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Face Detection and Recognition using HSV Color Model and HAAR Wavelet Transform

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Abstract— In the presented work, face detection problem in a group photograph is worked out using the HSV color format and statistical features. The face detection starts with the segmentation of the given group photograph. Normally the given photograph is in rgb or jpeg format. In the presented work, primarily the face area is detected based on HSV color combination. The HSV color combination is discussed in subsequent section of the paper. The HSV based face area detection is the primary step. After the face area is detected, the image is thresholded to binary image by making the face area as white and other than area as black. The binary image is now segmented using the pixel neighborhood algorithm using 8-connectivity. Further the segmented faces are confirmed using the eccentricity and area analysis. Once the Faces are detected form the group image, the faces are recognized in wavelet domain using haar wavelet and eigen values approach. A minimum of standard deviation between the data base face image and face under scanner is sought for face recognition.

Keywords— HSV, Eigen Value, HAAR Wavelet, DCT, eccentricity

I. INTRODUCTION

Face detection and recognition is very important routine requirement for many access systems in almost all the organizations. there are many researchers who have worked on the same and inferred their conclusion in terms of detection and recognition accuracy and speed of performance. Further, the face detection performance gets poorer if the luminance conditions are not perfect. If there are different illuminance conditions for the same group photograph, then there may be different results. In the presented system, face detection and recognition algorithm is proposed using HSV color model and HAAR Wavelet transform. Face detection problem is addressed using the HSV color values, where HSV represents hue, saturation and value of color intensity. The face recognition is addressed in wavelet domain using the eigen values of the decomposed LL sub band image. A facial data base image is generated for a particular class and attendance is recorded in a text file. The text file can be analyzed computationally for the percent attendance and attendance based evaluation.

II. RELATED WORK

The face identification is very commonly performed by using the facial marks. This is very erroneous technique as the face posture varies, the features are completely changed and a very poor performance is observed while recognizing the given face image from that of the data base image.[1] Face detection problem may be analyzed in different color coding sachem like RGB color format, YCBCr format and HSV format. Each color scheme has their own advantages and disadvantages. In each color coding scheme, primarily skin color is detected for face detection. However, it is quite obvious that while retrieving the face part based on skin color, other body parts may also get extracted and confuses the system. This is the very basic problem while extracting or detecting the face image from the group photograph using the skin color detection. [2]. Face recognition problem is very successfully addressed in the neural network domain. A self organizing map based neural network is designed using face features as input neuron and based on the winning neuron optimization, face recognition is performed. [3]. A self organized map is a supervised learning approach and works well when input neurons are normalized in between the range [-1 1]. Further, the output is obtained in form of a winning neuron that is vectored approach for identifying the face from the data base. [4] Again , a skin color based information, the face part is detected with combination of R, G and B values and taking their combinations [5] The skin color based information is used for detection of face location in group photographs. [6] Face recognition is very well solved in frequency domain using the DCT. DCT coefficients are discrete cosine transform coefficients and give a color intensity frequency map based on facial color intensity variation. [7]

III. ALGORITHM

The presented work is divided into three sections:

A. Face Detection
B. Face recognition

C. Attendance Recording

A. ***Face Detection***

HSV color format stands for Hue (color-depth - H), Saturation (color-purity - S) and intensity of the Value (color-brightness - V). Hue refers to color type, such as red, blue, yellow and takes values from 0 to 360. Saturation refers to the vibrancy or purity of the color and takes values from 0 to 100% Lower the saturation of a color, the more "grayness" the color is represented. Value component refers to the brightness of the color. The face area from group photograph is extracted using the HSV color combination as follows:

Facial skin part is identified using the hue values equalities as: 0.1 <= hue <= 1.8, saturation as 0.23 <= Sat. <=0.68.

If Hue ≥ 0.1, and Hue <= 1.8, and
Sat. >= 0.23 and Sat. <=0.68

Then,

The Pixel belongs to Face Color

Further, now the face area pixels are masked as white and rest are masked as black. This gives a binary image having different segments. These segments may have non-facial segments along with facial images. The next target is to identify the facial segments from these segments.

The different segments are separated using the pixel neighborhood connectivity. The pixel connectivity used here is 8-pixel connectivity.

The neighborhood pixel connectivity based segmentation gives a labeled image and mark each segment a unique label. These labels are extracted by their label no. and well segmented images are obtained.

The eccentricity and area of each segment is computed using the eccentricity command in matlab. The segment area is computed by counting all the white pixels in the segmented image.

