COMBATING TERRORISM WITH BIOMETRIC AUTHENTICATION USING FACE RECOGNITION

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ABSTRACT

In today's fast insecure world, the need to maintain proper security at the border is both increasingly important and increasingly difficult. Recently, waves of terrorism attacks are beginning to spread from countries to countries and thus a proper security approach needs to be adopted by the government. This paper focuses on terrorist detection at the airport and border points which the terrorists can use to gain entrance to the country. We implemented an authentication system based on face recognition for use at the airport and country border points. We trained some images which we take as the images of known people on world's terrorists list using principal component analysis and then combine with a feature based technique. For the feature based technique used, we extract some key features i.e. the red, green and blue colours of the eyes, the width and height of the eyes etc and ratios between them. We computed weights for each image based on these features and record the weights in the database with the name of each person in the database. We finally combine these feature weights with the weights computed from the principal component analysis and used it as the final weight to perform recognition. The system then authenticates any immigrant by matching their faces with the faces of the known terrorists in the database. If a match is found then the person must be a terrorist and is arrested.

1.

2. **Keywords**: Principal Component Analysis, Feature based technique, Biometric, Authentication, Face recognition, Surveillance.

1.0 INTRODUCTION

The ever increasing rate of security system break-ins has been a source of concern to many countries, thus maintaining proper security at the border, though increasingly difficult has become increasingly important and necessary. Recently, waves of terrorism attacks are beginning to spread from countries to countries and thus a proper security approach needs to be adopted by the government. A critical look at most of the current terrorist attacks shows lapses in people authentication and access control at major entry points, the criminals therefore take advantage of a fundamental flaws in the conventional access control systems because the systems do not grant access by what makes the people distinct but by rather by, that what they possesses such as ID cards, passports and visas. These don't really define individuals as being unique personalities and thus if someone steals, duplicates, or acquires these identity means, he or she will be able to successfully impersonate as someone else.

A major breakthrough to counter this is the emerging field of biometrics which allows verification of true individual identity. This is the focal point of our research work wherein a face recognition system is implemented.

Authentication is the verification that you are who you say you are, i.e. genuinely proving ones identity (Matyas et al, 2008) for example, the user ascertain that the identity presented is actually his/her own . Common applications of these are seen when users log onto a network or perform an on-line transaction etc in which an authentication is required before the facility requested is granted, the authentication process verifies to ascertain the users identity by providing the system with a characteristic or combination of characteristics that are associated with their identity. Ultimately, biometrics authenticates humans more reliably when compared to other methods of authentication.

Biometric is an automated method of identity verification or identification based on the principle of measurable physiological or behavioral characteristics such as fingerprint, iris pattern, facial characteristics or a voice sample (Matyas *et al*, 2007). Therefore, in authentication applications a user is either accepted or rejected, that is, the output is a binary response, yes or no.

Face recognition has gained much attention in recent years and has become one of the most successful applications of image analysis. It is one of the few biometric methods that possess the merits of both high accuracy and low intrusiveness. It has the accuracy of a physiological approach without being intrusive; it is hands-free and continuous while being accepted by most users. A typical application is to identify or verify the person of a given face in still or video images.

The important applications of face recognition are in areas of biometrics i.e. computer security and human computer interaction (Kresmic et al, 2005). Several approaches to modelling facial images exists, these includes Principal Component Analysis, Local Feature Analysis, Linear discriminant analysis and Fisher face which are all based on dimensionality reduction. Also neural networks, elastic bunch graph theory, 3D morphable models and multi-resolution analysis are some other techniques usually used. Our work focuses on biometric authentication using face recognition. Our system detects at the airport or border point, the entry of any known terrorist, by known terrorist, we mean people already certified to be terrorists and our already on countries' security watchdog's list. This is achieved by training our system to identify any of the known terrorist i.e. on the list of INTERPOL. Our preferred technique is the principal component analysis; a holistic approach, among the various techniques available. Principal component analysis is based on Karhunen-Loeve transform and is our choice because of its simplicity, learning capability, robustness to small changes in the face image, speed and lesser computational overhead when compared to other techniques.

