



## An Efficient Architecture for Face Detection in Complex Images

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**Abstract** – In today's scenario security is very important issue in real life. Security is very much related with the biometric term. Face is one of the main features of biometric. So, this paper is related with the face detection only. In this paper, we address the problem of face detection in still images. We propose a fast algorithm for detecting human faces in colour images. The algorithm uses skin colour modelling in conjunction with half template matching to quickly locate faces in a given image. The proposed algorithm has been verified theoretically and is found to be quite satisfactory. This paper presents a new face detection method which combines the Skin Colour Detector and the Half Face Template Matching Method. First we can use the skin Colour Detector to find the faces. In the Skin Colour Detector, we can use the YCbCr model. The YCbCr model can be used to easily detect the Skin colour or Non-Skin colour in the images. But in the Skin Colour Detector, it can also detect the faces or some non-faces. Finally, we can use the Half Face Template Matching Method. This method is used to remove the non-faces and to detect the faces more accurately.

**Keywords**-Skin Colour Modelling, Template Matching, Color Model, Normalization, Chrominannce

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### I. INTRODUCTION

Face detection is an interesting and difficult task in computer vision area. This task is the first step in a large number of problems such as human face, face recognition or facial expression extraction, sex and race detection and searching and filtering image content on the web. All of these applications are based on the assumption that the areas of human skin are already detected and located [1]. Skin colour detection also used in many different applications in motion capture, HCI (human-computer interaction), access control, surveillance, and content-based image retrieval and indexing of image databases [2]. Our current study helps us to overcome well-known face detection challenges such as rotation invariance for variable face orientations, changeable lighting conditions, time complexity regarding template matching. The approaches developed for face patterns modelling can be divided in two major groups – the model-based approaches and the feature-based approaches. The first category assumes that a face can be represented as a whole unit. The methods in the second category treat face as a collection of discrete components with geometrical features (such as eyes, nose and mouth, for instance).

The faces are detected by using the extracted feature locations and topological relationships. Both categories have some disadvantages that are augmented by specifics of different application areas. They might be large search space, missing colour information, insufficient face geometry features etc. Colour is a powerful fundamental cue that can be used as the first step in the face detection process. Many researchers utilize skin colour models to locate potential face areas, and then examine the locations of faces by analysing each face candidate's shape and local geometric information such as eye and lip positions. From the analysis of existing face detection methods, we found that rotation invariant face detection has an important impact on speed, detection rate etc. An algorithm computational efficiency in term of time and storage is also a desired feature for face detection methods.

The proposed system is designed to overcome those drawbacks. Our proposed system uses skin colour model to reduce the search space. Orientation invariant threshold based on geometric model and improves system further. For reliable template matching, feature extraction and selection based on novel combination of geometric filter with SCM filter is introduced. Proposed system is composed of two major components: first, skin regions are segmented using skin colour model. In the second part, segmented regions are filtered using half face template matching. Fig. 1 illustrates generic model of face detection. In this paper, we have proposed a new method which is the combination of skin colour detector and half face template matching method. Related work is explained in section II. Proposed work is explained in section III. Experimental results are described in section IV. And finally, conclusions are given in section V.

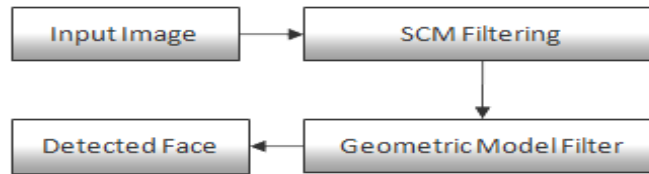


Fig. 1 Block diagram of the face detection system.

## II. RELATED WORKS

### A. Skin Colour Modelling

Colour is a powerful fundamental cue of human faces, distribution of skin colour clusters lay on a small region of the chromatic colour space [3, 4]. Skin colour can be used in the information of the facial features such as geometry, shape, etc. The skin colour detection is an important role in the face detection. It can be used to detect the skin region or non-skin region in the images. First we can choose the suitable colour spaces in the skin colour detection. There are various colour spaces such as, RGB (Red Green Blue), NTSC, YCbCr, HSV, CMY, HIS, YUV, CIE-Lab etc. In the NTSC colour space, the main advantages of this colour space are that grey-scale information is separate from colour data. It consists of three components such as luminance (Y), hue (I), and saturation (Q). The YCbCr colour space is widely used in the digital images and the digital videos. In the YCbCr, Y is the luminance information of the component, and colour information is stored as two colour difference components, Cb and Cr. Cb is the difference between the blue component and a reference value and Cr is the difference between the red component and a reference value.