It has been observed that the eccentricity of facial images is less than 0.8. The eccentricity is the ratio of the distance between the foci of the ellipse and its major axis length. The value is between 0 and 1. (0 and 1 are degenerate cases; an ellipse whose eccentricity is 0 is actually a circle, while an ellipse whose eccentricity is 1 is a line segment.) This property is supported only for 2-D input label matrices.

Maximum area of the segmented faces is computed by sorting the segments based on area. Any area less than 50% of the maximum area and eccentricity greater that 0.8, are left out. This gives the facial images of the faces present in the group photograph.

B. ***Face Recognition***

For, face recognition, the detected images are decomposed using HAAR wavelet into LL, LH, HL and HH frequency sub bands. The LL sub band image contains the maximum energy out of all the four sub bands. The advantage of decomposition is that for (NxN) image, a (N/2 x N/2) image is obtained and that is in denoised form.

The decomposed LL sub band image is now exposed to eigen value computation. The eigen values are computed using the eig command in matlab.

Further, the eigen values are computed for all the data base images using the above procedure and arranged in column wise in an array as follows:

Eigen Values

Standard Image				Test Image
E^1_1	E^2_1	E^3_1 …	… E^N_1	T_1
E^1_2	E^2_2	E^3_2 …	… E^N_2	T_2
E^1_3	E^2_3	E^3_3 …	… E^N_3	T_3
E^1_4	E^2_4	E^3_4 …	… E^N_4	T_4
…	…	… …	… …	…
…	…	… …	… …	…
…	…	… …	… …	…
E^1_M	E^2_M	E^3_M	… E^N_M	T_M

The average of the differential eigen values i.e. difference of standard and test image is given by:

μ1 μ2 μ3 … μN μT

where,

$\mu i = \Sigma (Si - Ti)/N,$ $i = 1,2,3 \ldots N$

The standard deviation is given by:

$\sigma i = \sqrt{\Sigma} (\mu i - Si)2/2xM2,$ $i = 1,2,3 \ldots 1152$

σ1 σ 2 σ 3 …. σ N

The standard deviation array is sorted for its minimum. As the face image that is best matched with the data base image will have the minimum standard deviation.

C. ***Attendance Recording***

Now, a attendance recording register is opened in notepad file using fopen command in matlab. All the matched face images are marked 'Present' and 'Absent' otherwise.

IV. Results

Presented algorithm is applied on different group images. Well separated face images are observed. Further, the identified images are masked with a rectangle and cropped out for insertion into the data base. Finally the algorithm has been tested in a classroom and showed acceptable results while detection and identification of the students based on the data base images as acquired during registration of the students.

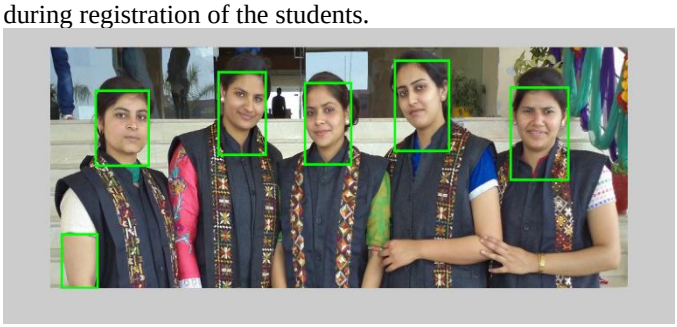

Fig. 1 Detection of Faces from Group Photograph

Fig. 2 Recognizing the face from group photograph with data base image

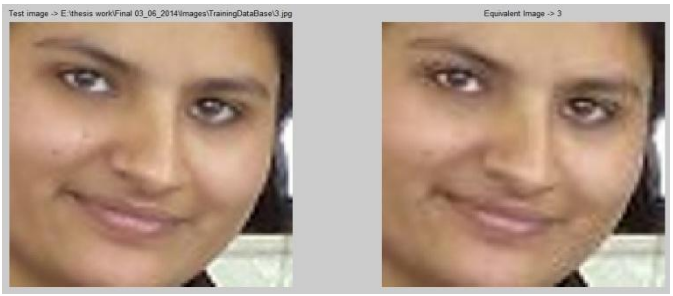

Fig. 3 Recognizing the face from group photograph with data base image

V. Conclusions

The algorithm has been developed in matlab version 7.5 and has worked fine when tested in class room of 30 students. The accuracy will decrease when the class strength increases. But that can be accommodated when using multiple cameras and combining the images of all cameras. The presented algorithm shows fair face detection from the group photograph. The area and eccentricity are the best estimate for confirming the face area. The area may be tuned to different group photographs depending upon the camera distance and can be formulated according to the camera distance.

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