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Hybrid Face Detection in Color Images

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Abstract

Face detection, plays an important role in many applications such as face recognition, face tracking, human computer interface and video surveillance. In this paper we propose a Hybrid face detection algorithm that could detect faces in color images with different complex backgrounds and lights. Our method, first detect face regions using HAAR classifier over an entire image and generate candidates for next classifier. HAAR classifier, usually detect all the faces in image but also miss classified some none-face object as face. So we first use HAAR classifier to detect all possible regions for face candidate and after that we increase accuracy by using simple feature based method named HSV color model to eliminate miss classified none-faces.

Keywords: *Face detection, video surveillance, face recognition and face tracking.*

1. Introduction

Image is one of the main parts of human life and a single image is more understandable than thousands of words. So, human-vision is the most important sense. As we know human brain can detect and recognize different objects with the least known character of it. Face detection is a sub-branch of object detection. The human face is a dynamic object and has a high degree of variability in its appearance, which makes face detection a difficult problem in computer vision [3]. We can divide face processing into face detection, face recognition and face tracking. Face recognition and face tracking have been used in many applications such as wrongdoer recognition, security systems, controlling systems [4]. We should consider that accuracy of these processing is directly related to accuracy of face detection because face detection is the first stage of these processing. This makes face detection an important part in image processing. Face detection should pass a long way, this caused by differences, variety and complexity of faces. Although many different algorithms exist to perform face detection, each has its own strengths and weaknesses [3]. Some use flesh tones, some use contours, and other are even more complex involving templates, neural networks, or filters. These algorithms suffer from the same problem; they are computationally expensive and do not have proper accuracy[4]. So in this paper we proposed a hybrid method to increase the accuracy and omit miss classified none-faces. We use Viola and Jones algorithm, called HAAR classifiers, to rapidly detect any object, including human faces, using AdaBoost classifier that are based on HAAR-like features and not pixels [9]. After that we use a color base model named HSV method to omit none-faces objects that previous classifier detect them as face and increase accuracy of detection. In section 1 we introduce face detection importance and its applications. And talk about the process of our hybrid method. In section 2 we present HAAR feature and in continue HAAR classifier to detect human faces. In section 3 we review skin color method to detect face region in image [9]. And compare different color model with each other [1]. In section 4 we proposed our hybrid method and it details. In section 5 we talk about our conclusions and in last section we show the experimental results.

2. HAAR Classifier

The main part of HAAR classifiers is the HAAR-like features. These features use change in contrast values between adjacent rectangular groups of pixels instead of pixels intensity values. HAAR features can easily be scaled by increasing or decreasing the size of the pixel group being examined. This allows features to be used to detect sizes. Notice Figure 1.

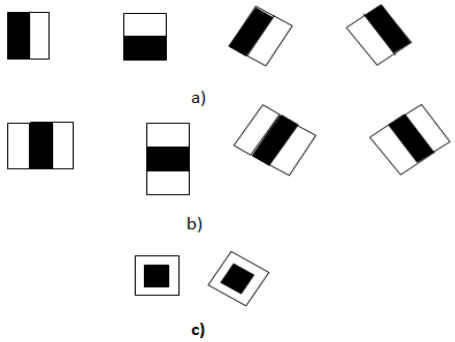

Figure 1: part (a) shows edge features, part (b) shows line features and part (c) shows center features

2.1. Train classifiers

In order to detect human face features we should first train the classifiers. So we implement AdaBoost and HAAR feature algorithm. To train classifiers we use to set of images, one set contain images that doesn't have the object in this case face. These images named as negative images. The other set contain images that have one or more instance of the object in different size and scale. These images named as positive images. We use 5000 negative images that consists objects such as mountain, natural scene. And we use Standards and Technology's (NIST) Facial Recognition Technology (FERET) database that contain 10000 positive images with more than 1000 faces under different light condition. In order to have a robust detection we need images with different people in race, age and gender. HAAR classifier has a negative point. It has a difficulty, that although it rarely misses the faces but this classifier detects other object as faces. So in our proposed method we try to omit negative point of this method.

