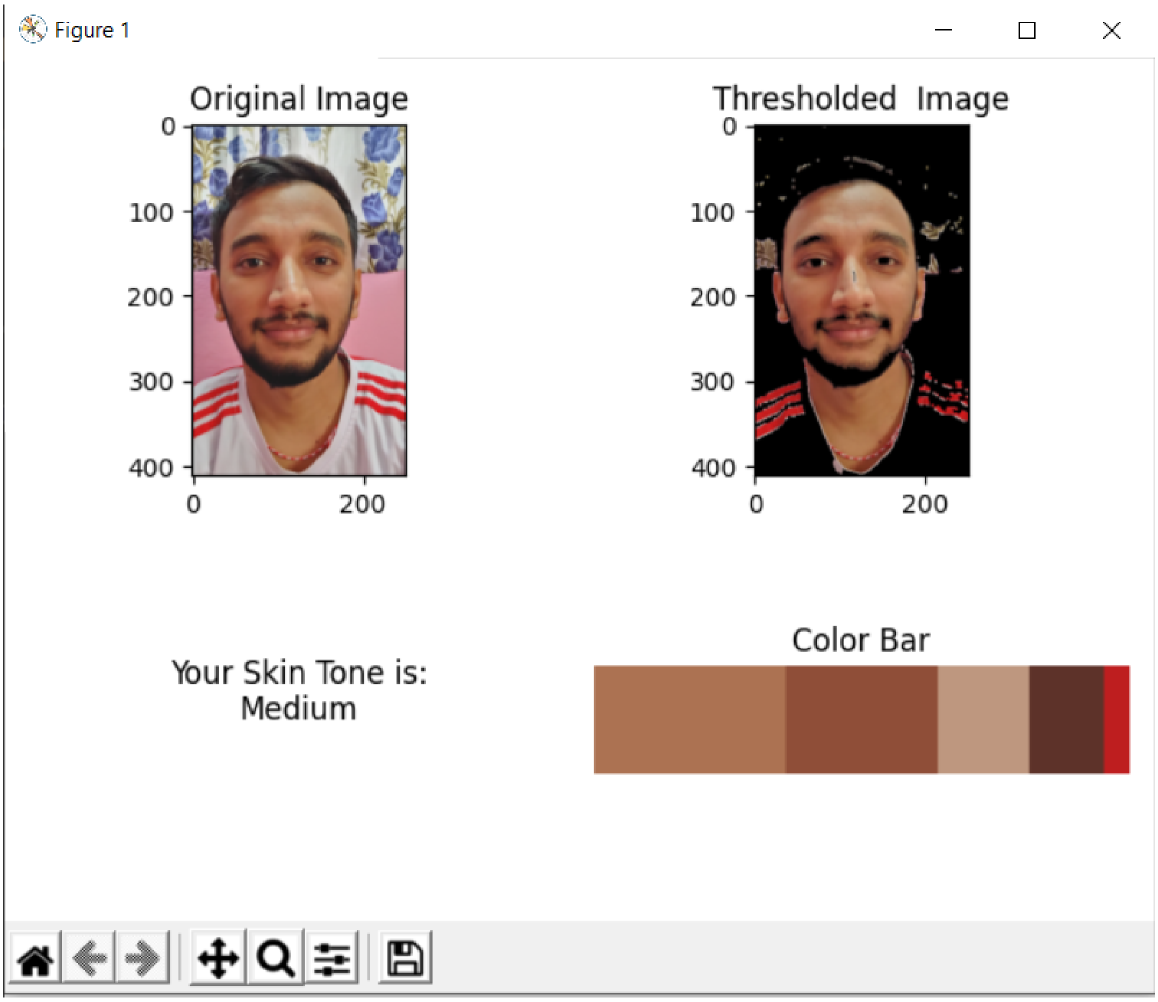

Figure 4.5: Output Window

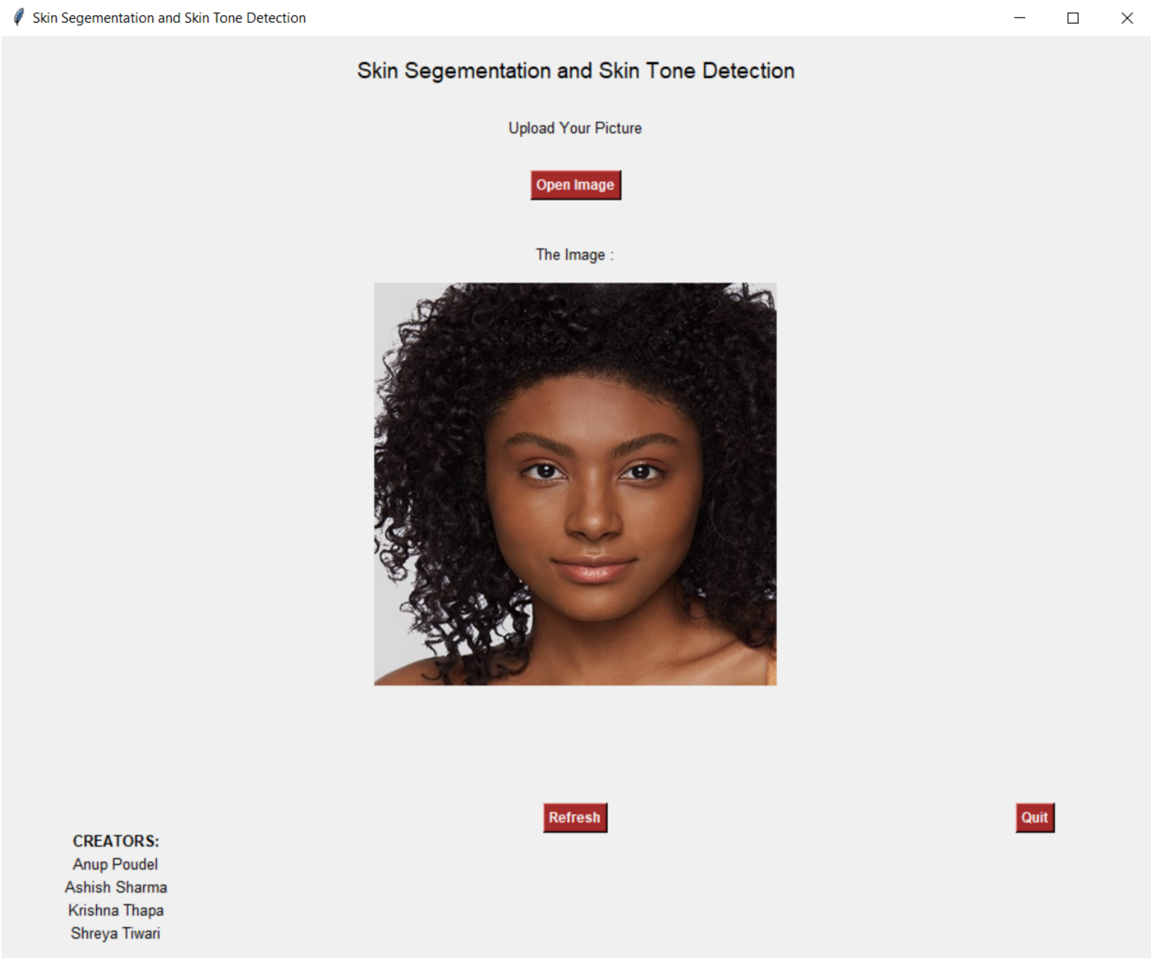

Figure 4.6: Image Uploading Window

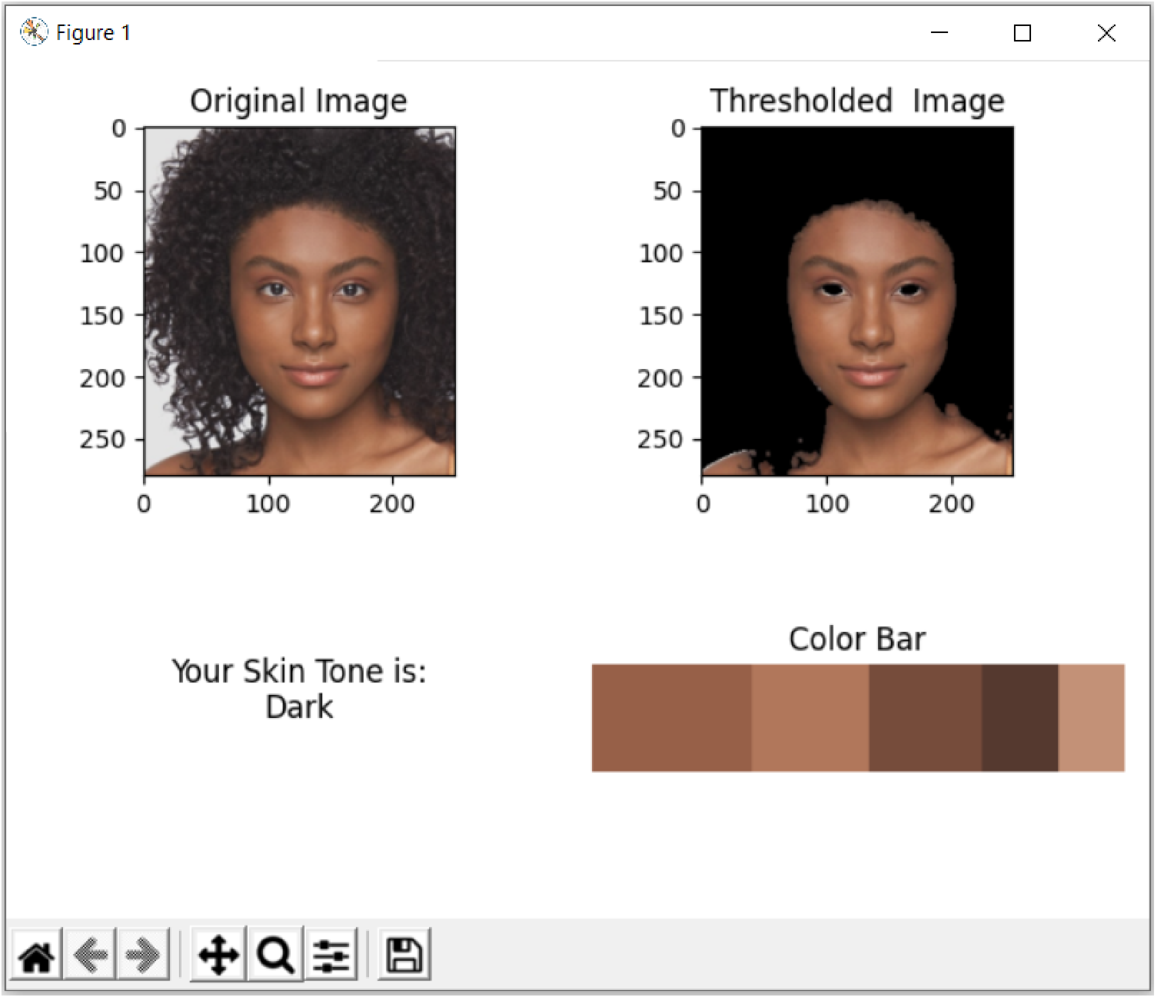

Figure 4.7: Output Window

CHAPTER 5
CONCLUSION AND FUTURE ENHANCEMENT

5.1 Conclusion

This project was primarily concerned with the implementation of K-means clustering to find the dominant skin color. Despite the availability of different traditional methods to identify one's skin tone, advancement in machine learning has enabled K-means to be an effective algorithm for this task. A well implemented tool and algorithm is capable of extracting skin tone with desired accuracy.

This project was completed in three stages using the incremental software development life cycle in python programming language. The first build target was accomplished by writing code to read images using OpenCV through a user friendly UI. The second build used gamma correction to balance the lighting of the image so that the altered brightness doesn't drive our output towards faultiness. And also, segmentation of skin was done using threshold values. Lastly, the final build proceeded with implementation of K-Means Clustering algorithm to find the different color shades of the skin inorder to determine the skin tone.

5.2 Limitation

Based on the experience of working on this project, the following limitations were seen on the system:

1. If the background of the image is in the range of natural skin color,then the application segments the background along with the skin.
2. Although we have applied gamma correction to adjust the brightness, the output is more accurate if the image is taken under the perfect lighting condition.

5.3 Future Enhancement

Future work for skin-color segmentation can be done by adding a method for dynamic skin distribution models. Machine learning can be also implemented to get the higher percentage of accuracy for defining skin-region explicitly. Also the extracted skin tone of the users can be implemented in different application areas. Some of the application areas are listed below:

1. This study can be popularized to cosmetics purchasing.
2. Analysis of facial group after big data are applied.
3. Facial color can be also a method for health or disease prevention.
4. It will be the basic work for the future fashion application with big data.
5. Facial color can be used to determine the typology of people.

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