Extraction of Face Segments based on Proportion

Akshay Kajekar, Shreyash Patel, Sweta Chauhan, Prof. Prashasti Kanikar

Abstract— A novel algorithm for extracting the regions of interest (ROI) from face images based on the human facial proportions. Despite the researches in image processing there has not been much development in this field. The available approaches are complex and require a thorough session of training for the users to use it. Moreover the images or the results obtained were more than often unclear and non-specific.
The novelty of our algorithm comes from the fact that it is simple to understand and incorporate into a working model as well as it gives the near perfect results.To achieve its task, the approach uses three modules: Skin detection, feature detection and feature extraction.

Index Terms—Feature extraction, human facial proportions, markov random field, matlab functions, rgb color space, segmentation and skin detection.

1 Introduction

Motivated by reports of increased self-confidence and driven by shifting cultural values, number of aesthetic maxillofacial plastic surgeries has increased dramatically in the past few decades. More recently, advances in computer modeling have allowed pre-surgical observation and simulation of the effects of such operations, thus reducing the risk of unwanted results.

In this work we have tried to focus on fine-tuning the frontal, two dimensional images those results from replacement of patients' facial features with those of the model.

The major contributions of this paper may be listed as follows:

- The method is based on facial proportions
- The cost of computation is less as it involves only the pixel comparison and basic mathematical functions on images.
- The algorithm colour face images.

The rest of the paper is organized as follows. Sec. 2 describes the previous approach for segmentation. Sec. 3 discusses the proposed approach and the results. Sec. 4 shows the comparison between the previous and proposed approach.Finally, we present the conclusion in the Sec. 5.

2 Previous Approach

We look at the previous approach "Markov Random Field Models" [1] used for the purpose of segmentation of the face and hair region from the background.

This approach starts by using learned mixture models of color and location information to suggest the hypotheses of the face, hair, and background regions.

In location distribution, the image to be segmented is matched with six hair masks. The different hair masks are shown in fig 1. The mask best suited for that particular input image is selected. Once the hair mask is selected, the color distribution is done. In color distribution, from the selected hair mask, we know the location of the hair in the image. Hence, the color of the hair is determined basically from the classes of colors: black, brown, blond, red and gray. Then the face color is also computed.
There are 3 classes namely:

1. Background
2. Hair
3. Face

Each pixel in the image is kept into one class.

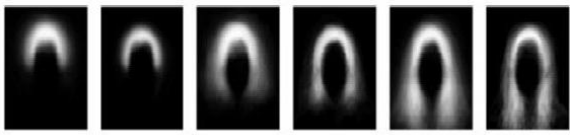


Figure 1: hair masks. each mask can be treated as a different hair style.

The image gradient information is used to generate the likely suggestions in the neighboring image regions. Either Graph-Cut or Loopy Belief Propagation algorithm is then applied to optimize the resulting Markov network in order to obtain the most likely hair and face segmentation from the background.
Disadvantages:

- Higher resolution problem

- *Akshay Kajekar is currently pursuing masters degree program in computer application in NMIMS University, India, PH-09833983952. E-mail: akshaykajekar@gmail.com*
- *Shreyash Patel is currently pursuing masters degree program in computer application in NMIMS University, India, PH-0985058944. E-mail: cj27041989@gmail.com*
- *Sweta Chauhan is currently pursuing masters degree program in computer application in NMIMS University, India, PH-09619188917. E-mail: swetachauhan@hotmail.com*
- *Prashasti Kanikar is currently an assistant professor at NMIMS University, India, PH-09920742851. E-mail: prashasti.kanikar@nmims.edu*

- Large Training set needed
- Manual creation of training set
- More processing time

3 PROPOSED METHOD

Segmentation is subdividing an image into its constituent regions or object. The level up to which the subdivision is carried out depends on the problem being solved.

In our approach, segmentation involves segregating the face into three regions which are:-

1. Eyes and the forehead
2. Nose and the cheeks
3. Lip and the chin

This is achieved by using the functions explained in the following sections.

