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A New Hybrid Approach on Face Detection and Recognition

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Abstract*: Face detection and recognition is an important paradigm when we consider the biometric based systems. Among various biometric elements, the face is the most reliable one and can be easily observed even from a distance as compared to iris or fingerprint which needs to be closely observed to use them for any kind of detection and recognition. Challenges faced by face detection algorithms often involve the presence of facial features such as beards, moustaches, and glasses, facial expressions, and occlusion of faces like surprised or crying. Another problem is illumination and poor lighting conditions such as in video surveillance cameras image quality and size of the image as in passport control or visa control. Complex backgrounds also make it extremely hard to detect faces. In this research work, a number of methods and research paradigms pertaining to face detection and recognition is studied at length and evaluate various face detection and recognition methods, provide a complete solution for image-based face detection and recognition with higher accuracy, a better response rate as an initial step for video surveillance.

Keywords: Face Detection, Face Recognition, Eigen Faces, Viola Jones.

I. INTRODUCTION

Face detection is an easy visual task for human vision, however; this task is not easy and is considered to be a challenge for any human computer interaction approach based on computer vision because it has a high degree of variability in its appearance. How can computers detect multiple human faces present in an image or a video with the complex background? That is the problem. The solution to this problem involves segmentation, extraction, and verification of faces and possibly facial features from a complex background.

Face recognition from image or video is a popular topic in biometrics research. Many public places usually have surveillance cameras for video capture and these cameras have their significant value for security purpose.
The actual advantages of face based identification over other biometrics are uniqueness and acceptance. As human face is a dynamic object having a high degree of variability in its appearance, that makes face detection a difficult problem in computer vision. In this field, accuracy and speed of identification are the main issues.
Face detection is a technology that persuades the sizes and the locations of human faces in the digital images. It recognizes faces and neglects anything else, such as trees, bodies and the buildings. Face detection might be recognized as a more general illustration of the face confinement. It is the center of all the facial analysis, e.g., face localization, face authentication, face recognition, facial feature detection, face tracking, and facial expression recognition.

II. LITERATURE REVIEW

Face detection and recognition have always been an area of interest for the researchers worldwide. There are several types of research in psychophysics and neuroscience studying about how we human performs recognition processes, and many of them have direct relevance to engineers interested in designing algorithms or systems for machine recognition of faces. There are certain arguments pertaining to this area. The first argument in these disciplines is that whether face recognition is a dedicated process against other objects or pattern recognition tasks. There has been certain evidence that proves that face recognition clearly has many advantages over other biometric features. Another argument which comes from a section of researchers is the holistic-based viewpoint which claims that human recognizes faces by the global appearances, while the feature-based viewpoint believes that important features such as eyes, noses, and mouths play dominant roles in identifying and remembering a person.
An Automated face recognition is an interesting area of computer vision problem with many commercial and law enforcement applications. Mug shot matching, user verification and user access control, crowd surveillance, enhanced human computer interaction all become possible if an effective face recognition system can be implemented. While research into these areas dates

back to the 1960's, it is only very recently that acceptable results have been obtained. However, face recognition is still an area of active research since a completely successful approach or model has not been proposed to solve the face recognition problem. The inadequacy of automated face recognition systems is especially apparent when compared to our own innate face recognition ability. Faizan Ahmad et.al [1] have discussed the various challenges in the area of image-based face detection and recognition. In this paper, they have evaluated a number of face detection and recognition methods existing and went on to develop a system for the said method's evaluation as the first milestone for video-based face detection and recognition for surveillance. As mentioned in this paper a general system overview is as shown below:

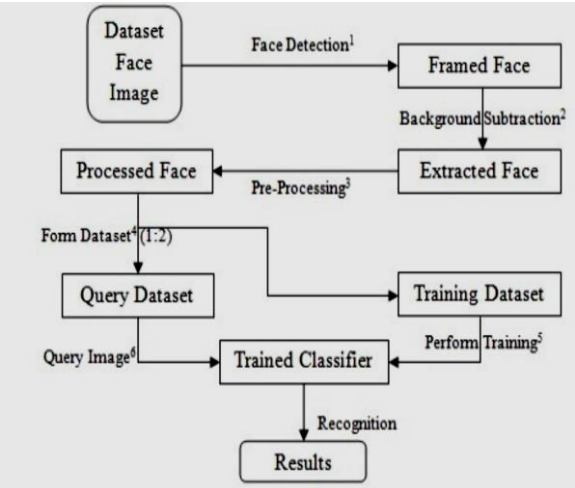

Figure 1: System Overview [1]