Our work is different from the existing works because of the application of several pre-processing algorithms to serve as multiple filters for the image in order to reduce the false acceptance rate (FAR) and false rejection rate (FRR) in our proposed system. This is obviously needed to make sure innocent people are not taken as terrorists or terrorists going free as innocent people. We also enhanced our system with a feature based technique. Also, our system works in an interactive time thus giving the user the real-time experience. The remaining part of this work is divided into four parts. The following section is the literature review, followed by the methodology and then the section showing our results. The last section contains our conclusion and future works.

2.0 RELATED WORK

Reference (Zhao *et al*., 2000) have a comprehensive survey of different face recognition techniques which include detailed description and classification of the algorithms both for still and video based recognition and should be consulted for further review.

Most works in computer recognition of faces has focused on detecting individual features such as the eyes, nose, mouth, and head outline, and defining a face model by the position, size, and relationships among these features. Such approaches have proven difficult to extend to multiple views and have often been quite fragile, requiring a good initial guess to guide them. Research in human strategies of face recognition, moreover, has shown that individual features and their immediate relationships comprise an insufficient representation to account for the performance of adult human face identification. Nonetheless, this approach to face recognition remains the most popular one in the computer vision literature.

One of the first works in face recognition was in (Galton, 1888), where a face recognition technique which focuses on detecting important facial features or key-points such as the eye corners, nose tips, mouth corners and chin edge was implemented. Relative distances between facial key-points were measured and a feature vector constructed to describe each face. These feature vectors were then used in comparing known faces in the database to unknown probe faces.

In reference (Bledsoe, 1966), semi-automated face recognition with a hybrid human-computer system that classified faces on the basis of fiducially marks entered on photographs by hand was implemented. Parameters for the classification were normalized distances and ratios among points such as eye corners, mouth corners, nose tip, and chin point. Also (Fischler et al, 1973) attempted to measure similar features automatically. They described a linear embedding algorithm that used local feature template matching and a global measure of fit to find and measure facial features. In (Yullie et al, 1989) the system was later improved on, based on deformable templates, which are parameterized models of the face and its features in which the parameter values are determined by interactions with the face image. In (Kohonen, 1989) and (Kohonen et al, 1981), an associative network with a simple learning algorithm that can recognize face images and recall a face image from an incomplete or noisy version input to the network was described and was later extended in (Flemming et al, 1990) by using nonlinear units and training the system by back propagation. In (Kanade et al, 1973), all steps of the recognition process were automated, using a top-down control strategy directed by a generic model of expected feature characteristics.

The holistic approach makes use of template matching and identifies faces using global representations i.e. the whole face is seen as one object (Huang, 1998), it then extract features from the whole face region. In this approach, as in the previous approach, the pattern classifiers are applied to classify the image after extracting the features.

A method of extracting features in a holistic system is by applying statistical methods such as Principal Component Analysis (PCA) to the whole image. PCA can also be applied to a face image locally; in that case the approach is not holistic. Irrespective of the methods being used, the main idea is the dimensionality reduction. A method usually used is the Eigenface Method by Turk and Pentland (Turk et al, 1991) which is based on the Karhunen-Loeve expansion. Their work is motivated by the ground breaking work of Sirovich and Kirby (Kirby *et al*., 1987, 1990) and is based on the application of Principal Component Analysis to the human faces.

The main idea here is the dimension-nality reduction based on extracting the desired number of principal components of the multi-dimensional data where the first principal component is the linear combination of the original dimensions that has the maximum variance; the n^{th} principal component is the linear combination with the highest variance, subject to being orthogonal to the n-1 first principal components. The sole aim here is to extract the relevant information of a face and also capture the variation in a collection of face images and encode it efficiently in order for us to be able to compare it with other similarly encoded faces.

