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Comparison of two different approaches for multiple face detection in color images

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Abstract: Human face detection has become a major field of interest in current research because there is no deterministic algorithm to find multiple faces in a given image. In this paper, the performance comparison has been made of two different algorithms for multiple face detection in color images. First algorithm combines HSI and YCbCr color models along with morphological operations. In the second algorithm, RGB color model with Viola-Jones algorithm is used. After making comparison, it is found that; first algorithm gives better detection accuracy (91%) as compared to the second method (88%). But, first algorithm requires more processing time which is matter of concerned in real-time face detection. The average processing time required for first algorithm is about 6.3sec, whereas for second algorithm it is 5.1sec.

Keywords: Color models, Multiple Face Detection, Morphological Operations, Viola Jones

1. INTRODUCTION

Face detection demand is growing with a rapid speed because of its vast application in the field of computer vision. The multiple face detection can be applied to check the status of various facial features of all the persons while taking a group photograph. In "Segmentation Algorithm for Multiple Face Detection for Color Images with Skin Tone Regions"[14] the author find multiple faces in an images but not defined properly the accuracy and processing time for multiple faces. In"Efficient Eyes and mouth detection algorithm using combination of Viola-Jones and skin color pixel detection"[16] the author described good accuracy for single face detection but have not been tested for multiple faces. For detecting face there are various algorithms including skin color based algorithms. Color is an important feature of human face [38]. Color processing is much faster than other facial features. Apart from this face detection also has potential applications in

- Human-Computer Interface
- Surveillance Systems
- Webcam based energy/power saver
- Photography[22]

Fig: 1 shows the system overview of the proposed face detection system, which consists of various detection stages. This research is basically on multiple face detection in color images. In this research, two methods are applied for this purpose and their accuracy and processing time is compared.
These methods are cited as follows:

Phase 1:

a. Implementation of two color models (HSI and YCbCr) for skin detection
b. Applying morphological operations to remove small blobs and enhance face area.
c. Applying face detection rules for locating faces in the image.

Phase 2:
Implementation of RGB color model for skin detection. Applying Viola-Jones method for face detection.

Phase 3:
Comparison of accuracy and processing time of methods used in phase 1 and phase 2.

2. SYSTEM OVERVIEW

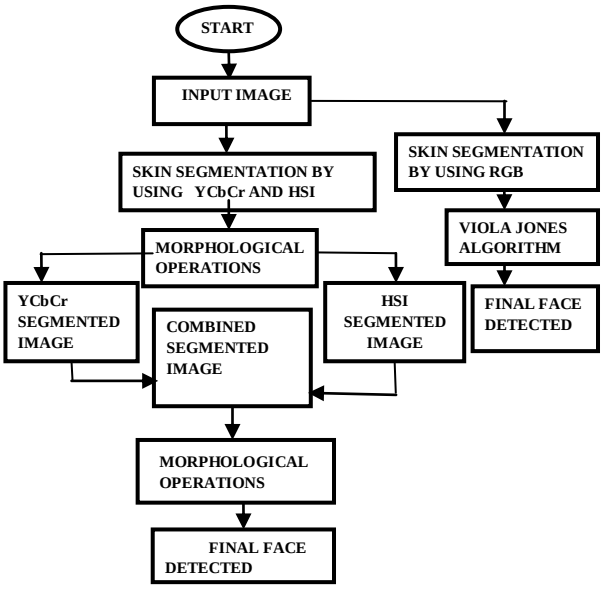

Figure1: Overview of Face detection Process

3. COLOR MODEL

For skin based face detection many color spaces have been proposed throughout the literature. Some popular examples of color spaces are: RGB, YCbCr (YUV), HSI(Hue, Saturation and Intensity) as well as many others.

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a) RGB Colour Space In order to detect skin color following set of rules have been found to be more accurate than other models[3,5].

(R>95) AND (G>40) AND (B>20) AND
(max –min > 15) AND (|R-G|> 15) AND (R>G) AND (R>B) AND (R>220) AND (G>210) AND (B>170) AND (R>B) AND (G>B)

b) HSI,HSV,HSL(Hue,Saturation,Intensity,Value ,Lightness)

Hue-saturation based colorspaces were introduced when there was a need for the user to specify color numerically.It describe color with intuitive values, based on the artist's idea of tint, saturation and tone.Hue defines the dominant color (such as red, green, purple and yellow) of an area , saturation measures the colorfulness of an area in proportion brightness.The "intensity","lightness" or "value" is to the color luminance[3,9,5]. The intuitiveness of colorspace components and explicit discrimination between luminance and chrominance properties made these colorspaces popular in the works on skin color segmentation. The most noticeable range which was used by algorithm to detect the skin for H value is:

$$0.05 < H < 0.07$$

c) YCbCr Colour Space

This colour space has been defined to meet the increasing demand of digital algorithms in handling video information and has become the widely used in digital videos. It has three components, two is of chrominance and one is of luminance[3,11].