The HSV (Hue Saturation Value) colour space is one of several colour systems used by people to select colours. The CMY (Cyan Magenta Yellow) colour space. The HSI (Hue Saturation Intensity) colour space, it is widely used in skin colour detection. YIQ and YUV are analog spaces, while YCbCr is a digital colour system [5].

### B. Template Matching Method

Template matching methods [6] that find the similarity between the input images and the template images (training images). Template matching method can use the correlation between the input images and stored standard patterns in the whole face features, to determine the presence of a whole face features. This method can be used for both face detection and face locations. In this method, a standard face (such as frontal) can be used. The advantages of this method are that it is very simple to implement the algorithm, and it is easily to determine the face locations such as nose, eyes, mouth etc., based on the correlation values. It can be apply on the various variations of the images such as pose, scale, and shape. Sub-templates, Multi-resolutions and Multi-scales have been proposed to achieve the shape and the scale invariance. Craw et al. presented a localization method based on a shape template of a frontal view face [7,8].

## III. PROPOSED WORKS

Proposed Face detection technique involves two steps namely skin colour modelling and half face template matching [9]. In the first step, skin colour modelling is performed to eliminate all non-skin pixels from the image. Second step employs an off-line created template to detect the face among the images of the skin colour images. Following subsections present the details of these steps.

### A. Skin Colour Modelling

The first step of the proposed technique is skin colour modelling which aims to detect skin regions in an image to reduce the search space for the face.

1) *Colour Model:* In order to segment human skin regions from non-skin regions based on colour, it is important to have a reliable skin colour model that is adaptable to different skin colour and different lighting conditions. The common RGB representation of colour images is not suitable for characterizing skin-color. In the RGB space, the triple component (R, G and B) represents not only colour but also luminance. Luminance may vary across a person's face due to the ambient lighting and is not a reliable measure in separating skin from non-skin region. Luminance can be removed from the colour representation in the chromatic colour space. Chromatic colours, also known as "pure" colours in the absence of luminance, are defined by a normalization process shown below:

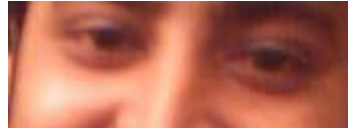
$$r = R/(R+G+B) \quad (1)$$

$$b = B/(R+G+B) \quad (2)$$

Colour green is redundant after the normalization because  $r + g + b = 1$ . If two points P1  $[r_1, g_1, b_1]$  and P2  $[r_2, g_2, b_2]$ , are proportional, then.

$$(r_1/r_2) = (g_1/g_2) = (b_1/b_2) \quad (3)$$

Then, P1 and P2 have the same colour but different brightness. Chromatic colours have been effectively used to segment colour images in many applications. They are also well suited to segment skin regions from non-skin regions. The colour distribution of skin colours of different people was found to be clustered in a small area of the chromatic colour space. Skin colours of different people are very close, but they differ mainly in intensities, this gives us basis to proceed to develop a skin-color model in the chromatic colour space. Figure 2(a) and 2(b) illustrate the training process, in which a skin-color region is selected and its RGB representation is stored.



(a)



(b)

Fig. 2 (a) Selected skin region in RGB image, (b) Selected skin in Chromatic Colour

The colour histogram as shown in fig. 3 revealed that the distribution of skin-color of different people is clustered in the chromatic colour space and a skin colour distribution can be represented by a Gaussian model  $N(m, C)$

$$\text{Mean}, m = E\{x\} [x = (rb)T] \quad (4)$$

With this Gaussian fitted skin colour model [10], we can now obtain the likelihood of skin for any pixel of an image. This skin colour model can transform a colour image into a grey scale image such that the grey value at each pixel shows the likelihood of the pixel belonging to the skin. Using appropriate threshold value, the grey scale images can then be further transformed to binary images showing skin regions and non-skin regions.

