A Novel Approach to Face Detection using Blob Analysis Technique

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Abstract: A first step of any face processing system is detecting the locations in images where faces are present. Face detection is one of the challenging problems in the image processing because of variation in scale of the image, location, orientation, pose (frontal, side-view), facial expression, occlusion and lighting condition present which may change the overall appearance of faces in the image. A novel approach to detect faces in a still image is presented here. This method is based on Blob analysis to detect presence of face from an still color image after segmentation with chromatic rules using YCbCr color space, as HSV color components gives lower reliability in complex background and RGB components suffers with changes in the lightning conditions. During blob analysis, the width to height ratio of human face as well as the eccentricity of the blob is taken under consideration. This technique provides good results in single upright frontal face based still color image.

Keywords: Face processing system, Face detection, Image processing, Blobs, YCbCr color space, HSV color space, RGB color space

1. Introduction

With the advancement of new era of Information Technology, more effective and friendly techniques for human-computer interaction are being developed. Moreover with the ever decreasing price of the coupling of computing system with the video Image acquisition techniques imply that computer vision system can be deployed in desktop and embedded systems. This further ignited the research in the field of face processing systems. Many research demonstrations and commercial application have been developed in this way.

Color is known to be a useful cue to extract skin regions, and it is only available in color images. This allows easy face localization of potential facial regions without any consideration of its texture and geometrical properties.

The Chromatic rules are generally defined using RGB, HSV and YCbCr color space. One of the major questions in using skin color in skin detection is how to choose a suitable color space. A wide variety of different color spaces has been applied to the problem of skin color modeling. Monge et al [1] in their review on popular color spaces and their properties, it is observed that for real world applications and dynamic scenes, color spaces that separate the chrominance and luminance components of color are typically preferable. The main reason for this is that chrominance-dependent components of color increased the robustness to illumination changes in the color images. HSV seems to be a good alternative, but HSV family presents lower reliability when the scenes are complex and they contain similar colors such as wood textures [2].

Moreover during the image acquisition, camera provides RGB image directly, so choice between RGB and YCbCr color comes here. RGB components are subject to the lighting conditions thus the face detection may fail if the lighting condition changes. So YCbCr color space is used here for skin color detection.

From the detected skin region the region of interest have been found and blob are been detected. It is found that the human faces are generally oval in shape and they are satisfying a particular range of eccentricity and width-height ratio. Here in this paper we have presented the face detection using these unique features to detect presence of face in a single upright frontal still color image.

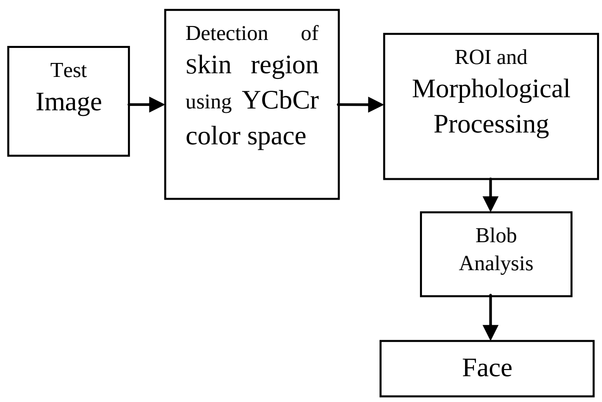


Figure 1. The proposed Face Detection System

2. Face Detection Algorithm

The proposed face detection system shown in Figure-1 consists of following categories; Detection of Skin-region using YCbCr color space. Extraction of Region of Interests (ROI), Classification of face region using blob analysis technique.

2.1. Detection of Skin-region using YCbCr color space

Color is a prominent feature of human faces. Using skin color as a primitive feature for detecting face regions has several advantages. In particular, processing color is much faster than processing other facial features. Furthermore, color information is invariant against scaling, rotations, translation and skewing. However, even under a fixed ambient lighting, people have different skin color appearance. In order to effectively exploit skin color for face detection, we need to find a feature space, in which human skin colors cluster tightly together and reside remotely to background colors.

Rowley et al [3], Hunke [4] , Esteki [5]and Hsu et al [6] have stated different techniques for locating skin color regions in the still color images.

