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Automatic Face Detection Using Color Based Segmentation and Computing Eigen face

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Abstract: **This paper introduces the face Detection that makes effective image analysis and understanding. Automating the process to a computer requires the use of various image processing techniques. In the present paper, a face detection method based on "color based segmentation" and "Eigen Face" for Color Face detection with detailed experimental results has been given. The algorithm designed uses color based segmentation, and detect a face from an online surveillance system or an offline image. The main component that should be detected is the skin area. This Paper proposes a skin based segmentation algorithm for face detection in color images with detection of multiple faces and skin regions. Skin color has proven to be a useful and robust cue for face detection, localization and tracking.The proposed algorithm has been tested on various real images and its performance is found to be quite satisfactory.**

Keywords Face Detection, Color space Model, PCA, closed circuit television (CCTV) cameras, Eigen Face.

INTRODUCTION

Face recognition (FR) is becoming popular in research and is being revisited to satisfy increasing demands for video surveillance security [1], annotation of faces on multimedia contents (e.g., personal photos and video clips) in web environments, and biometric-based authentication [2]. Because of the increasing instances of identity theft and terrorism incidences in past few years, biometrics based security system has been an area of quality research. Modern day biometrics is a cutting edge technology which enables the automated system to distinguish between a genuine person and an imposter. Face recognition is one of the areas of biometrics which is widely used because of the uniqueness of a human face to other human face [3]. Face recognition has basically two parts; one is face detection and other one is recognition. Skin color has proven to be a useful and robust cue for face detection, localization and tracking. In Face Detection, we check in given input image whether it contains human face or not, if so, then returning the location of the human face [4].

Basically due to lots of research, wide variety of applications (like in computers, communication, image data base management, law enforcement, security, smart home application and automatic control systems etc) and difficulties in face detection has become interesting topics of research for the researchers in past decade [5]. Face detection is used in many places now a day's especially the websites hosting images like Picasa, photo bucket and online Face detection. Actually Face Detection is first essential step in Face Recognition system for localizing and extracting the features of given image. Since faces have lot of variation in appearance based approach, face detection is not a simple or straightforward, it consists of a long list of these factors, such as pose variation, occlusion, image orientation, illuminating conditions, facial expression, structural components, facial size found in the image, the scene and complexity of images background and others[6]. Generalized face recognition system, which have different modules; Sensor, pre-processing, feature extraction, template generator, post-processing etc [7]. A biometric system is essentially a pattern recognition system that acquires raw biometric data from a person using single or multi sensor, and do some pre-processing on that data, and extracts features using feature extraction then generate the template, and match the output image (which is got after post-processing) to store template in the database, and executes an action based on the result of a comparison [8].

RabiaJafri et.al, discussed different survey of face recognition techniques that operate on intensity images, deal with video sequences, and those which require other sensory data such as 3D information or infra-red imagery [9]. Rajkiran Gottumukkal et.al, presented an improved face Detection technique based on modular PCA approach and compared with conventional PCA method under varying conditions and got better results compared to conventional PCA [10]. MandeepKaur et.al, proposed a Recognition of Facial Expressions with Principal Component Analysis and Singular Value Decomposition, in which Principal Component Analysis (PCA) is implemented with Singular value decomposition (SVD) for Feature Extraction to determine principal emotions for Face Recognition [11]. Srinivasulu Asadi et.al, made a comparative study of face Recognition with Principal Component Analysis and Cross-Correlation Technique. They applied a different technique of face recognition on different test samples and got better results if samples are increased, then accuracy is decreased [12] .

Types of Face Detection

1. Feature based methods.
2. Knowledge based methods.
3. Machine learning methods or Appearance based methods.
4. Template matching method.

In Image based approach, a predefined face pattern or database is used to match with the segments in an image to determine whether it is a face or not. It uses training algorithms to classify regions into face or non-face classes.

