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A Novel Approach for Human Face Detection in Color Images Using Skin Color and Golden Ratio

Faizan Ullah*[1], Dilawar Shah[1], Sabir Shah[1], Abdus Salam[2], Shujaat Ali[1]

Department of Computer Science, Bacha Khan University, Charsadda, KPK, Pakistan[1]
Department of Computer Science, Abdul WaliKhan University, Mardan, KPK, Pakistan[2]

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ABSTRACT

Due to increasing incidence of identity theft and terrorism in last few years, biometric based security is an actractive for researchers. Automatic human face detection is an area of biometric system which uniquely identifies human face. To extract a face from a given input image, the major component is detection of skin color. In this Study, a robust model has been proposed for locating human face in colored images. The model uses color histogram for skin (in HSV space) with combination of edge information to detect human face in a given image. The objective of proposed algorithm is to improve the detection of human face in given images. The approach has been applied on many real life images and its result were found reasonably accurate.
KEYWORDS: Face Detection, Skin color classification, Edge detection, Golden ratio.

1. INTRODUCTION

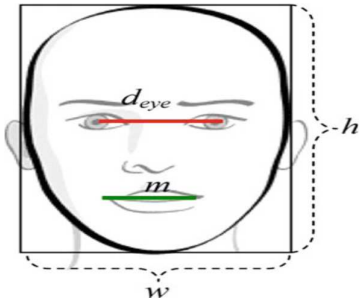
Face detection is a preliminary stage of any automatic face recognition system. Such systems detect and separate human face from a given image. Face detection applications have been increased in many areas like security control system, surveillance system, and video conferencing, content based image retrieval and intelligent human computer interaction system. Majority of the existing face recognition systems assume that face is easily available for the next stage of recognition process, but in reality after capturing image of face it contain extra background area. To remove this extra information, we need a system which is capable to locate and detect only human face region from videos or still images. The main goal of any face detection system is to find the scale and location of all faces in a given image. This task is easier for human brain but still difficult and challenging for computers to detect an accurate face. This is due to many internal factors like glasses, facial expression, mustache and beard etc. Human face is also affected by internal factors like contrast between background and face, lighting condition, scale and orientations of the face. Human face detection is now an active area of research [3, 8] in the recent years. Many researchers have proposed different approaches to solve the issue of face detection [2]. differentiate image based and feature based techniques in face detection techniques. Image based approach consist of neural network [1,4], linear subspace techniques i.e. Fisher face, Eigen face, Eigen face with background learning [6] and statistical techniques like high order statistic and support vector machine [5]. Feature based approach utilize skin color, edge information, symmetry measure, motion, snake, feature analysis, Point Distribution Model (PDM) and deformable templates. The issue of face detection is more difficult and more challenging than videos. There are two main problems in automatic face tracking techniques. Firstly, there is no exact and clear-cut definition of human face. For example, what is the height and width of human face? Secondly there is no correct definition that what exact detection is. Sometime an algorithm may be considered successful if the bounding area having mouth and eyes, while other algorithm needs a whole face which contains hairs and forehead. Different definitions by different researchers are found in the literature [13].

In previous research, people of different races of different skin color have been observed to fall in a color space in a compact region [7, 9]. So skin color can be detected by using compactness. But there are many disadvantages of using skin color only i.e. if more than one human faces are too near to each other the skin area of both face are combined. To solve this issue, edge information and connectivity of skin are used.

2. Moalities in 2D Face Detection

M. Hassaballah [11] stated that golden ratio is found in human body and especially in human face. The distance between eyes and the length of mouth, and the width of face over the length face is golden ratio. By using golden ratio, face size can be detected on the basis of the distance between eye.

***Corresponding Author:** Faizan Ullah, Department of Computer Science, Bacha Khan University, Charsadda, KPK, Pakistan. email: faizanullah62@gmail.com



Three type of perfect face feature are detected. The green rectangle represents approximate size of human face constructed on the bases of distance between two eyes. Many of the face parts have close relation to golden ratio like, 2D face model and geometric information for feature detection. The green dot on the face represents the mid-point or centroid of the face are being used.