Reference (Lee *et al*, 1999) proposed a method using PCA which detects the head of an individual in a complex background and then recognizes the person by comparing the characteristics of the face to those of known individuals. Also, in Crowley et al, 1999), PCA was used for coding and compression for video streams of talking heads. They suggest that a typical video sequence of a talking head can often be coded in less than 16 dimensions. Also in (Moghaddam et al, 2001), a similarity measure for direct image matching based on a Bayesian analysis of image deformations was proposed. They modelled two classes of variation in object appearance: intra-object and extra-object. The probability density functions for each class are then estimated from training data and used to compute a similarity measure based on the posteriori probabilities. They further present a novel representation for characterizing image differences using a deformable technique for obtaining pixel-wise correspondences. This representation, which is based on a deformable 3D mesh in XYI-space, is then experimentally compared with two simpler representation i.e. intensity differences and optical flow.

In (Murugan *et al*, 2010) the use of PCA and Gabor Filters was suggested. Firstly, Gabor Filters, Log Gabor filters and Discrete wavelet transform were used to extract facial features from the original image on predefined fiducial points. PCA was then used to classify the facial features optimally and reduce the dimension. The approximation coefficients in discrete wavelet transform was extracted and was then used to compute the face recognition accuracy instead of using all the coefficients. They suggest the use of combining these methods in order to overcome the shortcomings of PCA. Also, (Moghaddam, 2002) argued that, when raw images are used as a matrix of PCA, the eigenspace cannot reflect the correlation of facial feature well, as original face images have deformation due to in-plane, in-depth rotation, illumination and contrast variation. Also they argue that, they have overcome these problems using Gabor Filters in extracting facial features.

Reference (Cagnoni *et al*., 1999) implemented a feature based system; they used a fairly simple fingerprint which includes eye and skin colour, ratios of distances between prominent facial features such as eyes, mouth, nose and chin, and absolute and relative values of width and height of the face and the eyes. The system described the overall geometrical configuration of face features by a vector of numerical data representing position and size of main facial features. First, they extracted eyes coordinates. The interocular distance and eyes position was used to determine size and position of the areas of search for face features. They claimed that their experimental results showed that their method is robust, valid for numerous kinds of facial image in real scene, works in real time with low hardware requirements and the whole process is conducted automatically as applicable for an amber alert system they implemented.

A feature-based technique for face recognition in which eigenface was applied to sub-images (eye, nose, and mouth) was implemented in (Cagnoni et al, 1999). In it, they applied a rotation correction to the faces in order to obtain better results.

3.0 METHODOLOGY

3.1 Proposed System Overview

Our proposed system though primarily based on the PCA technique, is enhanced by being combined with a feature based technique. Our aim is to get the advantage of the two techniques and thus a more efficient system. Our system passes through different stages after acquisition and before recognition, the first being the extractions of some facial features which we think are very important. Here, we select some features and use them as distinct fingerprints for each individual image in the database, we then compute some weight for each fingerprint and total the aggregate weight for each image in the database, and the score is then labelled for each image.

After extraction of the needed features, we apply the PCA to the same image set in the database, this gives us some weight descriptors for each image after the eigenface has been computed and thus gives us the possibility of adding the total score we got for each image from their fingerprints to the new score computed based on their weight from the eigenface. For any probe image we are recognizing, we also make it to go through the above steps, such that the important features are also extracted and scored and the eigenface computed. We finally add the two weight scores i.e. from the eigenface computation and the features extracted and then compare the score with the aggregate scores in the database, if it matches the score of any image in the database, we recognize it as known. The steps are detailed as below:

(1) Face database formation phase: Acquisition and pre-processing/normalization of face images are done here, then the images are stored in the database. Training is performed on the images in this database and their corresponding eigenfaces and eigenvalues created. The system operates on 128 x 128 images in the database, to perform image size conversions and enhancements on face images; we have pre-processing steps for normalization which rescale all images to 128 x 128. Here, we also perform histogram equalization and background removal to improve face recognition performance. For each face acquired, we have two entries in the database such that one is for the image itself while the other is the weight vectors computed after training is done, as will be seen later in the chapter, this weight vector will be used to compute the ultimate weight for each image. It must be noted that the images we used for this work are images from our own face database. However, this should work fine for any image database given.