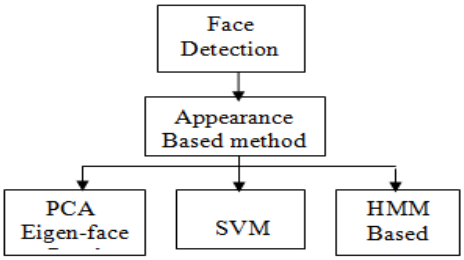

Fig.1: Block diagram of Face Detection method (PCA Eigen-faces)

Face Detection Algorithm

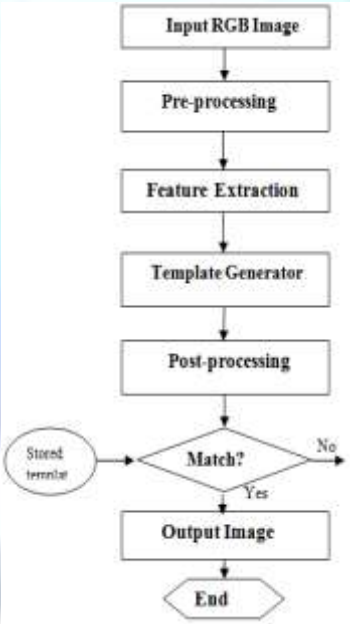

Fig. 2: Flow chart of Face detection Algorithm

Flow chart for the proposed algorithm has been shown in fig (2).This Algorithm applying Image-based techniques depend on multi-resolution window scanning to detect faces, so these techniques have high detection rates but slower than the feature-based techniques [12]. Eigen-faces are examples of image-based techniques. This approach has advantage of being simple to implement, and also good for frontal view but it cannot effectively deal with variation in scale, pose, and shape. Face detection is an interdisciplinary field which integrates different techniques such as :(i) Image processing,(ii) Pattern recognition,(iii) Computer vision,(iv)Computer graphics, (v) Physiology, and (vi) Evaluation approaches.

In general, the computerized face recognition/face detection includes four steps.

(i) Face image is acquired, enhanced and segmented. (ii) Face boundary and facial features are detected. The extracted facial features are matched against the features stored in the database.(iv) The classification of the face image into one or more persons is achieved. Figure 1 shows the basic block diagram of face recognition system. The first step of face recognition is to acquire an image either online or offline. After acquisition of image, preprocessing operation is carried out. The unique features of the image are extracted with the help of different image processing algorithms. After the features are extracted, it is matched with the feature database and the final result is obtained.

The RGB Color Space

Separation of RGB color in the original image. A color is specified by Trichromatic Coefficient define as:

$$X = \frac{X}{X+Y+Z} \qquad (1)$$

$$Y = \frac{Y}{X+Y+Z} \qquad (2)$$

Similarly,

$$Z = \frac{Z}{X+Y+Z} \qquad (3)$$

Now,

$$X+Y+Z=1 \qquad (4)$$

Where,
The amount of "RED","GREEN" and "BLUE" needed to form any pattern color are called Tristimulas Value. and are denoted to X, Y, Z respectively.

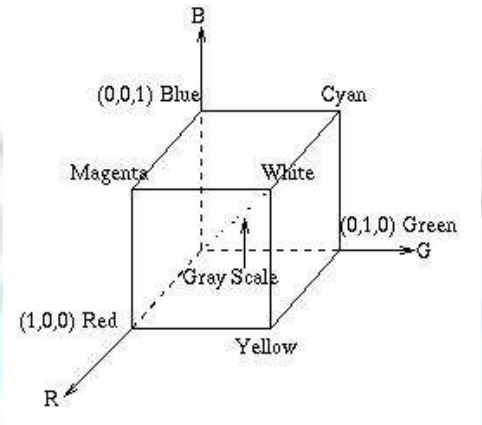

Fig.3: RGB color model

The Color Space "RED", "GREEN" and "BLUE" are shown in the original image fig.(4)