2) *Skin Region Segmentation:* Our main goal in this segmentation process is to remove the background of the image from skin regions using previously discussed skin colour model. First, input image is converted to chromatic colour space. Using Gaussian model, a grey scale image of skin likelihood pixels is constructed and skin pixels have some set of constant values for each r, g and b component. Every pixel in normalized image has three values and they are normalized-red, normalized-green and normalized-blue. Segmentation process extracts these normalized components and constructs two images. Each of these images is converted into black and white image by applying different threshold for normalized input image such that  $r = 0.38-0.52$  and  $g = 0.23- 0.34$ . Finally, we perform an 'AND' operation between these two black and white images where white pixels are skin and blacks are non skin pixel.

In this approach, due to noise and distortion in input image, colour information of some skin pixels acts like non skin region and generate non contiguous skin colour region. To solve this problem, first morphological closing operator is used to obtain skin-color blobs. Boundaries of skin-color regions are determined using a region growing algorithm in the binary image. Regions with size less than 100 pixels of image size are eliminated. At the end of segmentation process black and white skin region image is multiplied by the original grey scale image and we then just get the skin region. Fig. 4 illustrates a simple block diagram for segmentation process.

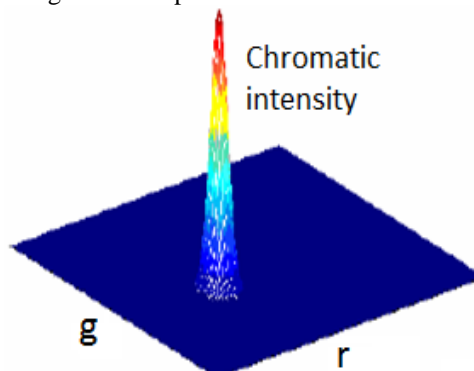


Fig. 3 Gaussian distribution for skin colour pixels, X and Y-axis are the chromatic r and g respectively. Y-axis defines the chromatic intensity values that fit the Gaussian model for skin colour pixels.

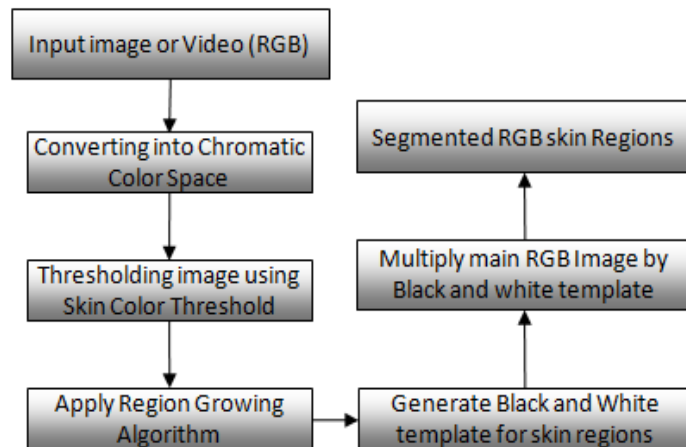


Fig. 4 Block diagram for skin region segmentation.