(2) Training phase: Training of the images in the database is done based on the PCA technique; principal component analysis is performed on the image set in order to calculate the eigenfaces which are then stored for later use, keeping only the M images that correspond to the highest eigenvalues. These M eigenfaces define the M-dimensional "face space". As new faces are experienced, the eigenfaces can be updated or recalculated. The corresponding distribution in the M-dimensional weight space is calculated for each face database member, by projecting its face image onto the "face space" spanned by the eigenfaces. The corresponding weight vector of each image in the database is then updated and recognition can be performed after we might have added the weights computed from the

feature based. The algorithm below depicts the steps taken when computing the eigenface and weights using the PCA.

1. Lets assume the face images in our database is $x_1, x_2, x_3, x_4 \ldots\ldots, x_M$ then we find the mean image which is $\Psi = \frac{1}{m}\sum_{n=1}^{m} X_n$
2. Next, we have to know how each face differs from the mean image above like this $\phi_i = X_i - \Psi$

   This set of very large vectors is then subject to principal component analysis, which seeks a set of M orthogonal vectors, U_n , which best describes the distribution of the data. The k^{th} vector, U_K, is chosen such that the eigenvalues $\boldsymbol{\lambda}_k = \sum_{n=1}^{m}(U_K^T\ \phi_n)^2$ which is also subject to eigenvector $U_I^T U_K$, where the vectors $\mathbf{U}_K$ and scalars $\boldsymbol{\lambda}_K$ are the eigenvectors and eigenvalues, respectively of the covariance matrix C of the training images depicted as

   $C = \frac{1}{m}\sum_{n=1}^{m}\phi_n\ \phi_n^T = AA^T$.

   In essence we are calculating the covariance matrix C.
3. The matrix $A = [\phi_1, \phi_2, \phi_3 \ldots\ldots \phi_m]$. The covariance matrix C, however is $N^2 \times N^2$ real symmetric matrix, and determining the N^2 eigenvectors and eigenvalues is an intractable task for typical image sizes. We need a computationally feasible method to find these eigenvectors.

Following these analyses, we construct the M x M matrix $L = A^TA$ where $L_{mn} = \phi^t_m\ \phi_n$ and then find the M eigenvectors, V_i of L. These vectors determine linear combinations of the M training set of face images to form the eigenfaces U_i. Which we represent as $U_I = \sum_{k=1}^{m} V_{IK}\,\phi_K$ where I = 1……M. The associated eigenvalues allow us to rank the eigenvectors based on how useful they are in characterizing the variation among the images. It should be noted that the eigenvalues is an integer value associated with the eigenfaces/eigenvector U_I. These eigenvalues are used to construct weights which are kept in the database with the label of that image i.e. the name of the person. Recognition is delayed till after extracting the important features and computing weight for the image with our feature based technique.

3.2 Feature Extraction and Ranking

Humans have always identify faces perfectly despite the marked similarity of faces as spatial patterns, this is possible because of our ability to extract invariant structural information from the transient situation of faces such as changing hairstyles, emotional expression, and facial motion effect. In fact, features are the basic elements for object recognition. Therefore, identifying and extracting effectively used features in human face recognition may be very useful. In this work, in addition to the eigenface method apply above, we carefully choose some features that we found to be very important and that mostly differs from person to person e.g. we found that the distances between the eyes, nose, and mouth were not useful as they vary little between people and thus we do not consider them for usage, likewise we found the eye and skin colour, ratios of distances between prominent facial features, and absolute and relative values of width and height of the face and the eyes to be useful.

For each facial image, we create fingerprint of some features, these fingerprints were determined based on our analysis of facial images and the variations between them. The list of our finally chosen features includes:

- red, green, and blue values of the eye colour
- ratios between the red and the green values of the eye colour denoted as RG
- ratios between the green and the blue values of the eye colour denoted as GB
- ratios between the red and the blue values of the eye colour denoted as RB
- the width and height of the eye
- the ratio between the width and height of the eye

- the ratio between the distance between the two eyes and the distance between the eye-line and the nose-tip
- the width and height of the face
- the ratio between the width and height of the face
- the RGB values of the skin colour
- The number of lines passing around the chin. Here, we use Hough transform to determine this.