While the input color image is typically in the RGB format, these techniques usually use color components in the color space, such as the HSV or YIQ formats. That is because RGB components are subject to the lighting conditions thus the face detection may fail if the lighting condition changes.
Peer et al [7] designed a set of rules to cluster skin regions in RGB color spaceMoreover since the reliability of HSV components become poorer with the increase in background complexity [2]. Thus this project used YCbCr components and as it is one of the existing Matlab functions thus would save the computation time. Rahman et al [8] and Sabottka et al [9] also observed that the varying intensity value of Y(Luminance) does not alter the skin color

Figure 2. The Original Test Image

distribution in the Cb-Cr subspace. In the YCbCr color space, the luminance information is contained in Y component and the chrominance information is in Cb and Cr.

Therefore, the luminance information can be easily de-embedded. The RGB components were converted to the YCbCr components using the following formula.

$$\begin{aligned} Y &= 0.299R + 0.587G + 0.114B \\ Cb &= -0.169R - 0.332G + 0.500B \\ Cr &= 0.500R - 0.419G - 0.081B \end{aligned} \quad (1)$$

To design a skin detector which is used as the basis for skin-like region segmentation, skin samples from 60 training faces(male as well as female) are used.
These samples are cropped into same size (15x15 pixels) and are filtered using a low-pass filter to reduce the effect of noise in the samples. Cb and Cr components of each sample are calculated. Then mean and covariance values are obtained from these Cb and Cr values.

$$\text{Mean, } m=E(x) \text{ where } x=(Cr, Cb)T \quad (2)$$
$$\text{Covariance, } C= E((x-m)(x-m)T)$$

The original Test image which is in RGB format is converted into YCbCr according to relation (1).Then the likelihood of skin for each pixel is computed using the relation given below [10];

$$\text{Likelihood}=P(Cr, Cb)=\exp[-0.5(x-m)T\ C^{-1}(x-m)] \quad (3)$$

Since people with different skin have different likelihood, so to improve the reliability of skin-detector adaptive thresholding process is used to achieve optimal threshold value for each run.

This adaptive thresholding is based on the observation that stepping the threshold value down may increase the segmented region. The threshold value at which the minimum increase in region size is observed while stepping down the threshold value is the optimal threshold. Here we have

Figure 3. The Skin likelihood Image

decremented the threshold value from 0.67 to 0.05 in steps of 0.1. Using the above procedure skin-like regions (Figure-3) are detected from the original image (Figure-2).

Now the next section will describe the steps for processing the image obtained in Figure (3) in order to obtain the Region of Interest (ROI) of possible skin areas in a test image .

2.2. Extraction of Region of Interests (ROIs)

The importance of region of interest (ROI) is to highlight the area for processing and differentiate it from the rest of the image. All the pixel values which have likelihood values higher than optimal threshold value are set to 1 and the rest of pixels are set to 0. Thus resulting a binary image.

After getting a binary image, morphological operations [11] such as filling, erosion and dilation are applied to separate skin areas which are loosely connected to obtain the region of interest shown in figure(4). Morphological erosion and dilation are applied by using structural element disk of size 8. Then the images are extracted from the ROI shown in figure(5).

Figure 4. The Region of Interests (ROIs)

Figure 5. Extracted Images according to Defined ROIs

2.3. Classification using Blob Analysis Technique

Human faces are generally oval in shape. The analysis of the characteristics of this oval shape provides the cue for the presence of face.

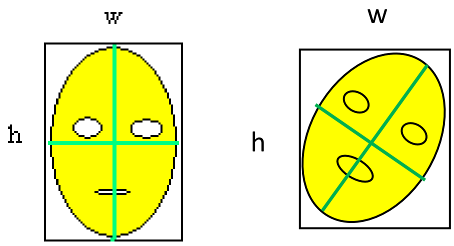


Figure 6. Oval shape characteristics of human face

The oval shape geometry shown in figure(6) provided two shorts of important parameter i.e the boundingbox ratio and eccentricity to examine and classify the shape of detected skin region as a 'face' or 'non-face'.

Each detected skin region can be made bounded by a box. The boundingbox ratio can be defined as the ratio of the width(w) to height(h) of the box encompass the region. After experimenting with 35 numbers of face regions and 55 numbers of non-face regions, it has been found that the ratio generally lies between 1.0 to 0.4. Face regions are generally having ratio less than 1 but value less than 0.4 indicates the presence of non-face region.

