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Face Detection using Convex Hull

Kanaka Sunanda Vemulapalli[#1], Kartheek Chintalapati[#1], SatyanarayanaPenke[*2]

[1]*Department of Electronics and Communication Engineering,*
K L University, Green Fields, Vaddeswaram, Guntur (Dist.), Andhra Pradesh-522 502, India. Phone: 08645-246948
kanakasunandav@gmail.com, carteak004@gmail.com
2Faculty in the Department of Electronics and Communication Engineering,
K L University, Green Fields, Vaddeswaram, Guntur (Dist.), Andhra Pradesh- 522 502, India. Phone: 08645-246948
satece@kluniversity.in

Abstract
A Face Detection System is a software application used to detect face(s) in a still image. This paper presents a simple humanface detection algorithm that uses skin color analysis. Face detection in real time may become complex because of the background and light intensity variations. In this paper, we used the convex hull process to complete the process of face detection. The algorithm is tested on different sequences of images and results are presented.

Keywords: Face Detection, Skin Color Analysis, Convex Hull, Image Segmentation, Centroid

I. INTRODUCTION

Face detection is a computer vision technology that detects the face(s) in any given image subjected to certain constraints depending on the algorithm used. Face detection becomes more challenging in real time because of various constraints such as light intensity, complex backgrounds, etc. With the advancements in technology, more robust algorithms have been developed for human face detection that efficiently detects human faces even in complex backgrounds and in real time[1].

Various techniques have been proposed for face detection under controlled as well as un-controlled environments [1].Chen [2] implementedthe plane shift object tracking system. One of the most successful face detection methods is Viola's frameworkdeveloped by Viola and Jones [3] fromLienhart [4]. Viola's framework used a set of Haar-like features in which each feature was described by the template.Bradski [5] proposed the continuously adaptive mean shift algorithm. To track the face, Maurer [6] used feature points on the face whereas Tsuhan Chen [7] used the method based on Statistical Color Modeling and the deformable template. All these algorithms have their own advantages and limitations as well.

One more thing that is to be taken under consideration is the color space. In this paper, we have used camera that produces True color RGB images for detection. Some of the most used color formats for image processing are RGB, HSV, Grey Scale, Binary and YC_bC_r. In this paper, we have used the HSV format of the image and convex hull process for robust detection.

The paper is totally organized into four sections. Section IIgives a good idea about the concepts used and the step by step procedure followed in the paper. Then, Section IIIpresents experimental results and discussions. Finally, conclusions were written under Section IV.

II. METHODOLOGY

A. *Software Description:*

The Software used is MATLAB R2013a. MATLAB is a high-level language.Also, it is an interactive environment for numerical computation, visualisation and programming developed by MATHWORKS. MATLAB can be used to analyse data, develop algorithms, and create models and applications.

MATLAB has a variety of Toolboxes which are application specific. This paper made use of Image Acquisition toolbox for acquiring images, Image Processing toolbox to process images and Computer Vision System Toolbox for video processing.

B. *Skin Color Analysis:*

Detection of Human faces in a still image can be doneusing different methodologies which can be classified as feature-based detection, appearance-based detection and color-based detection. Feature based detection detects human face using facial features such as nose and eyes or a combination of them. Appearance based detection learn from a set of training images and finds relevant characteristics using machine learning algorithms and statistical relations. Color based detection is a computationally efficient process which is best suited for applications requiring low computational efforts. Many recent papers have also proposed Skin color based detection.

Detection of skin color is one of the widely used techniques for detecting the human face. Though the captured image is in RGB color space, it is usually straightforward and requires high bandwidth compared to other formats. It is also noisy and not the best mapping for representing visual perception. YUV color-space is more efficient in codingand reduces the Bandwidth more than RGB capture can. HSV can separate the chroma, color information and luma, image intensity components which is essential for robustness to lighting changes or removing shadows.