3. Skin Color Methods

In this part we review two color base models one is RGB model and the other one is HSV model. We used following color models for different representation of a pixel. By comparing these methods we come into result that HSV method has a better performance than RGB method. So we implement HSV program as the second part of our paper. By using this method we can increase the accuracy of previous classifier.

3.1. RGB model

As we said before face detection plays an important role in many applications and a lot of researches have been done on face detection. The well-known method is using a skin-color model that is modelled by a single Gaussian model. And skin-color of different people can be represented by a Gaussian model. So the main part of this project was to find an appropriate skin-color model. The skin-color model should be adaptable for any skin color with different lighting conditions. The common RGB representation of color images is not suitable for lightening images so we use normalization:

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

$g = G/(R+G+B)$ (2)

The normalized blue color is calculated as: $r + b + g = 1$.

Skin colors of different people appear to vary over a wide range, they differ more in brightness than in color [1]. So, the colors of human skins fit in a small color space. In order to estimate the skin color model we collected two sets of 15 color images with human faces. First set are images of people with white skin, second one is set of people with brown and black skin. As shown in Figure 2 skin-color can be represented by a Gaussian model. We can estimate Gaussian model with mean vector and covariance matrix as bellow:

Mean: $m = E\{x\}$ where $x = (r\ g)^T$ (3)

Covariance: $C = E\{(x - m)(x - m)^T\}$ (4)

A Gaussian model, for the skin is given by formula:

$$p(x) = \exp[-0.5 (x - m)^T C^{-1} (x-m)] \quad (5)$$

Where $x = (r\ g)$, m is mean vector, C is covariance matrix.

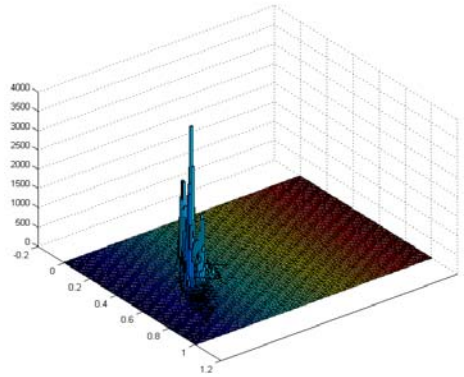

Figure 2: Shows color distribution for skin-color of different people.

The probability of each pixel is calculated by formula (5). The values of probability can be easily transformed into grayscale values. So skin regions are brighter than the other parts of image. Figure 3 shows the result.

Figure 3: Shows the values of probability and it transformed into grayscale values.

The second step is creating a skin-segmented image by using a threshold value of probability. If the probability of a pixel in skin image is more or equal to estimated threshold value, we suppose that this pixel represents skin color. Otherwise, we suppose that this pixel represents none-skin color. The skin color pixels are white and the other ones are black in skin-segmented image. Estimating a threshold value is very important for next steps of image

processing. We can use fixed value for every image or adaptive threshold. As it is obvious accessing a true value for face detection is difficult so in practise it is not a good way. So we use another color representation. Figure 4 shows the binary image by using a threshold.

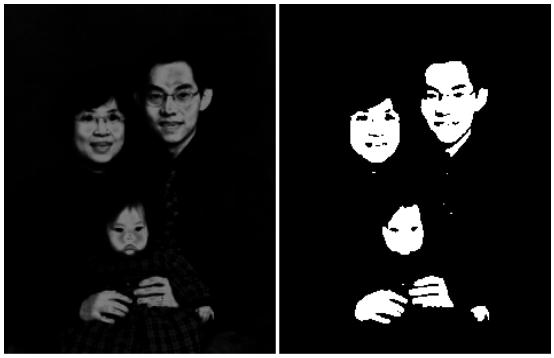

Figure 4: Shows binary image by using a threshold on grayscale image.

3.2. HSV model

First described by Ally Ray Smith in 1978, HSV method seeks to depict relationships between colors, and improve upon the RGB color model. Standing for hue, saturation, and value, HSV depicts three-dimensional color. If you think about HSV as a wheel of cheese, the center axis goes from white at the top to black at the bottom, with other neutral colors in between. The angle from the axis depicts the hue, the distance from the axis depicts saturation, and the distance along the axis depicts value. H varies from 0 to 1 on a circular scale and the colors represented by H=0 and H=1 are the same. S varies from 0 to 1, 1 representing 100 percent purity of the color. The Saturation shows how much the color is polluted with white color. You can see the HSV method dimensions in figure4 and skin color model in HSV color space in figure 5. According to previous papers this method has better performance than other related color models. So we use this method as our second classifier.