Fig.4 Original Image

Convert RGB image into HIS

Given original RGB color image format the H component of each RGB pixel is obtained using the equation

$$\begin{bmatrix} C \\ M \\ Y \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix} - \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

$$\begin{bmatrix} Y \\ I \\ Q \end{bmatrix} = \begin{bmatrix} 0.299 & 0.587 & 0.114 \\ 0.596 & -0.275 & -0.321 \\ 0.212 & -0.523 & 0.311 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix} \qquad (5)$$

Conversion between RGB and HSI is somewhat more complicated Colors in HSI are defined with respect to normalized RGB values as

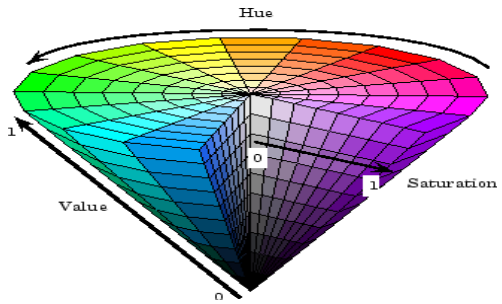

Fig.5: Hue Saturation Value Color Model

$$I = \frac{1}{3}(R + G + B)$$

$$H = \cos^{-1}\left\{\frac{\frac{1}{2}[(R-G)+(R-B)]}{[(R-G)^2+(R-B)(G-B)]^{1/2}}\right\}$$

$$S = 1 - \frac{3}{(R+G+B)}[\min(R,G,B)] \qquad (6)$$

Even these equations need some correction $H = (360^0 - H)$ if $(B/I) > (G/I)$ and H is normalized by $H = H/360^0$
H is not defined if S = 0
S is undefined if I = 0

Fig. 6: HSV image and H component of image

All the above equation finds out the value of "Hue Saturation Component". This RGB Value has been normalized to the range [0, 1] and the angle θ is measured with respect to red axis. And better HIS images results shown in fig. (6) The next step of Face Detection Algorithm, the original image converted into the binary image.

Binary Image

Binary images are produced from color images by segmentation. Segmentation is the process of assigning each pixel in the source image to two or more classes. If there are more than two classes then the usual result is several binary images. The simplest form of segmentation is probably Otsu thresholding which assigns pixels to foreground or background based on gray scale intensity [13]. Another method is the watershed algorithm. Edge detection also often creates a binary image with some pixels assigned to edge pixels, and is also a first step in further segmentation as shown in fig. (7).

Fig.7: Binary Image

Point Spread Function

The point spread function (PSF) describes the response of an imaging system to a point source or point object. A more general term for the PSF is a system's impulse response, the PSF being the impulse response of a focused optical system. The point spread function may be independent of position in the object plane, in which case it is called shift invariant [14]. In addition, if there is no distortion in the system, the image plane coordinates are linearly related to the object plane coordinates via the magnification *M* as:

$$(x_i, y_i) = (Mx_o, My_o) \tag{7}$$

Mathematically, we may represent the object plane field as:

$$O(x_o, y_o) = \iint O(u,v)\ \delta(x_o - u, y_o - v)\ du\, dv \tag{8}$$

Mathematically, the image is expressed as:

$$I(x_i, y_i) = \iint O(u,v)\ \mathrm{PSF}(x_i - Mu, y_i - Mv)\ du\, dv \tag{9}$$

In which PSF $(x_i - M_u, y_i - M_v)$ is the image of the impulse function $\delta\ (x_o - u, y_o - v)$.PSF Results shown in figure 3.4.