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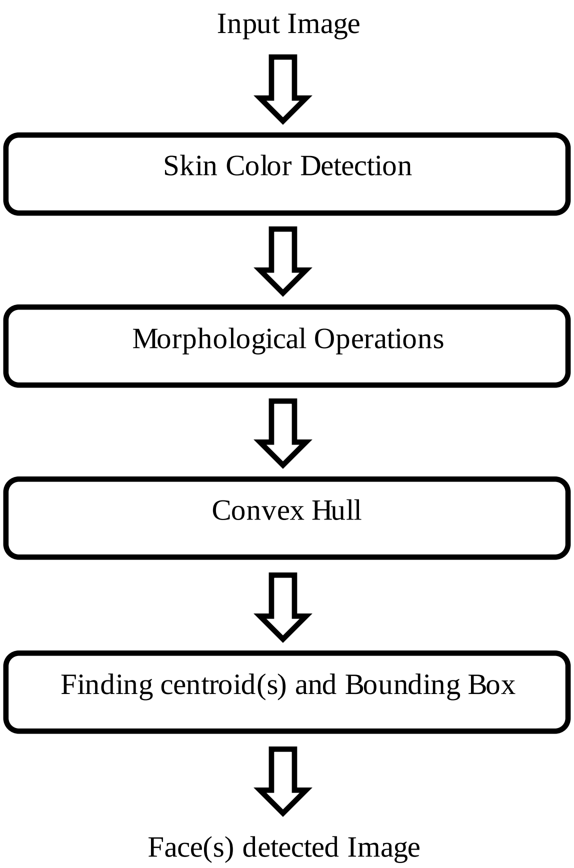
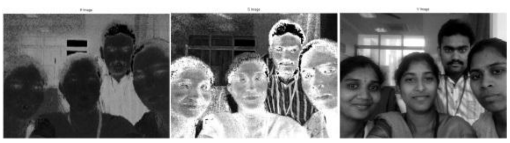


Fig 1. Algorithm for Face Detection

As an initial step, the image is converted into HSV [8]and YC_rC_b[9] formats and the range of H,S, V, Y, C_r and $C_b$values for face(s) are noted down. The ranges considered in this paper are:

Table 1. Threshold Ranges of Skin for different components

Component	MinimumValue	Maximum Value
H	0.01	0.20
S	0.18	0.97
V	0.08	0.55
Y	10	250
Cb	90	135
Cr	135	170



(a) **(b)** **(c)**

(d) **(e)** **(f)**

Fig 2. a) H-Image, b) S-Image, c) V-Image d) Y-Image, e) C_b- Image, f) C_r-Image

From Table 1, it was observed that H alone is sufficient for detectingthe human skinin the image.

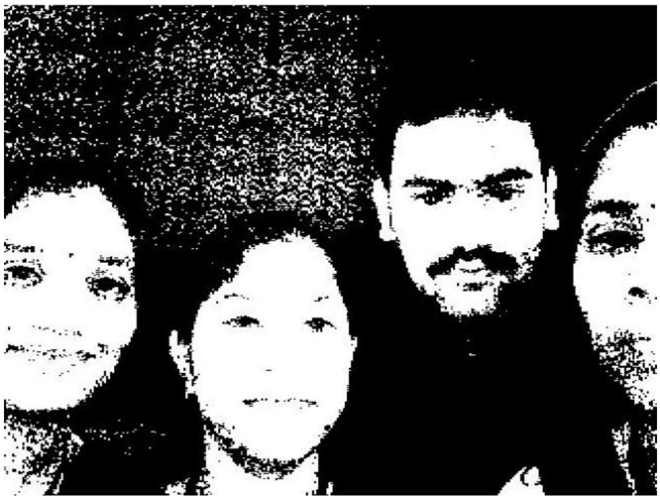


Fig 3. Raw Segmentation Result

C. Morphological Operations:

The result of Skin color segmentation is noisy. In order to remove the unnecessary background components, we perform some morphological operations on the image such as erosion, dilation, opening and filling. These operations can be done using a desired structuring element. The structuring element can be a rectangle, a disk, a line or even a diamond. Square is used as the structuring element used in this paper.

