



## An Innovative Face Detection Method Based on YCgCr Color Space and Half Face Template Matching

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**Abstract:** This paper propose a novel face detection method that detect the human faces in color images. It represents a hierarchical face detection method based on skin color model in YCgCr chrominance space and the half face template matching algorithm. The proposed method includes two different classifiers. The first is called rough classifier, which filtrates the most of the non-face. The second one is called a core classifier, which uses template matching to detect the face based on the result from the first classifier. Better detection rates can be achieved by using this approach of face detection.

**Keywords:** Face detection, Skin Color Detector, YCgCr color space, Color Balancing, Half face template matching method.

### I. INTRODUCTION

There are various aspects of human physiology that are used to authenticate a person's identity. Biometrics is the science of ascertaining the identity with respect to intrinsic characteristics trait of human being. With improved technology, biometric authentication has been widely used for law enforcement, access management and security system. There are a number of ways in which a person can be identified by his behavioral traits which includes faces, fingerprints, iris, hand geometry, ear pattern, voice recognition, keystroke pattern and thermal signature.

Face Detection and recognition is an interesting as well as challenging problem in the field of research. Face Detection in pattern recognition technology and computer vision technology poses high commercial value and also an academic value. First step in applications such as video surveillance, face recognition system and image database management is human face detection and localization. Prerequisite for face recognition is locating and tracking the human faces in the image. It is quite difficult to detect and locate faces in complex background image due to variability of face appearance and insufficient prior information. To track the location of probable faces in the images is main aim of face detection.

For locating and detecting a human face, the system needs to process and search the image for important features, and then using these features to find the location of the face. In the image the presence of objects similar to skin-like color will produce wrong classification of skin and non-skin pixels using only color space information. By using only color space model the face will be partially detected, therefore it is necessary to combine this segmentation scheme with other techniques (e.g., template matching) for adding the undetected regions to the detected face region, in order to improve the results of the segmentation process.

In this paper we proposed a approach which first acquired a input image. Then use YCgCr color space to identify the skin pixel[2]. After identification of skin pixel, half face template matching is applied on the skin region to identify the faces in the image[3].

The flow chart of general method for face detection is given in figure 1.

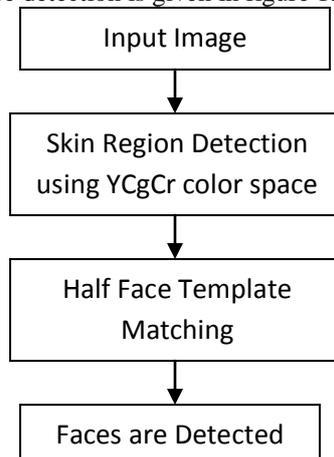


Fig 1: Flow Chart

In this paper Related work is explained in section II. Proposed work is explained in section III. Experimental results are described in section IV. Advantages of proposed system are described in section V and finally Conclusions and future work are given in section VI.

## II. RELATED WORK

There has been significant progress of face detection system in the recent years that includes a number of face recognition and modeling systems.

Smt. M.P.Satone and Dr. G.K.Kharate[1] describe an algorithm for a color based technique used to detect frontal human faces in images. Kamarul Hawari Bin Ghazali, Jie Ma, Rui Xiao and Solly Aryza lubis[2] propose a face detection method based on skin color model in YCgCr chrominance space. Wei Chen, Tongfeng Sun, Xiaodong Yang and Li Wang[3] have successfully implemented face detection using half face template matching. Sheikh Amanur Rahman, M. A. Ansari and Santosh Kumar Upadhyay[4] have proposed a face detection method which combines the Skin Colour Detector and the Half Face Template Matching Method. Smita Tripathi, Varsha Sharma and Sanjeev Sharma[5] presents a face detection method which combines the skin color detector and the template matching method. Yogesh Tayal, Ruchika Lamba and Subhransu Padhee [6] has proposed & successfully implemented the color based segmentation for face detection.

### A. Skin Color Modeling

Skin color may be used for obtaining information related to facial features like their geometry, shape, etc. In face detection the skin color model plays an important role. Skin color model can be used to detect the skin or non-skin region in the images. The first step includes choosing the suitable color spaces in the skin color detection. Skin region may be detected by various color spaces like, RGB, NTSC, YCbCr, HSV, CMY, HIS, YUV, CIE-Lab etc[4]. To easily detect the skin color and non-skin color, YCbCr color model is widely used in the digital images and the videos. In the YCbCr, Y component stores the luminance information, whereas Cb and Cr stores color information as two color difference components. Cb is Blue difference chroma component whereas Cr is the red difference chroma component [5]. HSV (Hue Saturation Value) color space describes colors similar to how the human eye perceives the various color[6]. The CMY (Cyan Magenta Yellow) color space is one of the several color space used by people to select colors [7]. This subtractive color model is used in color printing, and is also used to describe the printing process itself.