Figure 1 shows the block diagram representing the system where:

O: Original Face Image

D: Desired Face Feature Segments

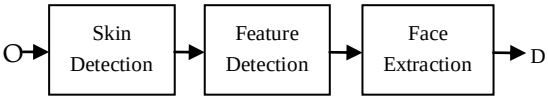


Figure 2: block diagram of proposed method.

Each of the module in the proposed method as depicted in the Fig 2 is explained in detail.

Constraint for Face Images:

- Background should be black or white.
- No tilted face
- Good quality picture is required. 1024 x 768 resolution image is required.
- No hair falling on face.
- Preferable passport photos.
- Picture only till neck.

3.1. Face Detection

While different ethnic groups have different levels of the melanin and pigmentation, the range of colours that human facial skin takes on is clearly a subspace of the total colour space, assuming that a person framed is not having face with any unnatural colour [2] & [3]. This algorithm takes the advantage of face colour correlation to limit face search to areas of an input image that have at least the correct colour components.

While RGB may be the most commonly used basis for colour description, it has a negative aspect that each of the coordinates is subject to luminance effects. Moreover the red, green and blue components are highly correlated. Hence cannot necessarily provide relevant information about whether a particular pixel is skin or not. Since hue, can be effectively used to describe the colour, the HSI colour space, however is much more intuitive and provides colour information in a manner more in line how human thinks of colours. The algorithm uses the range of Hue for the skin detection.

The most noticeable range which was used by algorithm to detect the skin for H (hue)value is:

$$0.01 <= H <= 0.1 \quad (1)$$

Otherwise it is non-skin pixel. By applying the mask based on this rule, HSI segmentation was achieved. YCbCr space segments the image into a luminosity component and chrominance components. The main advantage is that influence of luminosity can be removed during processing a image. Using the reference images different plots for Y, Cb and Cr values for face and non-face pixels were plotted and studied to find the range of Y, Cb and Cr values for face pixels. After experimenting with various thresholds the best result were found by using the following rule for detecting the skin pixel:

$$100 <= Cb <= 110 \quad (2)$$

$$140 <= Cr <= 150 \quad (3)$$

For each pixel of the image calculate:

$$\mathrm{Cb} = 0.148 * \mathrm{R} - 0.291 * \mathrm{G} + 0.439 * \mathrm{B} + 128 \quad (4)$$

$$\mathrm{Cb} = 0.439 * \mathrm{R} - 0.368 * \mathrm{G} + 0.071 * \mathrm{B} + 128 \quad (5)$$

And hue value of each pixel can be found by the built-in function rgb2hsv().

The flow chart of the algorithm developed for skin detection is given in Fig 3. Fig 4 (a) is the test image. And Fig 4 (b) is the output of the skin detection module.

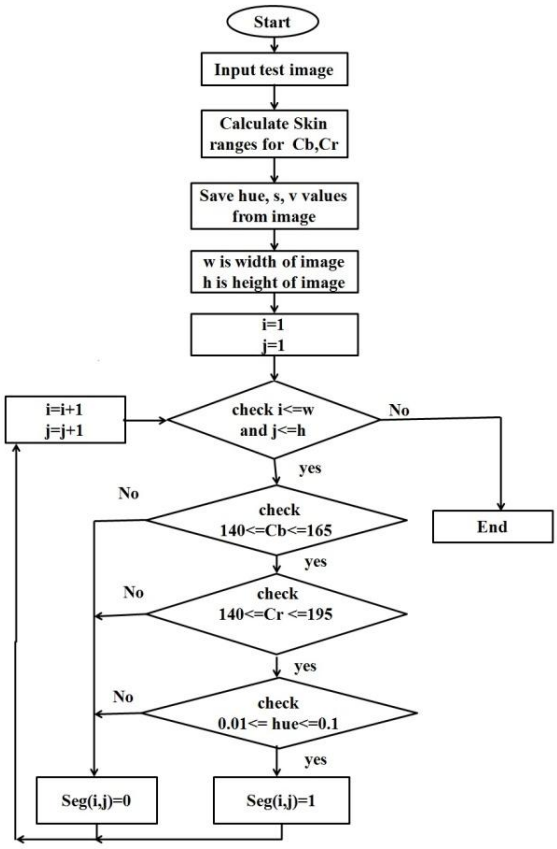


Figure 3: flowchart of skin detection module.