After determining the features to be used, we extract them and then compute the values for them, and record the values in the database. The procedure is stated as below:

(1) We first determine the location of the two eye pupils and extract the eye colour by computing the average red, green, and blue values of each pixel in a determined area encompassing the eye pupil, excluding pixels which represent a skin colour.

(2) We also calculate the ratios between these values, that is, the red and green, green and blue, and red and blue values of the eyes and record them in the database for each image. It must be noted that for each record stored, we label it according to the name of the person whose face is in the database and we are currently processing.

(3) Using the location of the eye pupils, we check a small rectangular region surround-ding the eye pupil for the outer most left, right, bottom, and top pixels which do not represent a skin colour. This gives us the width and height of each eye, however, each eye may differ slightly in width and height and thus we will sum up the widths and heights of the two eyes and divide by two to obtain the average width and height of the eye, this is also recorded in the database as well as the ratio between the original widths and heights. The diagram below shows the procedure
Average eye height (H)=(a1+a2)/2.
Average eye width (W) = (b1 + b2) / 2
Ratio between the width and height of the eye = H/W
Ratio between the left and right eye's height = a1/ a2.
Ratio between the left and right eye's width = b1/ b2.

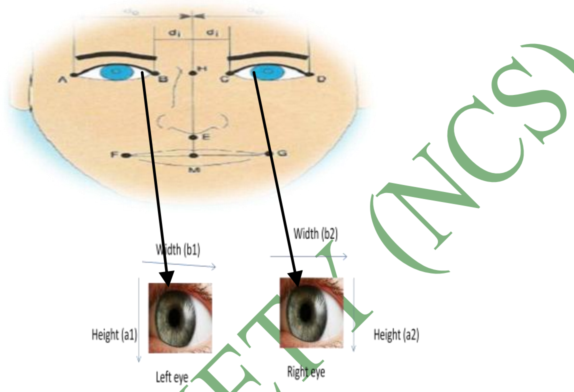

Figure 1: Eye and head midpoint localization and Left and right eye measurement.

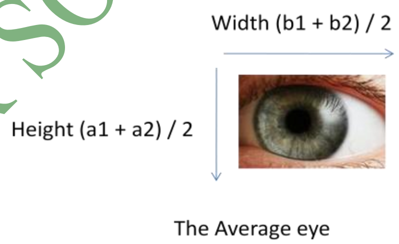

Figure 2. Average eye used.

(4) After that is done, we make a "face mask" by locating the nose and a rectangular shape in which, for every pixel, we have to check whether it represents a skin pixel. We will also use a smaller range allowed for a pixel to be recognized as a skin pixel in order to avoid picking up hair colour as skin.

(5) We check whether each pixel is at a specific distance from the nose (this should be shorter near the eyes, longer near the chin and the forehead). If this is true, and this pixel is also a skin pixel, we include it in the face mask. Since we are only interested in ending the most extreme points of the bounding box for the face, we keep track of the rightmost, leftmost, bottom and top pixels of the face mask only.

(6) We also have to compute the width and height of the face, as well as the ratio between them, and record it in the database.

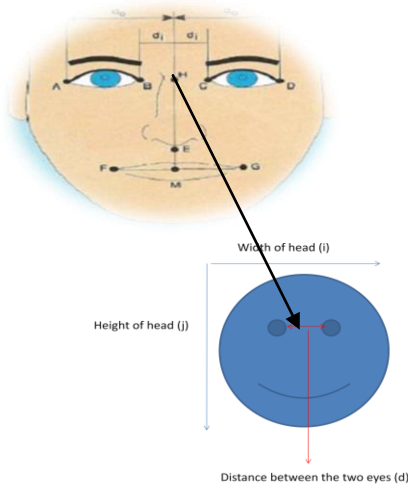

Figure 3. The face measurement.

The eye midpoint = d / 2.

(7) We then compute the red, green, and blue values for each skin pixel and calculate their average, which we also record in the database.

(8) Hough Transform is performed to detect

(a) All regions in the image which resemble straight lines, then

(b) The angle of each line is determined.