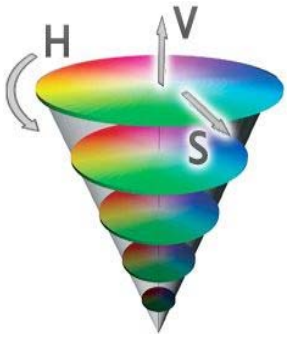

Figure 5: Shows the HSV method dimensions that standing for hue, saturation, and value.

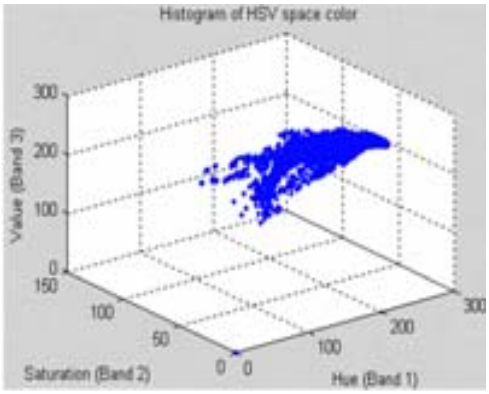

Figure 5: Shows the color model in HSV color space.

4. Hybrid Face Detection Method

In this part we propose a hybrid method that contains two main classifiers. We first use an AdaBoost classifier with HAAR features. Using HAAR feature have a benefit that it can use for images with different scaling and resizing because we work on contrast in adjacent rectangular instead of working on each pixel separately. In the second part we use a color base method to correct previous detections. In first part we use HAAR classifier and detect primary face regions. HAAR classifier usually detects all faces and also some none-face objects as face. Using HAAR classifier as our first classifier and using HSV method as our second classifier for face detection causes a better performance and it detects all the faces and omits none-faces objects. So we first detect all possible area for face regions and send face candidate to next classifier to omit mistakes and increase the accuracy of the detection.

Experimental results

We have evaluated on several face image databases, containing different photo collection. Face database named CMU usually contain grayscale images and it is not useful for colorful algorithms. And other databases such as grimace, FERET, face94 and face95 only have images with single face and it is more proper for face recognition and trains our classifier. So we search for a database that contains colorful and also complex images to run our program. We find a database named BaoDatabase and it has 221 images with face and none face objects. So it is a proper database to test our hybrid algorithm. Our algorithm can detect multiple faces of different size. It use for complex images. In figure 6 we see the results of converting image from RGB space to HSV space. Figure 7 shows detected faces using HSV color model. As we can see, it has detected all the faces but it detects 3 none-faces as human face

too. In figure 8 we use HAAR classifier to detect primary face regions, so we use this as an instrument to detect all possible areas for faces. It hasn't a good performance and it has detected 7 none-face regions as human face. In figure 9 we see the selected face regions from HAAR classifier by blacken the none-faces areas. Figure 10 show the result HAAR classifier in HSV color space. Figure 11 shows the result of HSV method on HAAR classifier results. And figure 12 shows the result of our hybrid method on main image, as you can see it has better performance and it has no error. Figure 13 to 19 show results of another image. As you can see again, HAAR classifier has 7 errors, HSV method has 2 errors and they detect none-face as human face but in our algorithm we have no error.

Figure 6: show the results of converting our image to HSV color model to detect faces on next step.

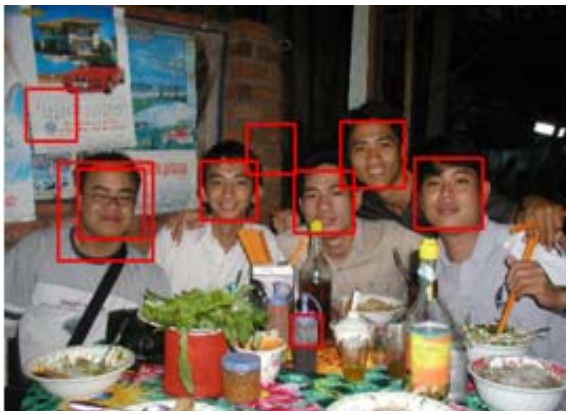

Figure 7: show the results of HSV method. It has about 3 errors on detecting faces and detects some none-faces objects as face.