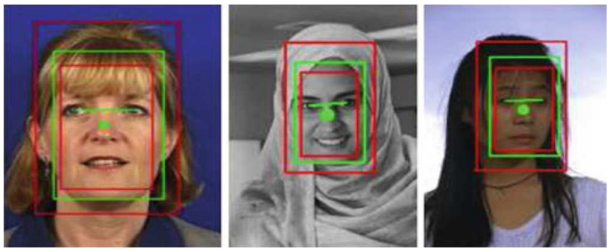


Fig. 1. Perfect face with golden ratio and the correct located face region.

Most common and well-established approaches which reduce the problem to minimizing the norm of the weight vector are discussed. A hybrid technique was proposed by using Adaboost-based face and skin color information in [13].

3. PROPOSED MODEL

Our proposed face detection model consists of three main phases. The first phase focuses on the identification of each pixel, whether it is skin pixel or non-skin pixel in any given image. The second phase classifies different skin area by using connectivity analysis. In the last phase, the model decides whether the selected skin area is face or non-face by using golden ratio.

A. Skin pixel classification.

Skin colour of human is an effective and fast way to track hand and detect face. As different people from different region have different skin colours, but different studies have shown that the main difference is between in intensity of human color rather than chrominance [12]. Many color spaces are used for human skin color detection, like YCrCb, HSV, normalized RGB, CIELAB and YIQ. Zarit et al stated [10] that HSV gives the most accurate results for skin color detection. We carried out our own experiment and find the same results. In the experiments we observed the supervision of HSV color space over YCrCb and RGB color space. Skin color can be modeled by histogram. A Mixture-Gaussian or a single Gaussian Jones and rehg [4] suggest that histogram model is superior to other model.It is computationally fast and easy to implement. In HSV color space, H stand for hue component, which mean shade of the color, S for saturation component, representing the purity of a color. While V mean value component, which defines the brightness level. If V component is removed, it causes varying lighting condition. H values varies from 0 to 1on a circular scale i.e. color described by H=1 and H=0 are equal to S value varies from 0 to 1. 1 describes 100 % purity of color level. H and S values are divided into 100 levels and color histogram is obtained by utilizing H and S.

To train skin color, we downloaded 4,500 images from the internet containing human face and manually inserted some non-face skin area. First the vales of H and S was calculated with increase of 1 in histogram. After completion of training, histogram was normalized. Resultant histogram can be viewed in 2 dimension and 3 dimension respectively shown in figure 2(i) and 2(ii). It looks like that there are two different areas with same high skin probability. It was also observed that skin color falls in very small area instead of whole HS space. The color bin represented by skin color is proportional to the height of bin in histogram. So we utilize threshold value between 0 and 1 to distinguish whether selected pixel is skin region or non-skin region. If the present threshold value is on the lower level, then skin pixel will be correctly identified. In this process some non-skin pixel will be identified falsely. If threshold value is high, then all non-skin pixel will be identified accurately. In

this case some skin pixels will also be detected as non-skin pixel. This show a trade-off among percentage of non-skin pixel classified as falsely as skin and percentage of skin pixel accurately detected.