The developed system to evaluate the face detection and recognition methods which are considered to be a benchmark. Some methods performed consistently over different datasets whereas other methods behave very randomly however based on average experimental results performance is evaluated, five datasets been used for this purpose. As shown in the paper, Haar-like features reported relatively well but it has much false detection than LBP which could be considered being a future work in surveillance to reduce false detection in Haar-like features and for the recognition part gabor is reported well as it's qualities overcomes datasets complexity.

Amr El Maghraby et.al [2] in their paper have discussed a hybrid face detection method using Viola-Jones method and skin color detection. In this paper, a fast, reliable automatic human face and facial feature detection is one of the initial and most important steps of face analysis and face recognition systems for the purpose of localizing and extracting the face region from the background. This paper presents a Crossed Face Detection Method that instantly detects low resolution faces in still images or video frames. Experimental results evaluated various face detection methods, providing a complete solution for image-based face detection with higher accuracy, showing that the present method efficiently decreased the false-positive rate and subsequently increased the accuracy of face detection system in still images or video frames especially in complex backgrounds. The proposed method can process different kinds of images and under different lighting conditions. The experimental results showed that our new approach was able to achieve a higher detection rate than any of the 2 methods mentioned prior, and clearly improved Viola - Jones face detection accuracy and decreasing false negative rates.

K M Poornima and Ajit Danti [3] have proposed human face recognition of still images using face detection by AdaBoost face detector, region of interest (ROI) extraction, feature extraction using discrete wavelet transform (DWT), dimensionality reduction by employing independent component analysis (ICA) and classification using k-Nearest Neighborhood (k-NN) classifier. The proposed system is evaluated by conducting the experiments on Faces 94 database. For experimenting the proposed system, 40 classes from "Faces94" database are chosen. For training and testing, 40 class each and each class containing 10 images are considered. Out of 10 images, 5 images from each class are used for training and remaining are used for testing. Out of 40 classes, 13 classes are taken from the female dataset, 21 classes are from the male dataset and 6 classes are from male staff dataset. Therefore, total 400 images are considered, out of which 200 images are used for training and remaining 200 images are used for testing. The proposed system achieved about 83.5% of recognition rate when k value is 1.Recognition rate decreases ask value increases.

Zahra Sadri Tabatabaie1, [4] present a hybrid face detection system using a combination of appearance-based and feature-based methods. They have combined Viola and Jones face detection method with a color-based method to propose an improved face detection method. They discuss a pixel-based skin detection methods, that classify each pixel as skin or non-skin individually, independently from its neighbors and combine it with Viola and Jones based face detection to improve the performance of face detection systems in terms of increasing the face detection speed and decreasing false positive rate. The results as shown that the proposed method efficiently increases face detection speed as well as decreases false positive rate.

Abhishek Maity et.al [5] have suggested a novel approach to face detection using image parsing and morphological analysis. The main objective of the paper as mentioned by the authors is to propose an algorithm for extraction of some fundamental information of an image efficiently and then finally use that to detect the human face on the image. The method which they propose is based on assumption that the image contains the frontal face. They describe a method which widely-used edge-based features. Firstly, the skin region is detected using a colour based algorithm and Brightness preserving histogram equalization techniques operated on RGB to determine the presence of human and the head region is calculated. Lastly, the probable calculated head region is extracted using Sobel Edge-Detection and matched with our trained database files for further classification of the segmented image.

