Parallel Processing for Multi Face Detection and Recognition

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Abstract— **In this paper, a robust approach for real time face recognition where the images come from live video is proposed. To improve the algorithmic efficiency of face detection, we combine the eigenface method using Haar-like features to detect both of eyes and face, and Robert cross edge detector to locate the human face position. Robert Cross uses the integral image representation and simple rectangular features to eliminate the need of expensive calculation of multi-scale image pyramid.**

Moreover, In order to provide fast response in our system, we use Principal Component Analysis (PCA) to reduce the dimensionality of the training set, leaving only those features that are critical for face recognition.

Eigendistance is used in face recognition to match the new face while it is projected on the face space. The matching is done when the variation difference between the new image and the stored image is below the threshold value.

The experimental results demonstrate that the proposed scheme significantly improves the recognition performance. Overall, we find the system outperforms other techniques. Moreover, the proposed system can be used in different vision-based human computer interaction such as ATM, cell phone, intelligent buildings, etc.

Keywords: Face Detection, Eyes detection, Face Recognition, Haar- like features, PCA, Eigenfaces, Roberts Cross Edge Detector, Human Computer Interaction, Real-time System.

I. INTRODUCTION

As the famous proverb says, "Face is the index of the mind". A face to face interaction between human beings is considered most important and natural way to communicate. Recognition of faces and processing the data is a challenging task with very large database using low-cost desktop embedded computing.

The face recognizing systems available so far maintain a database that has each pre-processed human faces and their corresponding unique features as determined from each face. These features are stored with the respective individual's face. Therefore, when a query is raised, the unique features are extracted from the face and then compared with the features in the database and results in a perfect match [1].

There are many areas of applications that use face recognition technology ranging from security applications for recognizing criminals in public spaces such as airports, and shopping centers, verifying access to private property, and casting votes, to intelligent vision-based human computer interaction such as ATM, cell phones and intelligent buildings [2].

Identifying the images and processing the data is a challenging task because of the various factors involved in this sophisticated process such as illumination, angle of pose, accessories, facial expression, and aging effects [2].

There are two sets of data involved in face recognition system. The first is the training set of data that is used in the learning stage. The second is testing set which is used during recognition [3].

There are numerous technologies and algorithms used in face recognition systems and the most popular among them is the Eigenfaces algorithm which we have implement in our system. Often real time response is understood to be in order of milliseconds and sometimes microseconds, which is the most crucial criteria in the system design.

The rest of this paper is organized as follows. In Section II, we glance at a variety of face detection and recognition methods. Section III contains an overview of the system, including a description of the Eigenface with Haar-like features, Robert cross edge detector, and details on the analysis methodology of the paper. We describe the steps to determine face detection and recognition. In Section IV, we provide details of the experiment and the results of our system. Finally, Section V concludes this paper regarding the potential usefulness of our system, and highlights some directions for future research.

II. RELATED WORK

Several methods have been suggested for face recognition over the past few years and a recent survey could be found in

[4]. The most common techniques used in face recognition are Principal Component Analysis (PCA), Partitioned Iterated Function System (PIFS), Local Feature Analysis (LFA), Wavelets and Discrete Cosine Transform (DCT), Neural Network, Template Matching, and Model Matching. The choice of using a particular method is specified by its suitability for a specific application [5].

In face recognition by Template Matching [6], salient regions of the facial image are extracted, and then these regions are compared on a pixel-by-pixel basis with an image in the database. The advantage of this method is that the image preprocessing is simple, but the database search and comparison are computationally expensive.

In face recognition by Neural Network [7] based on learning of the faces in the training phase, the learning set of faces should be large enough in number to realize the variations in real life situations. Neural Network solutions model the face recognition problem very well, but they take significant training time.

In Local Feature Analysis (LFA) [8] technique, dozens of features from different regions of the face and the relative location of these features are utilized and incorporated to identify and verify the face image. Although LFA method offers robustness in carrying out a match with local variations on the facial image, the technique is not robust against global facial attributes.

In [9] Hidden Markov Models (HMM) and Wavelets for face recognition are used, and during the learning model the best matching model, offers a query image. Success of Model Matching methods depends mainly on building realistic representative model.

Eigenface [2] method is one of the well-known face detection and face recognition algorithms. In Eigen presentation phase, every face in the database can be represented as a vector of weights, and then PCA is used to encode face images and capture face features. The face recognition is done by locating the images in the database whose weights are the closest in Euclidean distance to the weights of the test images. Automatic learning and later face recognition is practical within Eigenface scheme, and it has advantages over other face recognition algorithms in making the application practical for its simplicity, speed, learning capacity, and insensitivity even to progressive change in the face e images.