Again the oval nature of the face provides another parametet i.e eccentricity which is the ratio of the length of minor axis to the major axis. These axis are shown in the figure(6) with green color line segment. Eccentricity property is more sensitive to the oval shape geometry for characterization. On experimenting again with the same numbers of face and non-face regions. It has found that the eccentricity value lies between 0.3 to 0.9 provides good classification between face and non-face.

Figure 7. The detected face region

On applying both the rules simultaneously on the extracted skin regions shown in figure (5), successfully the face region is detected shown in figure (7).

3. Experimental Results

Unlike in face recognition where the classes to be discriminated are different faces, in face detection the two classes are "face area" and "non-face area".

This face detection system was implemented using MATLAB 7.0 on a Intel Core2Duo processor with 2GB RAM.

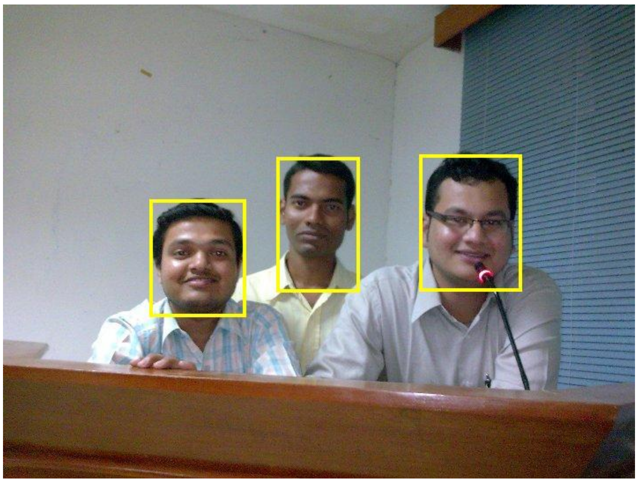
The proposed Blob analysis technique along with YCbCr adaptive segmentation technique was experimented with 65 number of color images having 135 faces and 210 non-faces.

The performance of the system was evaluated with the parameter i.e successful detection rate(SDR), which has been defined as the percentage ratio of the successful detected faces to the total number of faces.

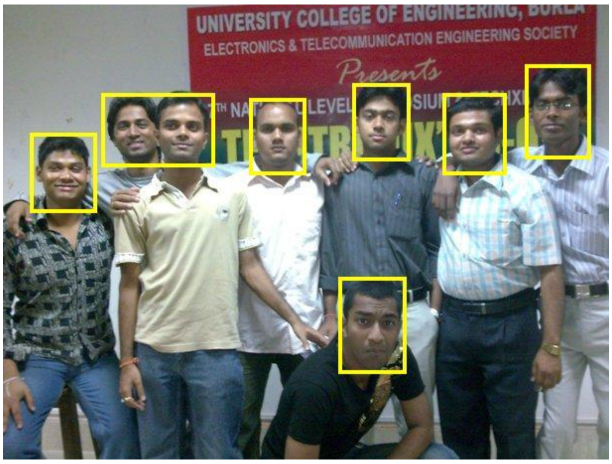
$$SDR = \frac{\text{Sucessfully detected faces}}{\text{Total number of faces}} \times 100\,\% \quad (4)$$

The proposed face detection system achieved a good detection rate of 95.6% by detecting successfully 129 faces out of 135.

(a) (b)



(c)



(d)

Figure 8. Detected Face images

4. Conclusion

This paper presents in detail the application of YCbCr color space and Blob analysis technique with necessary image processing procedures to detect the presence of human faces in color images.

In face detection system because of the different illumination conditions and variety of positions of the face in the image, detecting a face becomes a tedious task.

The problem of illumination can be more accurately solved using these YCbCr color space by carefully choosing threshold range for skin color detection.

In future work the problem relating to occlusion of face in an image can be removed by refine use of Morpholgical operations on the extracted blob regions.

Moreover, it can become an efficient pre-processing step of a face recognition system , as the falsely detected faces can be easily eliminated out using correspondence with the database of already known faces as used in recognition system.

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