Sayantan Thakur et. Al [6] have proposed a face detection method using skin tone segmentation. They have proposed an algorithm which ingeniously uses a novel skin color model, RGB-HS-CbCr for the detection of human faces. Skin regions are extracted using a set of bounding rules based on the skin color distribution obtained from a training set. The segmented face regions are further classified using a parallel combination of simple morphological operations. Experimental results on a large photo data set have demonstrated that the proposed model is able to achieve good detection success rates for near-frontal faces of varying orientations, skin color and background environment. The model proposed by the authors utilizes the additional hue and chrominance information of the image on top of standard RGB properties to improve the discrimination between skin pixels and non-skin pixels.Skin regions are classified using the RGB boundary rules and also additional new rules for the HS and CbCr subspaces. These rules are constructed based on the skin color distribution obtained from the training images. The classification of the extracted regions is further refined using a parallel combination of morphological operations.

III. FACE DETECTION

Early activity in the face detection has passed over as promptly as the start of the 1970s, where the basic heuristic and anthropometric systems were used. These systems are generally rigid due to different assumptions, for example, frontal face, plain foundation, a common visa photo situation. For all these frameworks, any change in the picture conditions ability means a fine-tuning, if not the complete overhaul. Regardless of all these issues, the development of an exploration investment stayed continuous until the 1990s, when a handy and genuine face differences and feature coding frameworks began to change into an actuality.

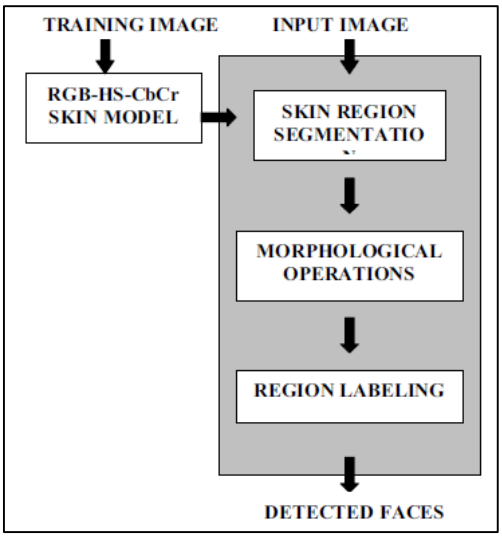

Figure 2: Detection System Overview

The objective of the face detection is to find out the existence of any appearances in the picture and, if it is present, gives back where it's owed and the degree of the each one face. While the face detection is an inconsequential work for the human vision, it is a test for the machine vision due to the varieties in scale, area, facial articulation, light condition, introduction, posture and other different appearance characteristics.
There exist two different types of face detection problems:

1) Face detection in images - Most of the face detection frameworks endeavors to focus a small quantity of an entire face, by allocating with the majority of the foundation and various zones of a singular's head, for example, hair that is not important for the face identification. With static pictures, this is regularly processed by executing a sliding "window" over a picture. The face detection scheme then searches if a face is present inside the window. Regrets, with static pictures there is a large hunt space of the conceivable areas of a face in the picture. The Faces can be expensive and be placed anywhere from upper left to an easier right of the picture.
2) Real-time face detection – The Continuous-face recognition involves the analysis of the face from an arrangement of casings from any feature-catching gadget. The Real-time face detection is really a bit more straight forward process than recognizing a face in the static pictures. It is on the findings that not at all like a huge portion of our nature, an individuals can dependably keep moving.
Applications of Face Detection

- **Facial recognition-** The Face detection is used within the biometrics, like as a piece of or together with a facial identification framework. Similarly, it is utilized as a part of the human machine interface, the video surveillance and an image database management.
- **Marketing-** The Face detection is selecting the enthusiasm of all the advertisers. A webcam power to be coordinated into a TV and to identify any face that strolls by. At that point the groundwork calculates the sexual orientation, race and age extent of face.
- **Photography-** Some recent digital cameras applies the face detection technique for the autofocus. The Face detection is very useful for selecting regions of an interest in photo slideshows that can utilize a pan-and-scale Ken Burns effect.
- **Smart captcha-** It is the mixture of an effectively existing captcha which uses sound and realistic pictures.

IV. VIOLA JONES FACE DETECTION METHOD

The basic rule of the Viola-Jones calculation is to sweep a sub-window to fit for discovering faces over a given info picture. The fundamental picture transforming the methodology capable of rescaling the information picture to various sizes and after that to run the changed size locator through these pictures. This technique ends up being monotonous because of the picking of the diverse size pictures. In opposition to the standard techniques, Viola-Jones rescaled the detector quieter than the data picture and execute the locator commonly terminate the picture each time with an alternate size. This locator is built by utilizing a supposed fundamental picture and some of the basic rectangular properties reminiscent of the Haar wavelets. The Viola-Jones face indicator has three recognized key commitments, which precise high handling rate and the discovery rates. These important commitments are the basic picture, an efficient taking in computation-focused around the Adaboost, and a course structure.