In our proposed methodology we use a multi algorithm combining PCA with eigenface method using Haar-like features and Robert cross edge detector applied on the same facial data to decide the identity of a subject. In this paper, we present a prototype system implementing our technique of face recognition.

III. NEW APPROACH

The main target of this research is to build a real-time system that could be used in real-world environment, where many technical systems require natural human-computer interfaces using different kind of cameras installed into everyday living and working environment.

As facial recognition is not possible if the face is not detected and isolated from the background as the first step to be processed for face recognition, our approach consists of two stages. The first stage is to locate the faces in the image, using the face detector to examine the image location which comes from a live video. The second stage after analysis of facial image is to declare a possible match face which is close enough from the faces previously stored in the database for the new face. The whole algorithmic architecture is shown in Figure 1.

A. Detection Process

Since face recognition algorithms are very sensitive to different parameters such as lighting conditions, facial emotion (angry, smiling, etc.), hair and makeup, it is extremely important to pre-process detected faces before applying face recognition.

Two face detection systems were trained: one with Haar-like feature set of Viola and Jones [10] in which the basic Haar features for the eyes and the face are added to Eigenface method , where is the detection is very fast and one with the Robert cross edge detector in which face edges are detected and added to the database.

The Eigenface detection technique is based on PCA [1], which considers as a best dimensionality reduction tool that helps to reduce the data set to a smaller one. In this approach, we preserve as much information as possible in the mean square sense. Suppose that we have the set of faces , and these faces is a subspace of the set of images, and it is K dimensional, it is possible to find the best subspace using PCA when you fit a hyper plane to the set of the faces.

PCA with computing Eigen faces is considered as first step to process the image database, i.e. store the set of images with labels.

After given a collection of n labeled training images, the Eigenfaces modeling works as follows [11]:

Step 1: Each image Ii in the training set is transformed into a column vector $\Gamma_{i.}$, and placed into the set.

$$S = \{\Gamma_1, \Gamma_2, \Gamma_3, ..., \Gamma_M\} \qquad (1)$$

Step 2: Compute the mean image Ψ , which equal to the average image face Vector.

$$\Psi = \frac{1}{M} \sum_{i=1}^{M} \Gamma_i \qquad (2)$$

Where M is the number of the face images and Γ is the face images vector.

Step 3: Find the difference Φ between the input image and the mean image.

$$\Phi_i = \Gamma_i - \Psi \qquad (3)$$

Step 4: Find the Covariance Matrix by

$$C = \frac{1}{M} \sum_{i=1}^{M} \Phi_i \Phi_i^{\mathrm{T}} \qquad (4)$$

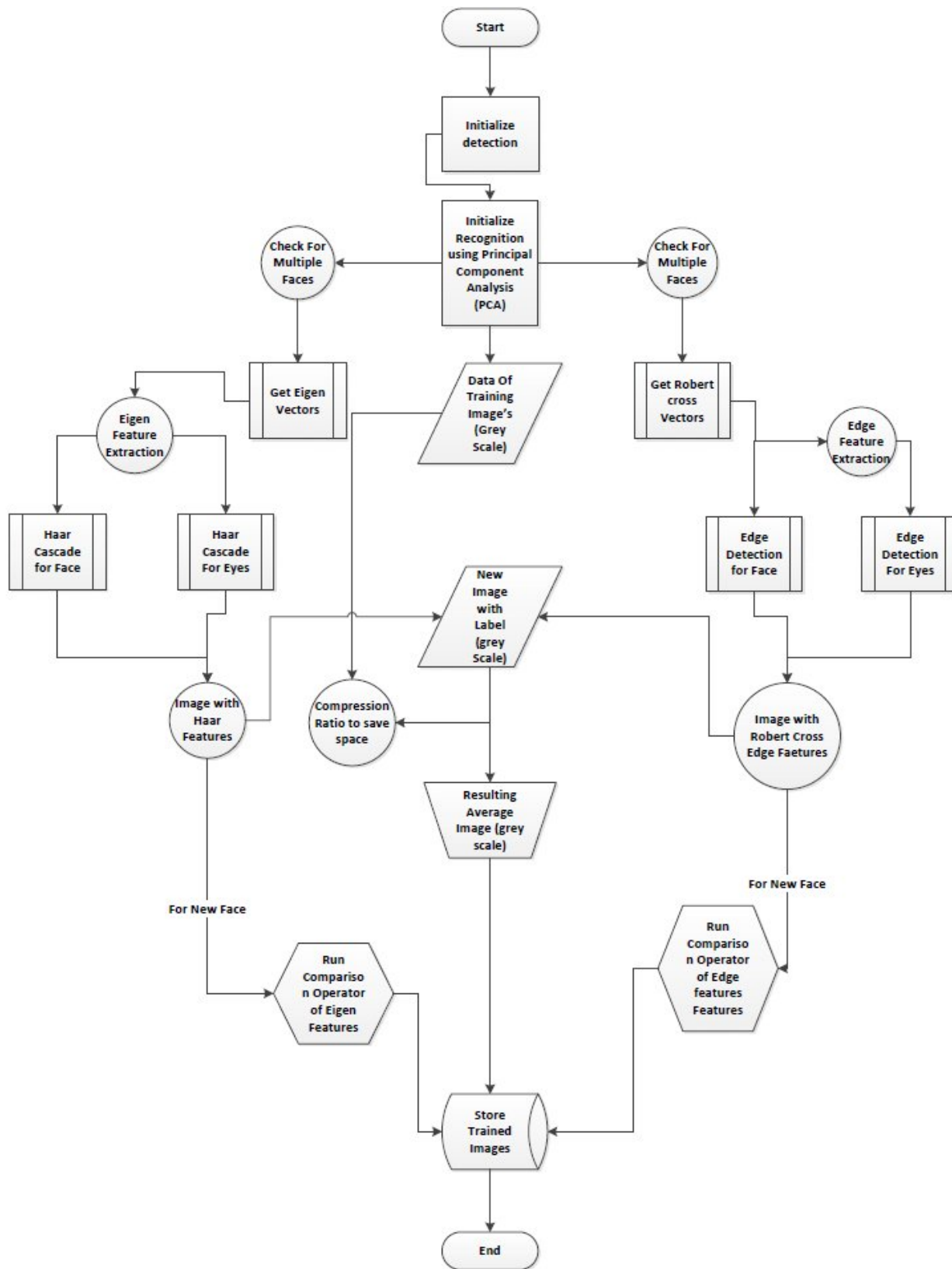*Step 5:* Compute the eigenvectors and eigenvalues of C .