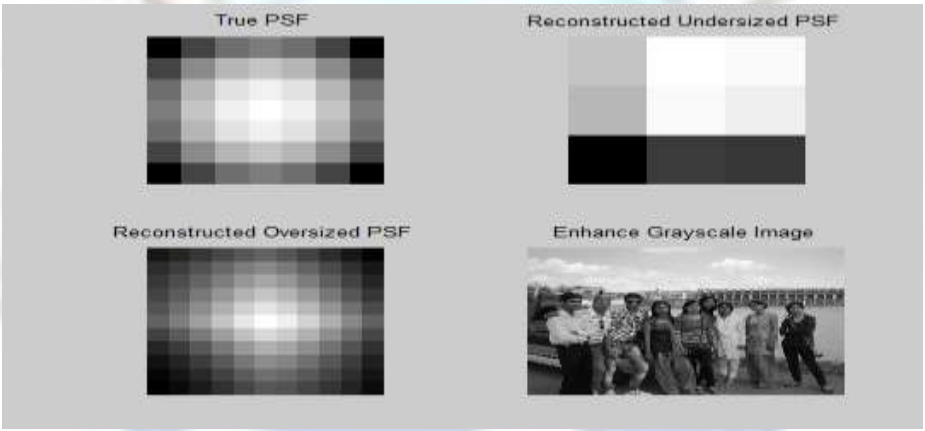

Fig.8: PSF Images

Continue proposed algorithm, Applying Skin and non-skin region for different color spaces.

Skin and Non-skin regions for different color spaces

Color is a prominent feature of human faces. Using skin color as a primitive feature for detecting face regions has several advantage. In particular, processing color is much faster than processing other facial features [15]. The first step of face detection is to segment the color image into skin and non-skin region. Different color space has different range of pixel which represent skin region and non-skin region.

Skin region in B color space lies in the following range

$$0.81G-69<B<0.79G+43$$

Non-skin region in B color space lies in the following range

$$0.847G-14<B<0.846G+45$$

Non skin region in H color space lies in the following range

$$21<H<244$$

Skin region in Cb color space lies in the following range

$$104<Cb<126$$

Fig.9: Face Detected in Box

Fig.10: Detected faces

Above find out the skin and non-skin region for different color spaces and all the faces are detected in the box .Then according to algorithm applying the Principal component analysis in these images. The purpose of this method is reducing the dimensionality of images and computing Eigen faces.

PRINCIPAL COMPONENT ANALYSIS (PCA)

The purpose of PCA is to reduce the large dimensionality of the data space to the smaller intrinsic dimensionality of feature space (independent variables), which are needed to describe the data economically. The jobs which PCA can do are prediction, redundancy removal, feature extraction, data compression, etc [16]. Because PCA is a classical technique which can do something in the linear domain, applications having linear models are suitable, such as signal processing, image processing, system and control theory, communications, etc. The main idea of using PCA for face recognition is to express the large 1-Dvector of pixels constructed from 2-D facial image into the compact principal components of the feature space [17]. This can be called Eigen space projection. Eigen space is calculated by identifying the eigenvectors of the covariance matrix derived from a set of facial images (vectors).A 2-D facial image can be represented as 1-D vector by concatenating each row (or column) into a long thin vector. Suppose we have *M* vectors of size *N* representing a set of sampled images. *Pj's* represent the pixel values.

$$xi = [p1 : : : pN]^T ; i = 1; : : : ;M \qquad (10)$$

Let *m* represent the mean image.

$$m = \frac{1}{M}\sum_{i=1}^{M} xi \qquad (11)$$

Where w_i be defined as mean centred image

$$w_i = x_i = m \qquad (13)$$

$$\sum_{n=1}^{M}(e_i^t \ w_n)^2 \qquad (14)$$

Is maximized with the ortho normality constraint

It has been shown that the e_i's and λ_i's are given by the Eigen vectors and Eigen value of the Covariance matrix

$$C = WW^T \quad (15)$$

Where W is a matrix composed of the column vectors W_i placed side by side. The size of C is N X N which could be enormous. For example, images of size 64 X 64 create the covariance matrix of size 4096X4096. It is not practical to solve for the eigenvectors of C directly [18]. A common theorem in linear algebra states that the vectors e_i and scalars $\lambda_i$can be obtained by solving forthe eigenvectors and eigenvalues of the M X M matrix W^TW. Face images in 2-dimesional (2-D) of size N×N array with 8-bit intensity values. These images can be thought of as a vector of dimension N_2 or a point in N_2- dimensional space. A set of images therefore corresponds to a set of points in this high dimensional space. Since facial images are similar in structure, these points will not be randomly distributed, and therefore can be described by a lower dimensional subspace [19]. Principal component analysis gives the basis vectors for this subspace (which is called the "face space"). Each basis vector is of length$N2$, and is the eigenvector of the covariance matrix corresponding to the original face images. An N×N matrix A is said to have an eigenvector X, and corresponding Eigen-value λ.