$$Y > 80$$
$$90 < Cb < 130$$
$$137 Cr < 177$$

4. SEGMENTATION

Segmentation process of subdividing an image into constituents objects. The objective of segmentation is to change or modify the representation of the image into meaningful and simplified way (easy to analyzed)[14].In the problem of face detection, skin segmentation helps in identifying the probable regions containing the faces as all skin segmented regions are not face regions and aids in reducing the search space[19,21]. Segmentation of an image based on human skin chromaticity using different colour spaces results in identifying even pseudo skin like regions as skin regions. Hence there is a need for further eliminating these pseudo skin regions. After skin like pixels detection convert the segmented image into binary form. The binary image contains skin regions, but don't know that, where is human face in segmented image. Work of next step is to remove non human face skin area from segmented image, by using morphological operations [39].

5. MORPHOLOGICAL OPERATIONS

The color segmentation generates a binary mask with the same size of the original image. However some regions similar to skin also appear white: pseudo color pixels like clothes, floors,building etc. [4,5].In addition, pseudo-skin pixels are scattered and generate hundreds of connected components. After color segmentation the left over noise in the background can smoothened using morphological processing. Hence the open (erode followed by dilate) operation was performed using a structuring element[28].It was observed that the open operation has resulted in huge reduction in the number of small noisy specs. Erode shrinks the selected area and expands the background, whereas dilate operation does the reverse of this[5,19].

6. VIOLA-JONES

Viola-Jones technique is based on exploring the input image by means of sub window capable of detecting features. This window is scaled to detect faces of different sizes in the image. Viola Jones developed a scale invariant detector which runs through the image many times, each time with different size[18,24].The system architecture of Viola Jones is based on a cascade of detectors. The first stages consist of simple detectors which eliminates only those windows which do not contain faces [16].These detectors constructed from integral image and Haar like features shown in figure.

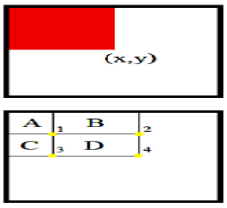

Figure 2. Integral image construction[16]

The first step of this algorithm is to convert the input image into an integral image. This is done by making each pixel equal to the entire sum of all pixels above and to the left of the concerned pixel. By doing so, sum of all pixels inside any given rectangle can be calculated using only four values.

Sum of the rectangle ABCD = D - (B + C) + A

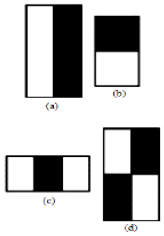

Figure 3. Viola Jones Haar like features[16]

The face detector in Viola Jones method analyzes a sub-window using features. These features consist of two or more rectangles. Each feature gives a single resultant value which is calculated by subtracting the sum of the white rectangle(s) from the sum of the black rectangle(s) [16]. Different types of features are shown in Figure 3. Viola and Jones used a simple classifier built from computationally efficient features using adaboost for feature selection. Adaboost is a machine learning boosting algorithm that constructs strong classifier through a weighted combination of weak classifiers[37].The detector detects the non face area in an image and discards that area which results in detection of face area. To discard non face

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area Viola Jones take advantage of cascading[25,26]. Final stage is considered to have a high percentage of face objects.

7.PROPOSED APPROACH

The our design consists of three phases. In phase one color model and morphological operations is used for multiple face detection. In second phase skin color pixel detection is used to extract all the entire skin color pixels from the image. Once they are extracted Viola Jones is applied to detect face. This increases efficiency of Viola Jones techniques and decreases processing time. In third phase compare the parameters ie. Accuracy and processing time of these two algorithms.

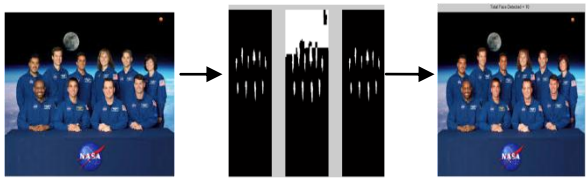
(a)Color Models and Morphological Operations: In this step a combination of colour spaces to identify the skin pixels for good segmentation is used.As all the skin segmented regions are not face regions, each segmented region is passed through a face classification algorithm to check whether the segmented region is face or not.

Step-1: The input image is skin segmented first using YCbCr color space. On this skin segmented regions various morphological operations such as erosion and dilation is carried out. Here set the value of dilate is 3 and to remove unwanted noise set the area of blobs is 62.It removes all objects in an image containing fewer than 62 pixels.This value set by hit and trial method.

Step-2: The input image is also skin segmented using HSI colour space. On this skin segmented regions various morphological operations such as erosion and dilation are carried out. Here set the value of dilate is 2 and to remove unwanted noise set the area of blobs is 50. It removes all objects in an image containing fewer than 50 pixels. This value set by hit and trial method.

Step-3: Segmented images obtained in Step-1 and Step-2 is combined into single segmented image by using AND operation.On this segmented regions various morphological operations such as erosion and dilation are carried out.