(a) (b)

Figure 4 (a) is the original image and (b) is the result after skin detection.

3.2 Feature Detection

Start

1. Convert the output of skin detection 'image' into black/white form.
2. Find the 1st white point
   (a) From left to right side of image.
   (b) From right to left side of image.
3. Compute midpoint
4. Correct ear coordinate
5. Compute
   (a) Eye coordinate:
   (b) Face top coordinate
   (c) Face tip coordinate
   (d) Nose coordinate

Stop

Notations used:

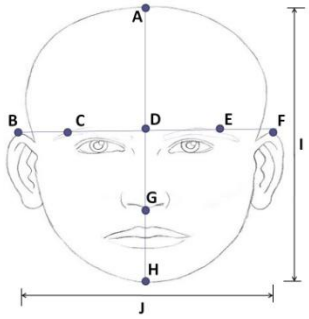


Figure 5: coordinates representation

Where:

A→ head_x , head_y

B→ left_xvalue , left_yvalue

C→ left_eye_x , left_eye_y

D→ mid_x , mid_y

E→ right_eye_x, right_eye_y

F→ right_xvalue ,right_yvalue

G→ nose_x , nose_y

H→ tip_x , tip_y

I→ length_face

J→ length_across_face

The following is the explanation in detail of the algorithm used for feature detection.

Step 1:

Convert the output of skin detection 'image' into black/white form.

(a) (b)

Figure 6 (a) is the original image and (b) is the result of this step1.

Step 2:

Find the 1st white point

(a)From left to right side of image. i.e. (left_xvalue, left_yvalue)

(b)From right to left side of image. i.e. (right_xvalue, right_yvalue)

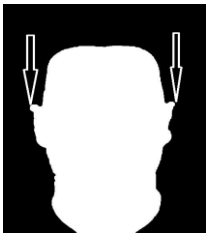


Figure 7: graphical representation of the Step 2.

Step 3:

Compute midpoint:

$$\text{length\_across\_face} = \text{right\_xvalue} - \text{left\_xvalue} \quad (6)$$

$$xm = \frac{\text{lenght\_across\_face}}{2} \quad (7)$$

$$\text{mid\_x} = xm + \text{left\_xvalue} \quad (8)$$

Reference to points
right_xvalue, left_xvalue and length_across_face from the fig 5.

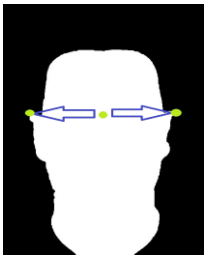
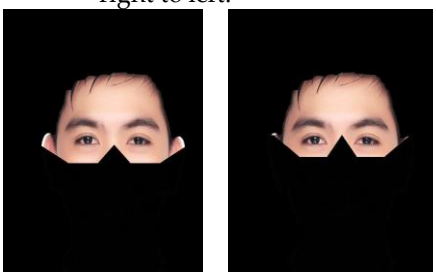


Figure 8: graphical representation of the step.

Step 4:

Ear point correction:

1. Go from left to right of the image
2. Save the point whose y-value is smaller than the left_yvalue.
3. Loop until the new point's y value is greater than the old value.
4. Similarly compute the values respectively from right to left.



(a) (b)

Figure 9 (a) is the original image and (b) is the result of this step.