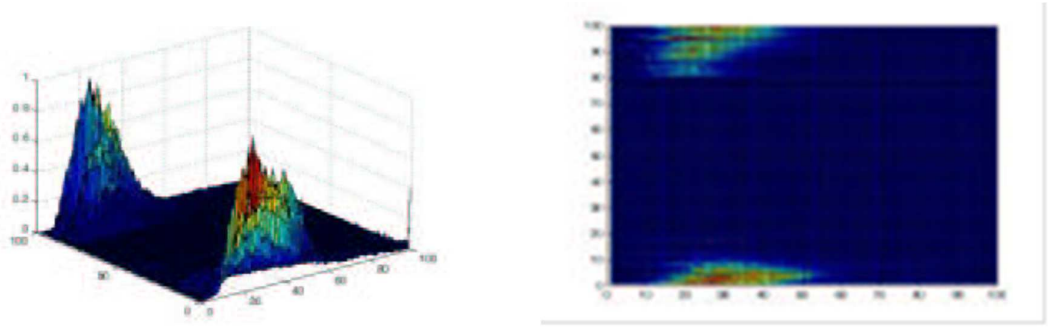


Fig. 2: HS histogram for skin pixels (i) 3D view (ii) 2D view

In input image every pixel is classified as non-skin or skin pixel by utilizing color information. If the values of S and H exceeds to the high bin of normalized histogram, then that pixel is called skin pixel otherwise the pixel is considered as non-skin pixel.

Edge information. Edge detection can be accomplished in many ways. Laplacian and Gradient are among the commonly used methods by most of the researchers. Gradient approach finds the edge by searching minimum and maximum in first derivatives. While Laplacian detect edge by searching zero-crossing in 2nd derivatives. Roberts, Previt and Sobel operators are the types of under Gradient approach and Mars-hildreth Laplacian approach. Among these approaches, Sobel operator is robust one which finds the edges in an image at lowest level with smooth direction edge. It also removes noise from the edges. In our proposed model we use Sobel operator to find edges in an image, as shown in figure 3(i) and (ii).

Fig. 3. Edge detection (i) Test input image (ii) Edge detected Image

We can increase the performance of skin color approach by applying edge information and change the way we detect skin pixel. figure 4(i) and 4(ii) show the result of algorithm using skin color and edge information, and skin color only. By using both edge information and skin color we observed that our proposed system detect all face in an image instead of one image.

Fig. 4. Face detection (i) Using only skin color (ii) by Using both edge information & skin color

B. Connectivity Analysis.
By using skin color, we are able to know where the detected pixel is skin or non-skin pixel, but we cannot predict either the pixel is face or non-face. To resolve this issue, skin pixels are grouped in different categories in order to get some meaningful information like hands and face. After formation of the groups, it is easy to combine a number of pixels which are geometrically near to each other. We combined skin pixel in an image which have 8 connected neighbors. If a skin pixel has got another skin pixel in any of its 8 neighboring places, then both the pixels belong to the same region. At this phase we got different region, for each region we have to find its face or non-face.
Golden ratio. After using connectivity analysis, we are able to locate a connected region of skin color pixel. But we do not know whether it is face area or non-face area. To resolve this issue, we use golden ratio. Finding percentage of skin color and width and height of connected region by the following parameters. The center of connected pixel calculated by average of the coordinates of all the pixels in that area.
To calculate height

- y coordinate of center is subtracted from y coordinate of total pixel in area.
- Calculate the average of all negative coordinate and positive coordinate separately.
- Sum the value of calculated averages and multiply it with 2.

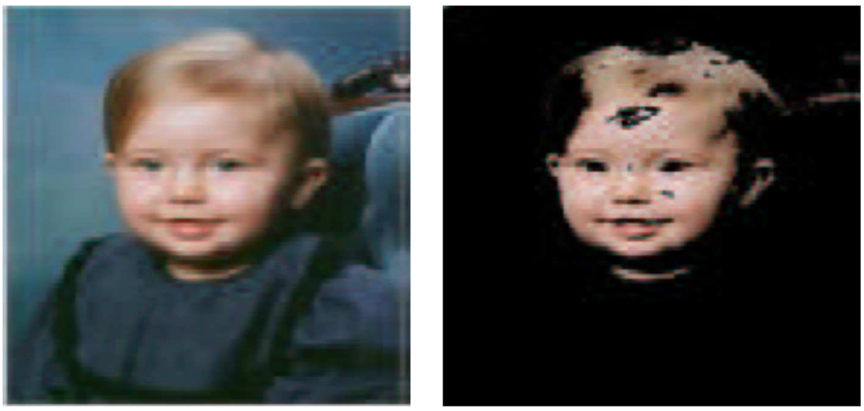
To calculate width

- x coordinate of center is subtracted from x coordinate of total pixel in area.
- Calculate the average of all negative coordinate and positive coordinate separately.
- Sum the value of calculated averages and multiply it with 2