Figure 5 shows the outcome of skin colour modelling

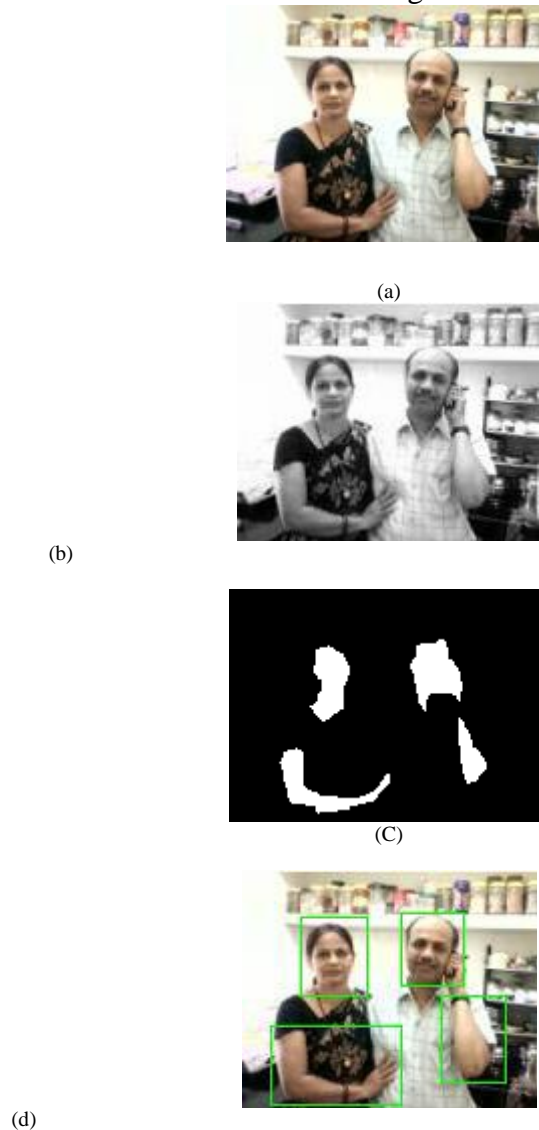


Fig. 5 Outcome of skin colour modelling

### B. Half Face Template Matching

The second step is half face template matching. The face detection method based on template matching chooses full face feature as the matched template, with which the burden of computing of face search is relatively large. However, most human faces are symmetry obviously. So we can choose half of the full face-template that is choosing the left half face or the right half face as the template of face matching which can reduce the burden of computing of face search.

1) *Face Template Constructing Method:* The quality of template immediate influences the effect of matching detection. To reduce the chanciness of local density of the template, the template based on the information of average face is constructed, such as average eye template and average face template. This method is very easy. At the instance of the affine transformation of the template, the face detection efficiency will be very certifiable. The process of constructing obverse average face-template as follows:

Step1 Choose the observe face images;

Step2 Determine the size of face area and select face area;

Step3 Normalize selected face areas into the same size;

Step4 Compute the average value of every corresponding pixel of face area.

2) *Average Full Face Template Construction:* In the situation that the distance between the face and the camera is fixed and the angle of air scape is  $15^\circ$ , 120 face images are sampled at the angle of obverse, left side  $30^\circ$  and  $45^\circ$ . For each angle, there are 40 images, and the number of the face image with and without cap are both 20. The sampled images are shown as fig. 6, obverse  $30^\circ$  from the left side  $45^\circ$  from the left side.

In the image, the obverse face includes the feature organs like eye, ear, nose, mouth, part of cheek and so on. The character of distribution of these images can be the basis for detecting the existence of face. So the eyes, ears, noses, mouths and part of cheek were selected as the main area of constructing the full face-template. This method can rule out the influence of abnormality area and the non-human ontic feature ones, like cap, beard and so on. 16 face images were sampled manually. The size of each image is  $22 \times 26$  pixels. As a comparison experiment, template must not only match the obverse images, but also the side ones. So the template could not be too wide. The obverse template is primarily representation, so the obverse average full face-template was just constructed.



30 degree from left side



45 degree from left side

Fig. 6 Face images at different angle

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

Furthermore, the average half face-template can be constructed based on the average full face-template, which can reduce the symmetry redundancy of density in the full face-template. The density of the left face and the right one are symmetrical in the perfect face-template, in other words, they are comparability pairs. In the practice, there is a little difference between the left face and the right one in the face images, and the distribution of density of them is not a fully symmetrical scene, so the comparability is decreased. Taking the left face for example, the left face can be detected at first, when searching the face image with the average half face-template examine whether there exists face image.

## IV. CONCLUSIONS

In this paper, an efficient face detection method using the fusion of skin colour modelling and the half face template matching method. The skin colour modelling is to detect the skin pixels which detect the faces or non-faces in the input images. To reduce the non-faces in the detection, we have used the skin colour data. And finally, we have applied the half face template-matching method. The main advantage of the proposed model is higher accuracy within a short span of time. In future we are going to use one or more colour spaces in the skin colour detector. Also we can find which combination of colour spaces gives the best performance.

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