Since each image has been labelled according to the name of each person in the database and the above procedure has been performed on all the images, this gives us the chance of recording all the records taken with the name of each person in the database which also correspond to the label of the image. We simply choose some values as multiplier for all the features extracted, these are just assumed values given for the features in order to construct the weights. These values must be the same for every image we process and are as below:

(a) We multiply each of the red, green, and blue values of the eye colour by a multiplier of 10.

(b) The ratios between the red and the green values of the eye colour denoted as RG by 20

(c) The ratios between the green and the blue values of the eye colour denoted as GB by 30

(d) The ratios between the red and the blue values of the eye colour denoted as RB with 40,

(e) The width and height of the eye with 50 each

(f) The ratio between the width and height of the eye by 60

(g) The ratio between the distance between the two eyes and the distance between the eye-line and the nose-tip by 70

(h) The width and height of the face by 80 each

(i) The ratio between the width and height of the face by 90

(j) The RGB values of the skin colour by 100

(k) The number of lines passing around the chin by 5.

The total feature extracted weight thus becomes:

Total_feature_weight = a + b + c + d + e + f + g + h + i + j + k as computed from above.

We then total the sum of these values to get the aggregate weight score (Total_feature_weight) which we then record in the database also with the name of the person in the image.

Finally, we look at the weight computed by the eigenface technique above for each of the image labeled identically and add the value to the corresponding weight aggregate from the features extracted, this we then keep in the database as our final weight ranking of each image.

The proposed system can be represented diagrammatically as below

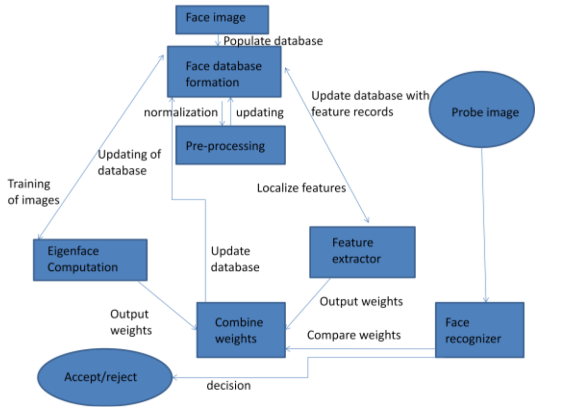

Fig 4.The Proposed Face Recognition model

3.3 Recognition and learning phase

Our focus here is to recognize and authenticate any probe issued by the user, the probe image is acquired from the webcam, rescale to the default size and normalized for any inconsistency such as lighting effect etc.

We then apply PCA to construct its weight vector with eigenface, thus,

(a) The new face image (X_{new}) is transformed into its eigenface components (i.e. projected onto "face space") by a simple operation $\omega^K = U^T_k.(X_{new} – \Psi)$. This is simply subtracting the mean image from the probe image. For k = 1 …. M'. This describes a set of point by point image multiplications and summations, operations performed at approximately frame rate on current image processing hardware.

(b) The weights form a feature vector, $\Omega^T_{new} = [\omega_1\ \omega_2 \ldots\ \omega_M]$ that describes the contribution of each eigenface in representing the probe face image, treating the eigenfaces as a basis set for face images and its size is (M′ x 1).

(c) The eigenvalues corresponding to the feature vector is then computed,

(d) After this, we also make the probe image to go through our feature extractor in order for us to compute our facial features weight as done above when computing for each image in the database.

(e) We then add the weight score from the PCA to the score just computed from the extracted features in order to get the ultimate weight for that image as computed for all the face database members.

(f) This is our classifier stage, in which we compare the ultimate weight computed for the probe image to the weights already computed for all the image database members. i.e. let the ultimate weights computed and stored with the labels of each person in the database be T1,T2……..Tn and the ultimate weight for the probe image be T_{probe} then this procedure is depicted as below

For j = 1 to n
If $T_j == T_{probe}$
1) *Accept image*
2) *Read the label of T_j and display it as a recognized face database member*

Else j = j + 1
End If
Else
1) *Reject image*
2) *Output information that the image is not recognized*
3) *Add to list of database member for next time use*

End for.