Step-4: After performing relevant morphological operations such as erosion,dilation, open and region labelling as in Step-3 , get the final segmented image.
This algorithm was applied about 10 group of images and satisfactory results were obtained



Input image Combined segmented image Detected Faces

Fig. 4: Face Detection Process using method 1

Fig. 5: Sample results of detection of multiple faces using method 1

Quantitative analysis is done using two metrics viz. Detection accuracy (DA) and False Alarm Rate (FAR). These metrics are calculated based on following parameters:

A. TP (true positive): No. of correctly detected faces

B. FP (false positive): Non faces detected (Also known as false alarms)

C. FN (false negative): No. of Lost faces (also known as misses).

These scalars are combined to define the following metrics:

Detection accuracy(DA)=TP/TP+FN ……..(1)

False alarm rate(FAR)= FP/TP+FP…….(2)

Success rate(%)=DA/DA+FAR…… (3)[12]

Processing Time(PT)= Total Time

Table 1.Color Models and Morphological operation

No.	Size of Image	TF	TP	FP	FN	FAR %	SR (%)	DA (%)	PT sec
1	251x201	10	10	0	0	0	100	100	7.0
2	179x182	4	3	2	1	40	65	75	3.6
3	318x158	3	3	0	0	0	100	100	7.3
4	275x183	4	4	3	0	42	70	100	6.6
5	300x185	2	2	1	0	33	75	100	9.1
6	300x192	4	4	5	0	55	64	100	7.9
7	276x183	7	7	0	0	0	100	100	7.2
8	279x173	6	3	8	3	72	40	50	4.5
9	259x186	7	6	1	1	14	85	85	4.5
10	300x140	5	5	0	0	0	100	100	5.6

Average accuracy : 91%

Average processing time: 6.3sec

(b) Viola jones and skin pixel information: In this step Skin color pixel detection is used to extract all the entire skin color pixels from the image. Once they are extracted Viola Jones is applied to detect face. This increases efficiency of Viola Jones techniques and decreases consumed time. The following steps are carried out for this algorithm:

Step-1: The input image is skin segmented using RGB colour space the following set of rules have been found to be more accurate than other models. (R>95) AND (G>40) AND (B>20) AND(max –min > 15) AND (|R-G|> 15) AND (R>G) AND (R>B) AND (R>220) AND (G>210) AND (B>170) AND (R>B) AND (G>B)

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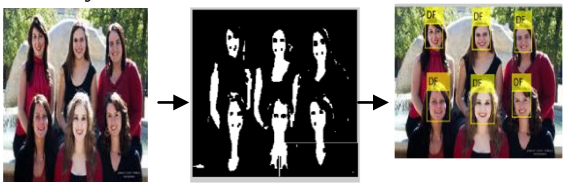
Step-2: When the skin is extracted after that Viola-Jones is applied to detect faces.

This algorithm was applied on 10 group of images and satisfactory results were obtained.



Input Image Segmented Image Detected Faces

Fig. 6: Face Detection Process using method 2

Fig. 7: Sample results of detection of multiple faces using method 2

Table 2. Color Model and Viola Jones

No.	Size of Image	TF	TP	FP	FN	FAR %	SR %	DA %	PT sec
1	251x201	10	5	0	5	0	100	50	6.9
2	179x182	4	4	0	0	0	100	100	3.4
3	318x158	3	3	0	0	0	100	100	5.7
4	275x183	4	4	0	0	0	100	100	5.5
5	300x185	2	2	0	0	0	100	100	5.4
6	300x192	4	4	0	0	0	100	100	6.2
7	276x183	7	7	0	0	0	100	100	5.4
8	279x173	6	6	0	0	0	100	100	3.2
9	259x186	3	2	0	1	0	100	66	3.3
10	300x140	3	3	0	2	0	100	60	6.0

Average accuracy : 88%

Average processing time: 5.1se**c**

8. COMPARISON OF TWO ALGORITHMS:

Table 3.Comparison Table of algorithm 1 & algorithm 2:

Sr. No.	Average Values of evaluation parameters	Skin color models and Morphological Operations	Skin color models and Viola jones
1.	Accuracy%	91%	88%
2.	Processing Time(sec)	6.3 sec	5.1 sec

9. CONCLUSION

In this research work, two different approaches were tested for multiple face detection in color images. In first approach, face detection is performed with the help of YCbCr and HSI color models and some morphological operations. In the second method, Viola Jones algorithm is tested along with RGB color model. It is found that accuracy of first algorithm is more but it requires more processing time as compared to other. The average processing time required for first algorithm is about 6.3sec, whereas for second algorithm it is 5.1sec.One more important observation is made in this work, that, if one method gives good results for an image then second method may or may not give significant results for the same image. It is observed that the first algorithm is suitable for simple background and different lightning conditions of images and the second algorithm is suitable for simple as well as complex background of images.

Future scope : In this work only two color models (YCbCr &HSI) are tested alongwith morphological operations and RGB color model tested with Viola Jones algorithms. In future, other color models can also be applied for further improvement of performance of these algorithms.

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