### B. Template Matching Method

To find the similarity between the input images and the template images (training images) template matching methods is used. In this method the correlation between the input images and stored standard patterns in the whole face features is used, to determine the presence of a whole face features[8]. For both face detection and face locations this method can be used. A standard frontal face is used to locate the faces in the image. The template matching method has many advantages such as it is simple to implement the algorithm, and is easy to determine the facial part locations such as eyes, nose, mouth etc., depending on the correlation values. It can also be applied on many variations of the images. To achieve the shape and the scale invariance, Sub-templates, Multi-resolutions and Multi-scales have been used.

There are also some limitation of the existing face detection system using color based segmentation such as illumination intensity, skin color differs from one person to another belonging to different ethnic group and also camera characteristics like different types of cameras generate significantly different color values for the same person under the same lighting conditions [9].

For using color segmentation as well as half face template matching for face detection, we have to solve these problems. The proposed system is also robust towards changes in orientation of skin color and can tolerate occlusion well.

## III. PROPOSED WORK

The technique of proposed face detection mainly involves two steps, the first one is skin color modeling and half face template matching is the second one. As the first step of technique to eliminate all non-skin pixels from the image we do the skin color modeling. While in the second step to detect the human faces half face template matching is used. The flow chart of the proposed approach is given in figure 2.

### A. Skin Color Modeling

In order to detect skin region of an image for reducing the search space for the face we follow the first step of technique that is skin color modeling. To detect the skin region YCgCr color space is used in this paper.

1) **YCgCr Color Space:** In the image processing, YCbCr color model is widely used. In the color space, Y is termed as the luminance component, Cb is the blue difference chrominance and Cr is the red difference chrominance.

The color space YCgCr was derived from YCbCr color space. Considering the YCbCr color space, human skin color space is considered as practically independent on the luminance effect and concentrated in a small region of the Cb-Cr plane[8]. YCgCr color space also has these advantages and also in the clustering effect it stands better than the YCbCr color space. So, this paper model is built with YCgCr color space.

Y, Cb, Cr and Cg are defined as follow:

$$Y = k_r * R + k_g * G + k_b * B;$$

$$k_r + k_g + k_b = 1;$$

$$C_b = B - Y;$$

$$C_r = R - Y;$$

$$C_g = G - Y;$$

( $k_r$ ,  $k_g$  and  $k_b$  are weighting factors, according to ITU-R BT.601,  $k_b = 0.114$ ,  $k_r = 0.299$ )[2]

The thresholds value to extract the skin color regions[10]:

$$76 \leq C_g \leq 125$$

$$136 \leq C_r \leq 202$$

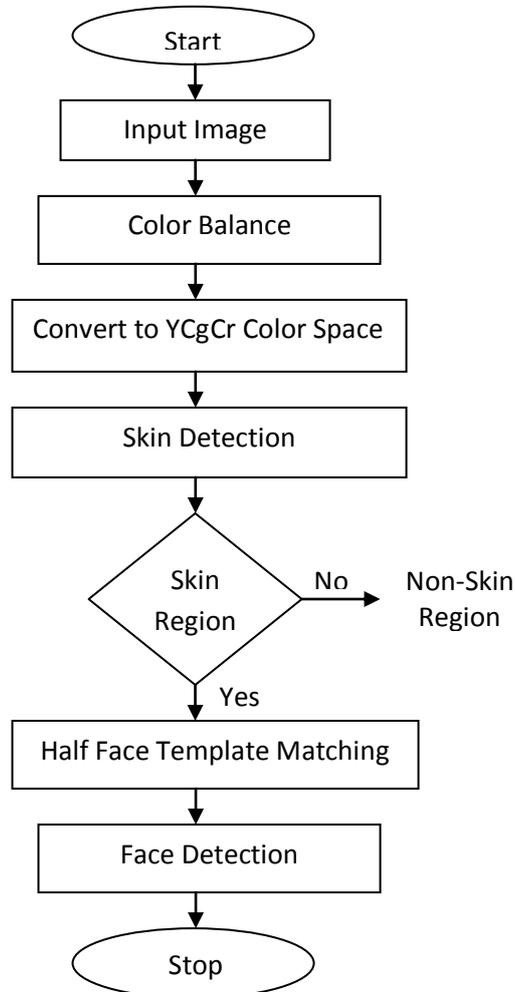


Fig 2: Flow Chart

The YCgCr color space is a variant of YCbCr color space that uses color difference (G-Y) rather than (B-Y). YCgCr color space may be derived from the YCbCr equations. YCgCr color space uses the below mentioned matrix expression[2]:

$$\begin{bmatrix} Y \\ C_g \\ C_r \end{bmatrix} = \begin{bmatrix} 16 \\ 128 \\ 128 \end{bmatrix} \begin{bmatrix} 65.481 & 128.553 & 24.966 \\ -81.085 & 112 & -30.915 \\ 112 & -93.786 & -18.214 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

In YCbCr color space, human skin color model is considered independent on the luminance and the skin color is coincide in the small region of Cb-Cr plane, this kind of virtue is also possessed by YCgCr color space. In Figure 3 distribution of skin color in Cg-Cr and Cb-Cr subspace; Cg-Cr subspace presents better clustering effect than that of Cb-Cr subspace[2].

Now according to features of RGB color components proportion: R>G>B in the skin region, so more accurate skin color information can be provided by Cg-Cr subspace.

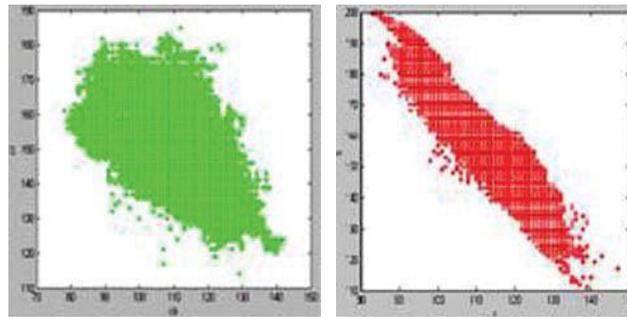


Fig 3: Skin color distribution in Cb-Cr(left) color space and Cg-Cr(right) color space[2]

**2) Gaussian Skin-Color Model:** To detect human skin regions from non-skin region based on color, a reliable skin color model is needed that is adaptable to the people of different lighting conditions and of different skin colors.

The distribution of skin colors of various people was found clustered in a small area of the chromatic color space. Although the skin colors of people changes in a wide range, they differ much less in color than in comparison to brightness. Or we can say that the skin colors of different people much close, but they differ mainly in intensities [1]

The color histogram shows that the distribution of various people's skin-color is clustered in the chromatic color space and a skin color distribution of human faces is represented by Gaussian distribution model (see Figure 4). In this work, each colorful image is converted into Cg-Cb color space, we get  $X=(Cg,Cb)^T$ ;  $m_x=E(X)$ ;

$$C_x = E [(X- m_x)(X-m_x)^T].$$

Where  $m_x$  is the mean, and  $C_x$  is the covariance matrix of  $x$ .

We now can obtain the likelihood of skin for any pixel of an image; the likelihood of skin for this pixel can then be computed as follows:

$$P(x) = \exp [-0.5(X-m_x)^T C_x^{-1}(X-m_x)] \quad [2]$$

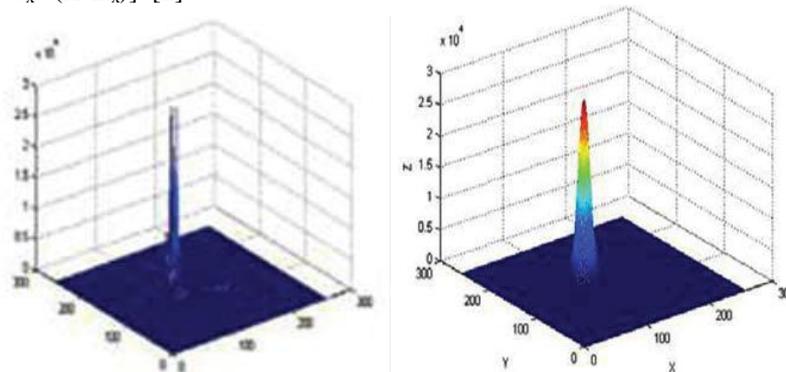


Figure 4: skin-color distribution and Gaussian distribution [1]

Thus, by using Gaussian skin-color model we can transform a color image into a gray scale image. With appropriate threshold, the gray scale images can further be transformed into a binary image that will show skin regions and the non-skin regions.