Thus if there be an image in the face database member that is similar to the acquired image within that threshold i.e. if a hit occurs (that is if there is a match whereby the new weight coincide with any of the weight already computed in the database) we check for the name of the image as it was labeled and output it as being recognized i.e. the face image is classified as "known". Otherwise, a miss has occurred and the face image is classified as "unknown". After being classified as unknown, this new face image is added to the face database with its corresponding weight vector for later use (we take this to be learning to recognize).

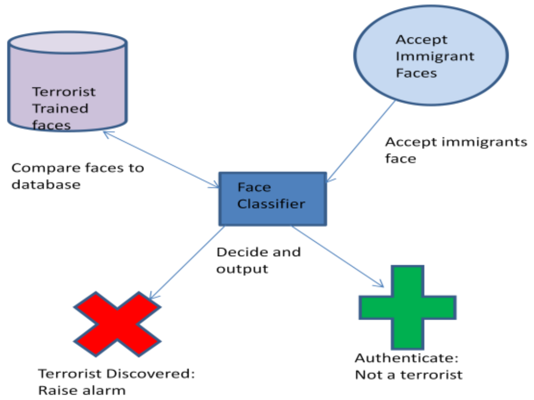

Fig. 5 the System classifying immigrants

For verifying people as being terrorists or not, our system is positioned at the every airport and border points. For any immigrants to be cleared and allowed access from the airport, such immigrant must be authenticated by our system. The system would have been trained with the faces of every known terrorists in the world such that for any immigrant the system just check to see if there is a match with any face ,in the trained database of the terrorists. If a match exist, an alarm is raised and the person arrested else the immigrant is not a terrorist.

4.0 RESULTSTS

We present the results obtained for the recognition rate on our illumination invariant face recognition system. The system was trained with our constructed face database of young people containing 15 subjects of 4 images each. The total image trained is 60 which are under different lightning intensity, scale and head pose. The testing was carried out using a total of 45 images, 3 images each of a subject from the people in the training database. We also tested the system with 15 images of unknown people, i.e. people that are not in the training database at all. The training of the system was carried out. Fuzzy-histogram equalization was applied for light variation. We also applied a rescaling algorithm for all the images to be of the same scale, background removal was not done to mimic a real scene experience but manual cropping was made where needed. The algorithms were implemented successfully using JAVA and trained and simulated on a Pentium-IV (2.0 GHz), 2GB RAM to provide valuable results.

In this work, we term the false acceptance to be the number of mistaken identity when any of the 15 unknown people as described above are used as probe and the system accept them as identified. Likewise, the false rejection is the number of mistaken identity when any of the real probe sets (45 images) is used and the system is not able to identify the person. The true acceptance depicts the recognition rate, i.e. the correct number of people the system is able to truly identify when the real probe set (45 images) is used and finally, the true rejection rate in this work is the number of people the system rejected as not identified when any of the 15 unknown images is used.

The table below shows the false acceptance and false rejection rate of the system.

False Acceptance	False Rejection	True Acceptance	True Rejection	Total Images Trained
2	8	39	12	60

Percentage of true acceptance/correct acceptance = 86.7%.
Percentage of false acceptance/mistaken acceptance = 13.4%.
Percentage of true rejection /correct rejection = 80.0%.
Percentage of false rejection /mistaken rejection = 17.8%.

5.0 CONCLUSIONS AND ACKNOW-LEDGEMENT

5.1 Conclusion

In this work, a face recognition based authentication system has been implemented. We combined two major techniques in order to increase our system efficiency i.e. principal component analysis was used to compute some weight for each image which was then added to the weights computed by our feature based approach.
We also applied some pre-processing steps like the histogram equalization, cropping and automatic rescaling of all images concerned in order to achieve illumination and scale invariance. Our system works well for the surveillance system we have

implemented and our training of images is done relatively fast. The result obtained showed that the system achieved a good recognition rate under real-time scenario. Future works can extend this work to include pose invariance and robustness to facial details such as beard and glasses worn by subject.

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