The scale invariant detector

The first step in the Viola-Jones face detection algorithm is to change the input image into an integral image. This is accomplished by making each pixel equivalent to the entire sum of all the pixels above and to the left of the concerned pixel. This illustrated in Figure 2.

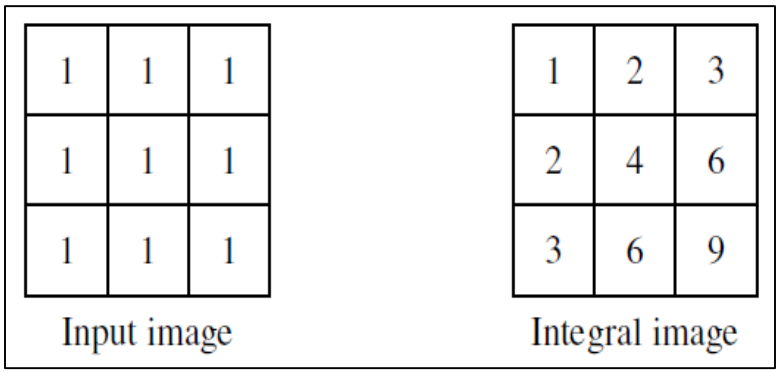

Figure 3: Integral Image

This permits for the calculation of the sum of all the pixels inside any given rectangle utilizing only four values. These four values are the pixels in an integral image that coexist with the corners of a rectangle in an input image.

V EIGEN FACES

This method is based on the eigen faces technique in which the Principal Component Analysis (PCA) is used. Principal Component analysis was developed by Karl Pearson in PCA is a statistical method which is used to reduce the high dimensional data space to the low dimensional characterized space.This method is best suited for data compression and removal of redundancy.It is the most successful technique that is prevalent in image recognition and compression.

The foundation of using Eigen faces in face recognition is based on the fact that each image can be represented as a matrix. A matrix has a set of eigenvectors that represents the principal components of the matrix. Eigenfaces are the eigenvectors of the covariance matrix of all faces. Similar faces can be described in a space with lower dimensionality. In mathematical terms, Eigenfaces are the principal components that divide the face into feature vectors (or we can say that basic approach of using PCA in a face recognition is to put across the large 1-D vector of pixels built from the 2-D facial image into its discrete components of the feature space. This can be said to be as an Eigen Face projection. A covariance matrix gives us the information about these feature vectors. These eigenvectors are the basis for measurement of variation among several faces. The faces are described by a linear combination of highest Eigenvalues. Each face can be considered as a linear combination of the eigen faces. Then the face can be estimated by using the eigenvectors occupying the largest eigenvalues. The best N eigen faces define an N-dimensional space, known as the "face space". Principal Component Analysis has been employed by L. Sirovich & M. Kirby (1987) to efficiently represent pictures of faces. They defined that face images could be approximately reconstructed using a small collection of weights for each face and a standard face picture. The weights describing each face are obtained by projecting the face image onto the eigen picture. Eigenface also found its application in the research work of M.A Turk & Alex Pentland who produced a comparatively more efficient technique in the face recognition system by using PCA.

VI. PROPOSED ALGORITHM

The below algorithm has been incorporated in the research work:

(a)Given image is in the form of (X_1, Y_1)…..(X_n, Y_n)

(b) yi=0,1….for positive and negative value.

(c) initialize the weight w1,i=$-1/2m$, $\frac{1}{2l}$ for yi=0,1 respectively.(where m,n are positive and negative integer respectively.

(d) for t= 1,…….T.

(1) normalize the weight wt..

Wt,i= $\frac{wt,i}{\sum_{j}^{n}=1\ wt,i}$ (1)

(where wt is probability distribution).

(2)For each feature j, train a classifier hj which is restricted to use a single feature.