Figure 1: The Framework for Multi face detection and recognition

Step 6: The M' significant eigenvectors are chosen as those with the largest corresponding eigenvalues.

Step 7: Project all the face images into these eigenvectors and form the feature vectors of each face image.

Since our design target is to build a real time system, we emphasize achieving very robust face detection rates. According to [10], Haar-like features are simple and inexpensive image features. A special representation of the image called integral image makes feature extraction faster. Using the integral image representation, it is possible to compute the value of any rectangular sum of rectangular features instead of pixels. Therefore, image scaling is not necessary, and it is replaced by scale the rectangular features.

Since some parts of human face are more important than other parts to successful face recognition, in addition to face detection, we use Haar-like features to detect the eyes too, in order to recognize the occluded face. Figure 2 shows the detected eyes and detected face in the image, and display the image with detected face outlined in green, and detected eyes outlined in blue.

Once the Eignface process strats, Robert Cross edge detection [12] is working simultaneously as a parallel processing.

There are many methods to perform edge detection, one of the main categories is gradient method, which detects the edges by looking for the maximum and minimum values in the first derivative of the image. In order to detect the edges in Robert Cross technique, 2-D spatial gradient measurement on an image is performed, where the regions of high spatial frequency which greatly correspond to edges is highlighted. Figure 2 shows the input image after edge detection using Robert Cross, and the results in grayscale edge segmented image is shown in Figure 3.

B. Face Recognition

Once the Eigenfaces are created in the first phase, we can project any of a test face images into Eigenspace [13]. Then
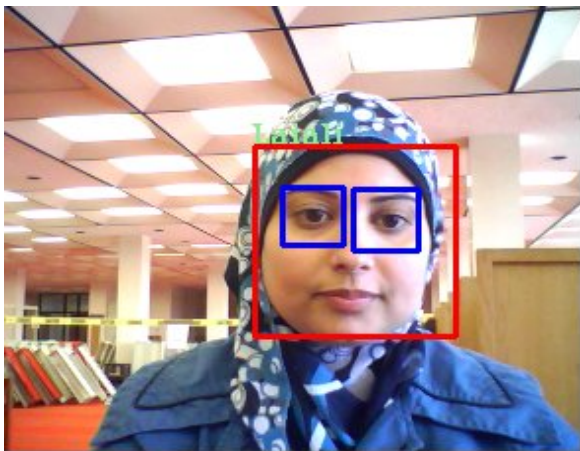