**3) Color Balancing:** Light in the image, also affect the skin color of the image, which may result into deviation from the real skin color. To avoid this we use lighting compensation algorithm known as Gray World Theory (GWT) [11] for the purpose of color correction in color images.  $R_{average}$ ,  $G_{average}$ ,  $B_{average}$  are the average of the each color channel.

$$\left\{ \begin{array}{l} R' = R * \left[ \frac{K}{R_{average}} \right] \\ G' = G * \left[ \frac{K}{G_{average}} \right] \\ B' = B * \left[ \frac{K}{B_{average}} \right] \\ K = \frac{(R_{average} + G_{average} + B_{average})}{3} \end{array} \right.$$

### B. Half Face Template Matching

Now the second step of the approach is half face template matching. In the face detection method which is based on template matching we choose full face feature as the matched template for the purpose of detecting faces, with this the burden of computing face search is relatively large[12]. However, most of the human faces are symmetry. So we will choose half of the full face-template to identify the faces that is choosing either the left half face of the image or the right half face for the template of face matching which will result in reducing the burden of computing face search.

**1) Face Template Constructing Method:** The effect of matching detection may also be affected by quality of template. To reduce the possibility of local density of the template, the template that is based on the information of

average face is constructed, like average face template and average eye template [3]. This is very easy method. At the instance of the affine transformation of the template, this will make face detection efficiency very demonstrable. The process for constructing obverse average face-template is given below[12]:

Step 1: Choose the obverse face images;

Step 2: In this step we determine the size of face area and also face area is selected;

Step 3: Normalize selected face areas into the same size;

Step 4: Compute the average value of every corresponding pixel of face area.

2) **Average Full Face Template Construction:** In the image given, the obverse face includes the feature organs like ear, eye, mouth, nose parts of cheek and so on. The basis for detecting the existence of face can be character of distribution of images. So the ears, eye, nose, mouth and parts of cheek of faces were selected as the main area for constructing the full face template[3].

3) **Average Half Face Template Construction:** The average frontal full face template may be regarded as combination of the almost the right face template and symmetrical left face template. So the obverse full face-template can be divided into the right face template and the left face template at the axis centre of symmetry.

Further, the average full face-template may also be used in constructing the average half face template, which may minimize the density of redundancy of the full face template. The density of the right and the left face are symmetrical in the perfect face-template, or we can say that, the pairs are equivalent[12]. In the practice, there is a little difference between the right and the left face in the face images, so the distribution of density between them is not completely symmetrical, hence the comparability is decreased. For example taking the left face, the left face can be detected first, during searching the face image with the average half face-template examine of whether there exists face image.

#### IV. RESULT AND DISCUSSION

The proposed face detection algorithm has been applied on a wide variety of images which are taken under different lighting conditions and also with the different backgrounds. The images taken also contain the skin areas from other parts of the body as well such as necks, hands and areas which color are very similar to that of skin color.

For evaluating the performance of the proposed system, the parameters that are taken into the consideration are number of photos, number of faces in the photo, total number of faces, number of hits and misses and also accuracy of face detection.



Fig 5.1: Image 1



Fig 5.2: Image 2



Fig 5.3: Image 3



Fig 5.4: Image 4



Fig 5.5: Image 5

Table 1: Performance Table

No. of Faces in Photo	No. of Photo	Total No. of Faces	No. of Hits	No. of Misses	Precision
1	10	10	10	0	100%
2	10	20	20	0	100%
3	10	30	26	4	86.66%
4	10	40	37	3	92.5%
More than 4	10	90	73	17	81.11%
Total	50	190	166	24	92.05%

Table 1 shows the performance evaluation of the proposed method and the overall accuracy is found out to be 92.05%.

## V. ADVANTAGES OF PROPOSED SYSTEM

The proposed system has below mentioned advantages:

- Fast face detection.
- Accurate face detection
- Reliable.
- High detection rate in Short processing time.
- Applicable on different types of images.

## VI. CONCLUSION AND FUTURE WORK

In this work, an efficient face detection method by using the skin color modeling and the half face template matching is implemented. In this skin color model using YCgCr color space, first detects the skin pixels of the input images. After that, the half face template-matching method is applied. The main advantage of this model is higher accuracy. Though, there are few cases of misses, the overall performance of the proposed algorithm is quite satisfactory. The results obtained by this proposed approach are very encouraging.

In future, we will work on improving this algorithm by combining it with other face detection algorithm in order to achieve better performance. The accuracy may also be increased by using complex geometrical features of face. This method can be also applied to other application like we can use it in the security field. Using this method can enhance the security system by detecting the faces and sending it securely to Security agencies that will help them in identifying the culprit.

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