The error is evaluated with respect to

w_{t,e_t} =∑I w_i /hj (xi) ,yi (2)

(3) Choose the classifier ht with lowest erroe rate e_t.

(4)Update the weight

W t+1,i= wt,$i^{\beta}\ t^{1-ei}$ (3)

Where ei =0 if example x_i is classified correctly.

$e_{i=1}$ Other wise

And

$$\beta_t = {}^{e_t}/_{1-e_t} \quad (4)$$

FINAL STORAGE CLASSIFIER:

h(ϰ)=1 $\sum_t T=1\ a_t h_{t(x)\geq 1/2} \sum_t T=1\ a^t$ (5)

where $a_{t=}$ log$\frac{1}{\beta_t}$

The system consists of real-time face detection and recognition implementation. The various phases of the system implementation have been discussed below:

Face Detection Phase:

Step 1: Read the input image

Step2: Read Frontal Face Object

Step 3: Obtain face co-ordinates

Step 4: Use coordinates to locate face on complex background using Viola Jones

Step5: Detect face

Training phase

Step 1: Crop face for detection

Step 2: Make bounding box of 240 x 320 pixels

Step 3: Grayscale conversion reduce the dataset.

Step 4: Apply Image Enhancement to enhance the quality of obtained Image by adjusting intensity value of pixels.

Step 5: Create Eigen faces from this image

Computing the average face

image m = (1/P)*sum(Tj's) (6)

for i= 1 to Number of rows

Computing the difference image for each image in the training set

A i= Ti – m (7)

temp = double(T(i) – m (8)

Merging all centered images

A = [A temp] (9)

end

Obtain covariance matrix

L = A'*A (10)

where A is center matrix Compute eigenvectors of L matrix

For i=1:eigen vectors

if(D(i,i)>1) , where D is the eigen vector of L matrix.

Eigen L=[Eigen_N,Eigen_values] (11)

end

eigen_ face= A * Eigen L (12)

Step 4: Form the database of all training sets.

RECOGNITION PHASE:

Step 1: Get the image to be recognized i.e. test image

Step 2: Apply Eigen faces algorithm on the test image

Step 3: Calculate Euclidean Distance from all eigen faces in database

Step 4: Minimum Euclidean Distance data set is recognized.

VII SIMULATION RESULTS AND ANALYSIS

The algorithm discussed above is implemented in MATLAB 2013a, using various available functions and mathematical techniques. The below discussion shows a step by step implementation of the algorithm.