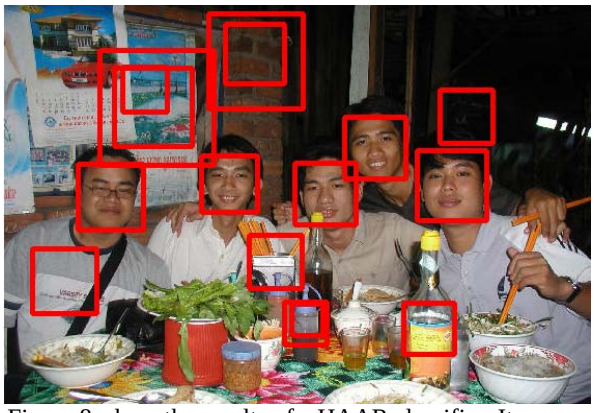

Figure 8: show the results of a HAAR classifier. It has about 7 errors on detecting faces and detects some none-faces objects as face.

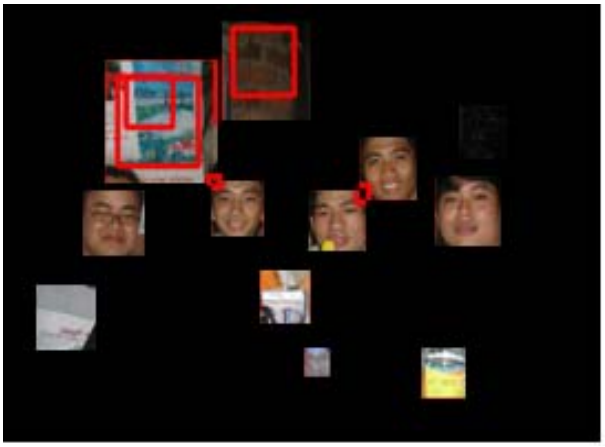

Figure 9: show selected face regions from HAAR classifier to use for next classifier.

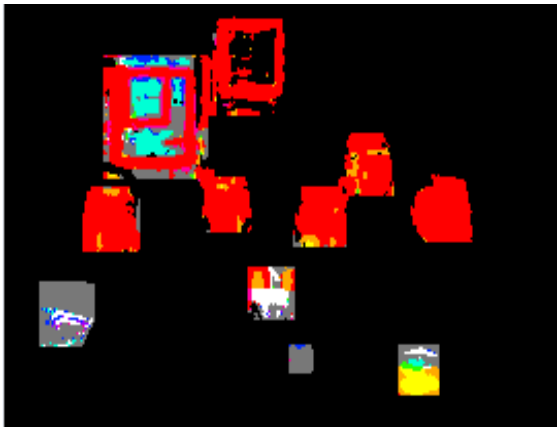

Figure 10: show the results of converting result of HAAR classifier to HSV color model to detect faces on next step.

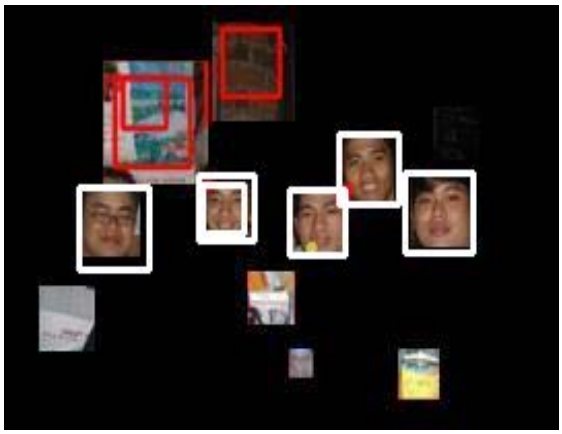

Figure 11: show the results of HSV color model on HAAR classifier results.

Figure 12: show the results of our hybrid method on main image. As you can see it has no error on detecting faces and detects all faces in image.

Figure 13: show the results of converting our image to HSV color model to detect faces on next step.