Step 5:

Compute:

(a)Eye Points:

$$L = 1.31 * \text{mid\_x} / 2.118 \quad (9)$$

$$\text{left\_eye\_x} = \text{mid\_x} - L \quad (10)$$

$$\text{left\_eye\_y} = \text{mid\_y} \quad (11)$$

$$\text{right\_eye\_x} = \text{mid\_x} + L \quad (12)$$

$$\text{right\_eye\_y} = \text{mid\_y} \quad (13)$$

Reference to points
mid_x , mid_y,left_eye_x,right_eye_x, left_eye_y, right_eye_y from the fig 5.

(b)Face Top points:

Find 1st black point from starting the loop from mid_x to the start of the image.

Save as head_x, head_y

Reference to points
head_x, head_y from the fig 5.

(c)Face Tip points:

$$\text{tip\_x} = \text{mid\_x} \quad (14)$$

$$\text{tip\_y} = 2.618 * \text{mid\_y} - 1.618 * \text{head\_y} \quad (15)$$

Reference to points
tip_x, tip_y from the fig 5.

(d)Nose Points:

$$\text{nose\_x} = \text{mid\_x} \quad (16)$$

$$\text{length\_face} = \text{tip\_y} - \text{head\_y} \quad (17)$$

$$p = (\text{length\_face} * 1.618)/2.6218 \quad (18)$$

$$\text{nose\_y} = p + \text{head\_y} \quad (19)$$

Reference to points
nose_x, nose_y from the fig 5.

3.3 Feature Extraction

After detecting the regions of interest from the given face we now proceed to the next step of extracting the given feature from the face. Here we consider the top most region i.e. the eyes and forehead section [7].

After detecting the given region we reduce the values of all the pixels in that region to zero i.e. we make it completely black. This image is then saved as a temporary image 'temp_img'. Next we carry out a subtraction of this image from the original image which will yield an image containing only our region of interest, in this case the eyes-forehead segment. This image is now stored as a new image which is then used in the following sections to be merged with the other segments.

The same concept is used in extracting all the other region of interests viz: the nose-cheek section and the lips-chin section.

The algorithm for the feature extraction:

Start

1. Blacken image till midpoint i.e. mid_x.
2. Blacken the eye parts.
3. Take feature extraction point. Save image as 'head less.jpg'
4. Blacken the face till the nose_yvalue. Save the image as 'bottom.jpg'
5. Compute the top part image i.e. (temp_img-headless). Save as 'top.jpg'
6. Compute middle = headless-bottom. Save as 'middle.jpg'

End

The following is the explanation in detail of the algorithm used for feature extraction.

Step 1:
Consider temp_img.jpg as only face fragment which is the output of the skin detection module. Blacken image till mid_y.

Step 2:
Blacken the eye parts such that the eyes are blacken in the image represented in fig 11. In fig 11, the blue shaded part is the region being blacken in this step.

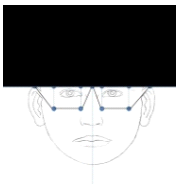


Figure 10: graphical representation of the step 1.

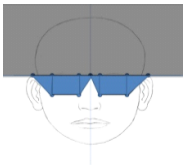


Figure 11: graphical representation of the step 2.

Step 3:
Save image as 'head less.jpg'.

Step 4:
Add some more value to the nose_yvalue.
Blacken the image till the new computed value.
The shaded gray part is the region being blackened in this step.
Save the image as 'bottom.jpg'

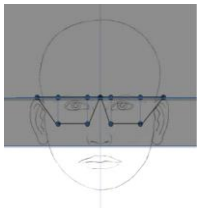


Figure 12: graphical representation of the step 4.