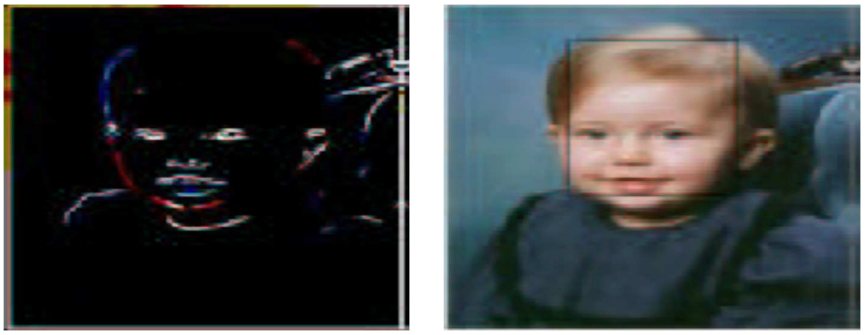
Since width to height ratio of faces comes within small region on real axis, utilizing this framework with percentage of skin in an area. Proposed algorithm will be able to ignore all skin pixels with non-face area. Width to the height ratio of human face comes in range of golden ratio $((1+\sqrt{5})/2)$. Proposed model locates all faces come in this scale and doesn't select any region as face which do not appear in this range. Skin color approach will give the desired results in case if there is a region in an image which looks like skin color but is not skin pixel. This will trigger false alarm. To solve this issue, we use edge information.

4. RESULTS AND DISCUSSIONS

The proposed model was tested on large number of images captured with different backgrounds and under different lightning condition. We also inserted images with non-face pixel of different parts of human body like hand and foot. We used Matlab 10 for implementation of our proposed algorithm. An image size 320 × 240 was detected in 0.5 seconds. The required time will be much less if the algorithm is implemented in C or C++. Histogram is trained over database of 500 images collected from different source on internet. Training database contain images of different people from different regions and different races. Different stages of the model are explained in figure 5. In first stage, the model identifies every pixel in given image as skin or non-skin pixel.



(i) (ii)



(iii) (iv)

Fig. 5. (i) input image of a boy (ii) Skin color detected image (iii) Edge image (iv) Result of the proposed approach

Fig 5(ii) shows the result of skin detected image. Fig 5(iii) shows the result of edge detected by utilizing sobel operator. In the next step, the model uses detected edge and skin image to verify the height width of image is equal to golden ratio and percentage of skin ratio in that region. For area verified as skin area it uses width and height of that area to draw a rectangular circle shown in Fig5(iv). During experiment it was observed that face has been correctly detected and located at right scale. While some false alarm has been also detected that are mostly on the hand skin area which have width to height ratio come in range of the golden ratio. A good pre - processing step is needed to avoid a rare occurrence of false alarm.

NO	Criteria	Skin Color only	Skin color with Edge	Proposed Approach
1	Number of all detected	412	452	477
2	Number of truly detected faces	410	416	462
3	Detection Rate	82%	83%	92.4%
4	Number of false positives	88	86	38
5	False positive rate	14%	12%	14%
6	Accuracy	77%	79%	84%

Fig.6 Comparison of proposed technique with skin color.

5. CONCLUSIONS

A robust model is proposed for face detection based on skin color, edge information, connectivity analysis and golden ratio. The overall performance of proposed algorithm is accurate but at the same time some false alarm were also observed. Proposed model is fast and can be implemented in a varient application. The model is tested over images captured in uncontrolled condition and real world images.

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