if

$$AX = \lambda X \quad (16)$$

Evidently, Eq. (1) can hold only if

$$\mathrm{Det}A - \lambda I = 0 \quad (17)$$

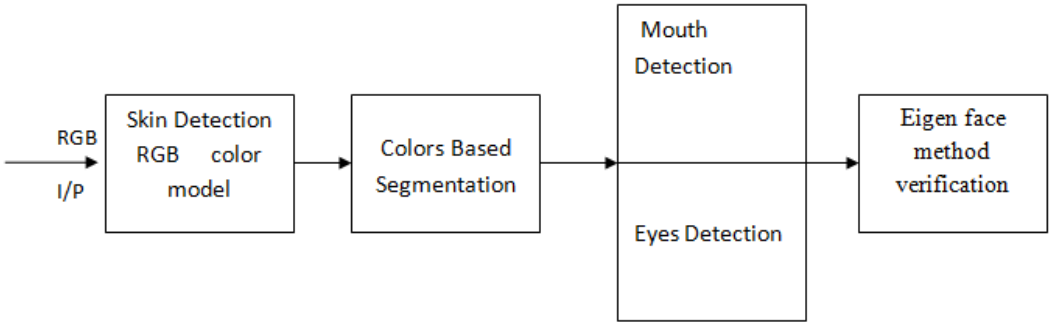

Fig.11: Computing Faces Using Eigen face Method

This, if expanded out, is Nth degree polynomial in λ whose roots are the Eigen values. This proves that there are always N Eigen values. Equal Eigen values coming from multiple roots are called "degenerate". Let the training set of face images are $\Gamma_1\Gamma_2$ ….. ...Γ_M then, the average of the set is defined [20].

$$\psi = \frac{1}{M}\sum_{n=1}^{m} \Gamma n \quad (18)$$

Each face differs from the average by the vector $\Phi i = \Gamma i - \Psi$. The Co-variance matrix,

$$c = \frac{1}{M}\sum_{n=1}^{M} \emptyset n \emptyset n T \quad (19)$$

Has a dimension of $N_2 \times N_2$. Determining the eigenvectors of C for typical sizes of N is intractable. Fortunately, we determine the eigenvectors by solving an N× N matrix. A set of original, HIS image, Binary image, PSF training normalized and average face detected image is shown in Fig. (4, 5,6,7,8 and 9) respectively.

FACE DATABASES

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This database is collected from Master's Degree students of Electrical Engineering Department of JEC Jabalpur India. This Database is using for computing Eigen faces each 12 image shown in fig (12).

Fig.12 Master's Degree students Face data base

EIGEN-FACES

Fig.13: Eigen faces of above Faces

Above Eigen faces shown in fig (13) are using for face recognition system, these Eigen faces are suitable for recognition system and got high accuracy Results.

CONCLUSION

The Proposed algorithm was implemented in MATLAB R2012b version 7.11.0.584 on more than 10 such test images which were given as an input to the algorithm directly from the camera output interface to the system. As an extension to the detection and 12 face data bases are using for computing Eigen faces, then this Eigen faces are used for face recognition using PCA analysis. The efficiency of the face detection was found to be near about 95% while that of face recognition using the detected crop images was found to be between 93-95%.The computation time for face detection was 10 to 15 second while for face recognition it was between 15 to 20 seconds. Hence it can be concluded that the present algorithm demonstrate the better performance with respect to speed, zero repeats, low false positive rate and high accuracy. One of the problems faced during the implementation of the algorithm is that when two persons are very close to one another, sometimes the region is given the same label as a result.

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