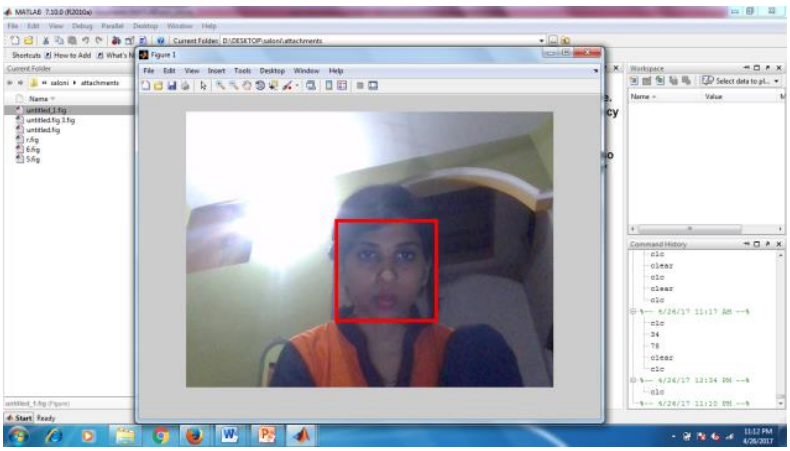

Figure 4: Face Detection

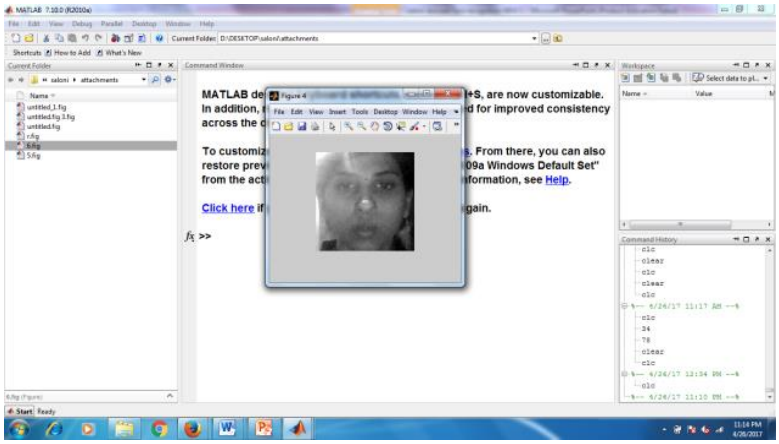

Figure 5: Face Area Detected, cropped and converted to grayscale

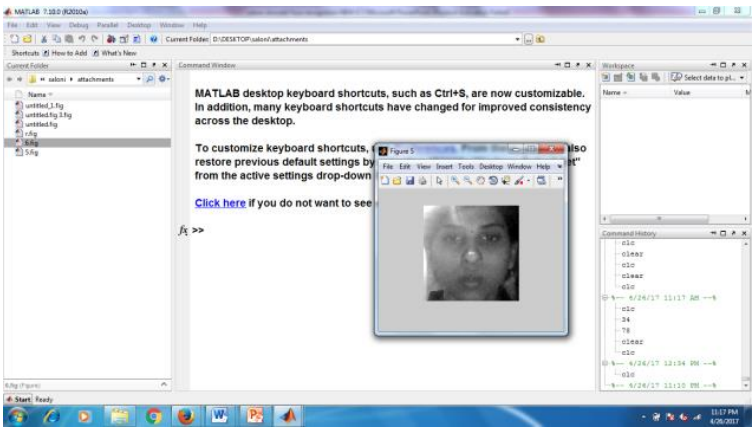

Figure 6: Enhanced Image

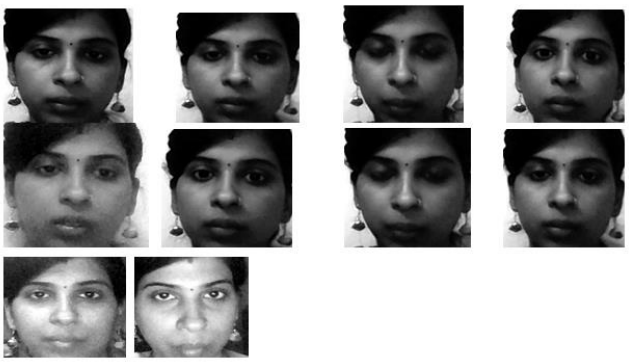

Figure 7: Training Dataset of 10 Images (Person 1)

Figure 8: Training Dataset of 10 Images (Person 2)

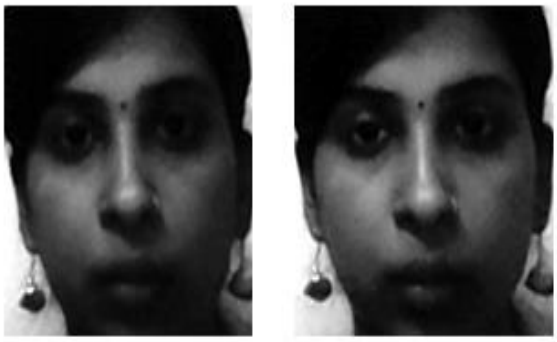

Figure 9: Recognised Face

The face detection and recognition were done with a number of faces. The following table shows the recognition rate of different faces:

Table I: Recognition rate

Person	**No. of correct Recognition**	**No. of Incorrect Recognition**	**Percentage**
Person 1	26	4	86.6
Person 2	25	5	83.33
Person 3	27	3	90.00
Person 4	26	4	86.6

CONCLUSION

This paper presents a real-time face detection and recognition algorithm implementation and its subsequent results on a number of test datasets of live images. The detection is performed using Viola-Jones Algorithm and the recognition phase uses eigen faces and Euclidean faces method. Image enhancement after detection of a face region from complex background has been used to improve the quality of the recognition system. The system performs satisfactorily well with a number of complex backgrounds tested in a number of illumination conditions.

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