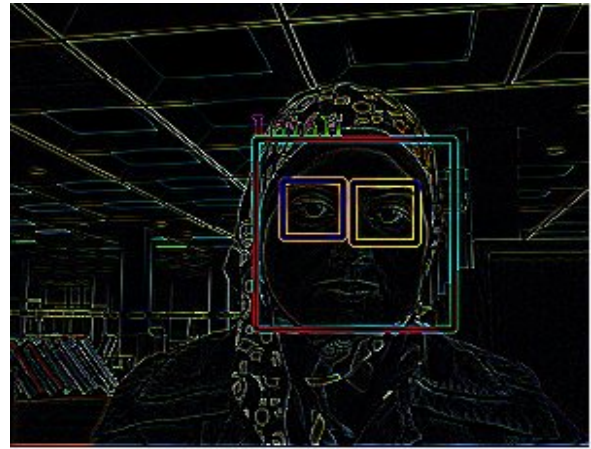Figure 2. Edge detected image using Robert Cross operator

Figure 3. Gray Scale image using Robert Cross operator

the classification can be made by a simple Euclidean distance measure between the projected vector and each face image feature vector. Euclidean distance formula can be found in [14]. After applying Euclidean distance measure, the closest face in Eigenspace is selected to recognize the test face image as the match if the distance to that face is above athreshold, otherwise, classify the face as an "unknown" face. Following this methodology we can classify the image as known face image, and unknown face image.

IV. EXPERIMENT AND RESULTS

The complete face recognition system is implemented in Visual C# in MS-Windows platform. A standard web-camera with 60/sec is used to capture video frames. The experimental results were conducted on a Pentium 2.4GHz computer system.

Figure 4 shows the interface used in our system. First the faces in an input image must be located and registered to the database, meaning enter the names of the people in the image manually. Then, once we have detected a face, later if the same face is detected again, the system will show how many faces in the image and for whom those faces are, since face recognition means figuring out whose face it is.

We conducted our experiments for people in different places using live video. The video includes different backgrounds. It is found that the system successfully detects almost all the faces and the eyes in the images.

Figures 4, 5 respectively show recognized occluded face with hand, and multiple recognized faces.

To evaluate the performance of our proposed face recognition system, a number of self-captured face images were used in the experiment. We measure the recognition rate for various face expressions and poses. The recognition rate is the ratio of successful attempts (cases where the best match is the correct match) to the total attempts [5].

The results show that the correction rate is 92%. This makes our multi-algorithmic technique very much suitable for many applications.
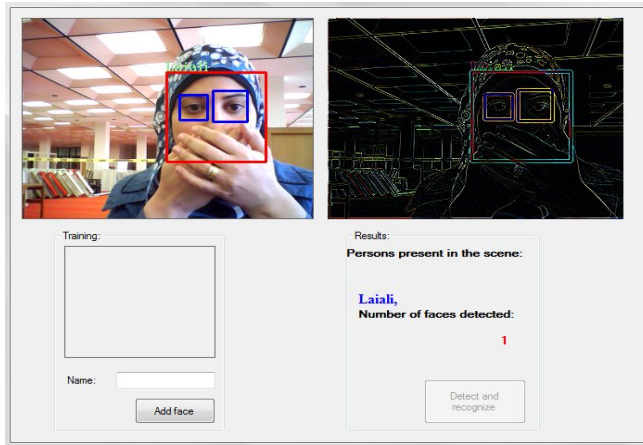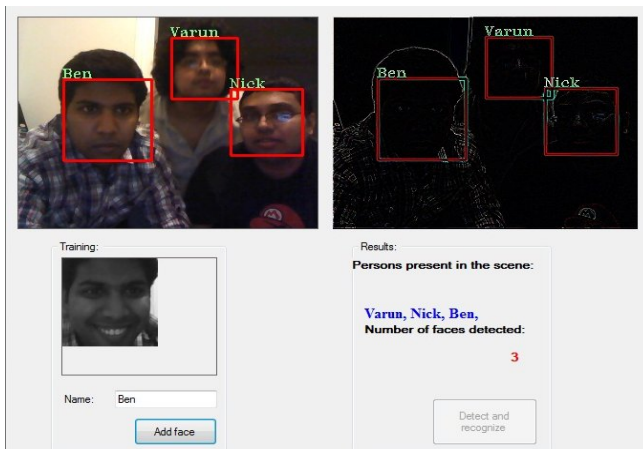
Figure 4. Recognized occluded face with the hand

Figure 5. Multiple recognized faces

V. CONCLUSIONS AND FUTURE WORKS

Face recognition can be used in many applications such as ATM, surveillance, video conferencing, etc. In this work, we propose a new technique that relies on an effective combination of multi algorithms. The approach is fast, easy, and it provides a practical solution to the recognition problem. The system has produced a success rate of 92% over a large set of database of faces.

As a future work, we plan to extend our work by implementing our technique using wireless multimedia sensor network boards using IMB400 multimedia boards.

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