Erosion shrinks objects in a binary image. Output after erosion is 1 at locations of origin where the structural element fits exactly into foreground. The eroded image g obtained by the erosion of an image f by a structuring element s is defined as

$$g = f \ominus s \qquad (1)$$

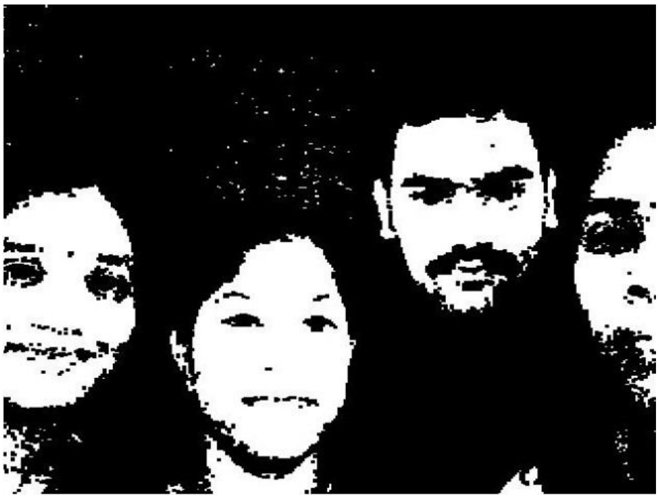


Fig 4. Eroded Result

Dilation grows objects in a binary image. Output after dilation is 1 at locations of origin of structuring element such that it overlaps at least one 1 valued pixel in input image. The dilated image g obtained bydilating an image $f$with a structuring element $s$is defined as

$$g = f \oplus s \quad (2)$$

Morphological opening removes small islands and breaks thin connections. Morphological closing smooth the objectcontours.
If A and B are the image and the structuring element respectively, then opening of $A$by $B$is represented as

$$A \quad B = (A \ominus B) \oplus B \quad (3)$$

and the closing can be represented as

$$A\, B = (A \oplus B) \ominus B \quad (4)$$

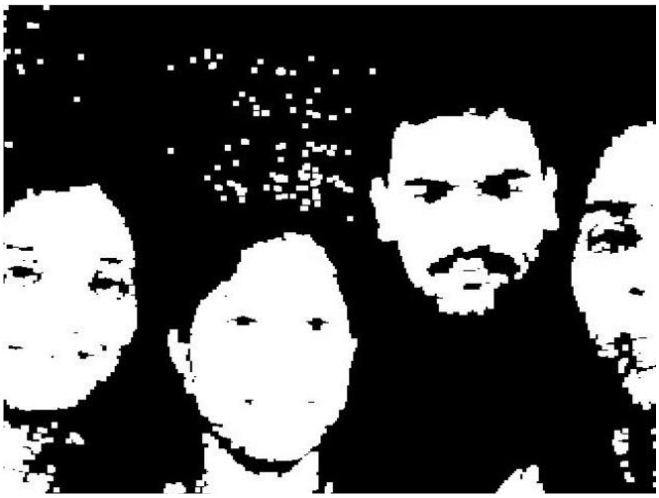


Fig 5.Result after Morphological Operations

Multiple dilation and erosion operations yielded more accurate results than one time dilation and erosion operation.

D. Convex Hull:

An image even after morphological processing may look unjoined. In order to join the connected blocks of an image, we use the convex hull process [8]. If for any two points of a shape, the whole connecting line segment is also a part of the shape, then the points are said to be convex. The convex hull for any subset of the plane is the smallest convex set that contains the subset.

Fig 5. Convex Hull Result

Even after applying Convex Hull on the dilated image, there will be some portions of the image which are not faces. To eliminate non-faces in the image, the image will be thresholded again with the following criteria: Segments with anarea larger than or equal to 26% of the largest segment area will be considered foreground and rest as background.

Fig 6. Final result after re-thresholding

E. Finding Centroid and Bounding Box:

The result of the above process is an image with hulls at the point(s) of detection of faces. In order to track these faces, we find the centroids for each hull. Centroid here refers to the center of mass of the hull.

Bounding box is the smallest rectangle containing the region or hull in this case. Bounding boxes are generally drawn for easy understanding of the observer.

The centroid(s) detected in the image are represented with a blue star.

III. EXPERIMENTAL RESULTS

(a) (b)

Fig 7. (a), (b) Final results with detected faces

IV. CONCLUSIONS

From the experimental results, it can be clearly shown that real time face detection algorithm was successfully tested on a series of images taken in real time. This system uses convex hull for face detection, which is a robust technique and produces results with an efficiency of 80%. Since the experiments were conducted in real-time, there were many obstacles such as occlusions, varying brightness levels,etc…

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