Figure 14: show the results of HSV method. It has 3 errors on detecting faces and detects some none-faces objects as face.

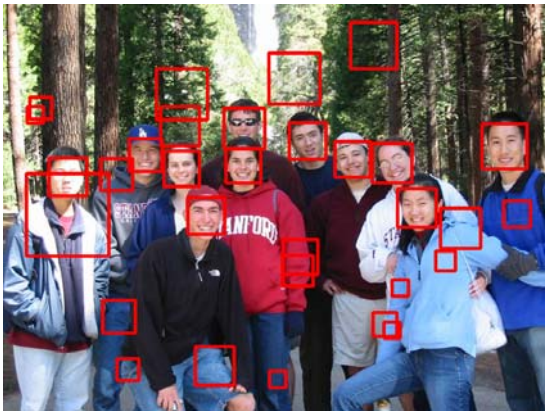

Figure 15: show the results of a HAAR classifier. It has about 20 errors on detecting face and detects some none-faces objects as face.

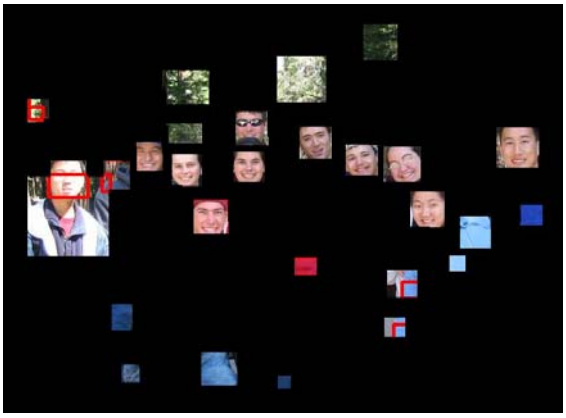

Figure 16: show selected face regions from HAAR classifier to use it for next classifier.

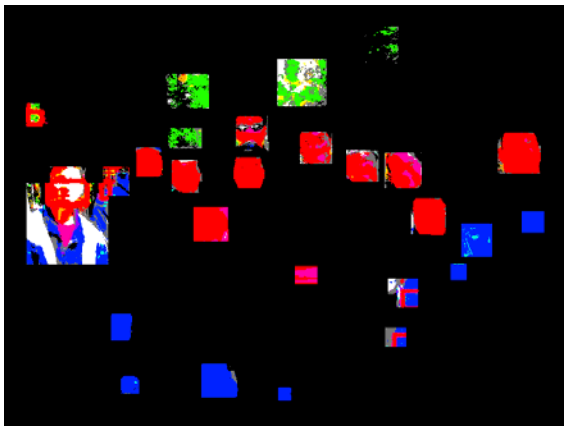

Figure 17: show the results of converting result of HAAR classifier to HSV color model to detect faces on next step.

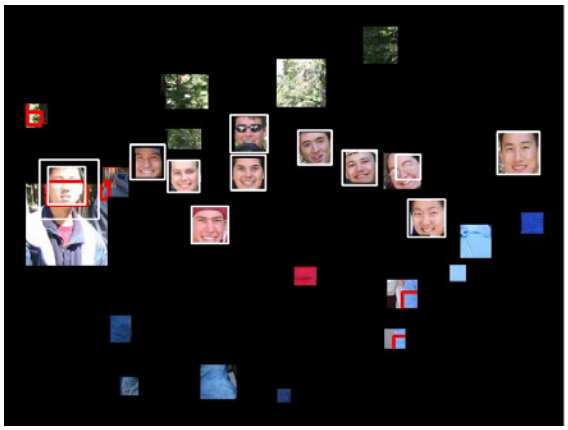

Figure 18: show the results of HSV color model on HAAR classifier results.

Figure 19: show the results of our hybrid method on main image. As you can see it has no error on detecting faces and detects all faces in image.

Conclusion and Future Work

As we said before HAAR classifier have a high complexity and it should works on whole image. Also it has miss classified some object as face. So we use a hybrid method with HSV color model, and a HAAR classifier. HSV method minimizes the searching space of HAAR classifier. And increase the performance. So this hybrid method has decrease the complexity and in addition it has better performance. Our goal as our future work is to modifying our classifiers to detect none-frontal faces in image.

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