Step 5:
Compute the top part of the face image i.e. 'top.jpg'

$$top = temp\_img - headless \quad (20)$$

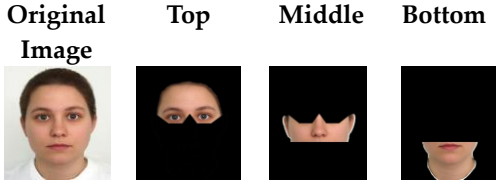
Step 6:
Compute the middle part of the face image i.e. 'middle.jpg'

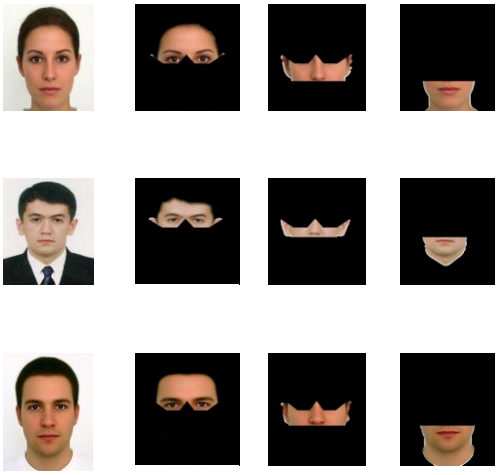
$$middle = headless - bottom \quad (21)$$

(a) (b) (c) (d)

Figure 13 (a) shows the output of the skin detection module. (b) shows the top.jpg image. (c) shows the middle.jpg image and (d) shows the bottom.jpg image.

Results on various images





4 Comparison between the Previous and Proposed Approach

Table 1
Comparison between Previous and Proposed Approach

Markov Random Field Models	Proposed Method
Higher resolution problem	No resolution problem
Large Training set needed	No Training set needed
More processing time	Less processing time
Error rates is between 8.8% to 9.4%	Error rates is between 5.8% to 7.4%
Hair and face segmentation	Face segmentation into top, middle and bottom
Difficult to implement	Easy to implement

Table 1 shows the differences between the previous approach 'Markov Random Field Models' and the proposed method.

5 Conclusion

In this paper, we have presented a novel algorithm for extracting the regions of interest from frontal face images. The advantages of or approach are the algorithm works even if the resolution of the image increases. Secondly, no training set required compared to Markov Random Field Model and also less processing time required, less error rate and it is easy to implement.

The possible applications where our approach could be applied are cosmetic surgery to extract features from face and also by detective agencies to identify people based on eye-witness accounts which is a good replacement to the manual technique now used.

Currently, our approach segments the face into three parts, the extension that we could add to it is of segmenting the face into more parts to get much better results.

Acknowledgement

We would like to thank Prof. Prashasti Kanikar who has helped us throughout to make this project a success. She has helped us with such great care and excellence that we can never thank her enough.

We would also like to thank our Dean Dr. D.J.Shah for providing us the best infrastructure and a great value education system in college.

References

[1] Kuang-chih Lee, Dragomir Anguelov, Baris Sumengen and Salih Burak Gokturk,*Markov Random Field Models for Hair and Face Segmentation.*

[2] Diedrick Marius, Sumita Pennathur, and Klint Rose, Detection Face Detection Using Color Thresholding, and Eigenimage Template Matching

[3] Dr. Arti Khaparde, Sowmya Reddy.Y Swetha Ravipudi, Face Detection Using Color Based Segmentation and Morphological Processing –
A Case Study

[4] C.J. Veenman, M.J.T. Reinders, and E. Backer, *A Cellular Coevolutionary Algorithm for Image Segmentation,* Vol. 12, No. 3, pp. 304-316, March 2003.

[5] Goin MK, Rees TD, *A prospective study of patients' psychological reactions to rhinoplasty, Annals of Plast Surgery*, 27(3):210, 5, Sep 1991.

[6] Arindam Biswas, Suman Khara, Partha Bhowmick, *Extraction of Regions of Interest from Face Images Using Cellular Analysis,* Science and Technology Dept.

[7] The golden proportion can be found on the site. *'http://majorityrights.com/weblog/comments/the_facial_proportions_of_beautiful_people'*.

[8] Gonzalez R. Woods. E., *Digital Image Processing Using Matlab* (Prentice Hall, Second Edition, 2002

[9] Rudra Pratap, *Getting Started With Matlab 7*

[10] Gonzalez R. Woods. E., *Digital Image Processing* (Prentice Hall, Second Edition, 2002)