Development of a Facial Recognition System with Email Identification Message Relay Mechanism

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***Abstract*— Attendance records play a vital role in the educational sector. It is so vital that students are not allowed to sit for examinations if they do not meet the class attendance benchmark. But students, instead of making sure they attend classes regularly, devise cunny ways of committing attendance fraud. This unpleasant trend has made it necessary to develop systems that can take accurate class attendance records and minimize fraud. The use of biometrics to develop attendance taking systems is becoming quite popular. One of such biometrics is The Face. In this paper, a facial recognition algorithm known as Fisherfaces or Fisher Discriminant Analysis (FDA) which is not sensitive to substantial variation in facial look and illumination is used to develop the facial recognition attendance taking system. The system implemented has a training database of Ten (10) students. Ten (10) facial images of each student are taken with different composures, looks and under different levels of illumination. Tests on nine (9) students in the database yielded accuracies of as low as 70% and as high as 90%. This validates the proof that the more the number of training facial image in the database, the higher the accuracy of Fisherfaces approach. The simple mail transfer protocol (SMTP) was interfaced with the database to send identification messages (name of student identified with time and date of identification) to the email address of the administrator (in this case the lecturer) in real-time to effectively monitor the attendance. The result was found capable of eliminating attendance fraud.**

Keywords—fisherfaces; extraction; simple mail transfer protocol (SMTP); facial recognition.

I. INTRODUCTION

The face as a form of biometric has a lot of advantages. Most biometric technologies require their users to perform some form of action. The fingerprint scanner gets the fingerprint of only users that place their finger on it. The user of an iris scanner must place his eye close to the camera without blinking. But in the case of recognizing faces, images of the face can be acquired by a camera from a distance without any effort or action on the part of the user. This is the advantage that is exploited in security and surveillance applications. Fingerprints can be easily spoofed and could get damaged by injuries. The equipment to acquire iris and retina images is expensive and is too sensitive to body motion. Background noises affect the accuracy of voice recognition and signatures can be forged. Facial recognition systems can be set up with inexpensive cameras. The risk of contracting infections due to the use of a biometric system by multiple users is never a concern when using the face as a biometric. The Face recognition technology used here compensates for variations in orientation, illumination and scale by using the robust algorithm, Fisherfaces.

One of the most popular means by which e-mails are sent and received from one sever to the other use the Simple Mail Transfer Protocol (SMTP). The SMTP protocol works fluidly across many transport service environments.

Feature extraction by dimensionality reduction, known as Fisher Discriminant Analysis (FDA) or Linear Discriminant Analysis (LDA) was used. It aims to use class-specific dimensionality reduction to discover what combination of features distinguishes best between classes. It also optimizes the between-classes to within-classes scatter. This ensures that same classes are gathered together in close proximity and different classes are reasonably separated from each other when they are represented in the lower dimension [23].

The use of face recognition technique has been growing rapidly in the past few years in the areas of law enforcement, biometrics, security, and other commercial sectors but very little has been done to apply face recognition technology in education. This forms the basis for the study. The study focuses on using face recognition technology to take student attendance in class and relaying the outcome via e-mail to authorized persons.

Face recognition does not always give a hundred percent accuracy rate. The fisher discriminant analysis (FDA) facial recognition algorithm used in this study has a very high face recognition accuracy rate due to its properties.

II. RELATED STUDIES

A. Face Recognition MethodsAuthors and Affiliations

Fisherfaces works on the principle of intensity images to recognize faces. This method of facial recognition can be done in two ways and they are:

1) Feature based method: In this method, the facial image is processed and important facial features are identified, extracted and measured. The geometric relationship between these facial features (eye nose, mouth etc.) and other fiducial

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points on the face is computed. The output of this process is a vector of geometric features. To match facial templates, statistical pattern recognition is used. A tolerance level is set such that the precision required to recognize individuals based on the best-fit-parameters without ignoring the minute facial details that distinguishes one face from the other is preserved. The feature based approach has the advantage of being robust to variations in the input image's position. This is possible because the special facial features are extracted before matching is done. [13]. Compactness and good matching speed are other benefits of this feature extraction method [17]. Automatic detection in feature extraction method is difficult to achieve. The designer of the algorithm has to decide which facial feature is important. A wrong decision could make the facial recognition system to become intrinsically deficient in discriminating between facial templates [13].

2) Holistic: In this method, faces are differentiated based on the overall outlook of the face and not on any one local facial feature. A great advantage of the holistic approach is its ability to preseve the image wholeness by concentrating on the most important points of interest.This also becomes a disavantange when there are variations in lighting conditions and image position. This method of facial recognition can be achieved in two ways and they are:

a) Statistical: The simplest of the two approaches to holistic extraction method, it converts the input image into a two dimensional array intensity values. Facial recognition is done by directly comparing and correlating the input image with the facial images stored in the database. It is prone to errors in matching as a result of poor lighting, face orientation, background clutter and noise. [22]. The direct matching method has the disadvantage of performing classification in a space of very highdimensionality [18]. To solve this classifying issue, other methods that employ statistical dimensionality reduction measures were developed. They include the Principal Component Analysis (PCA)[19] and Turk and Pentland's eigenpictures[5].

b) Artificial Intelligence: Neural networks and machine learning tools are utilized in recognizing faces. Experiments and prototypes of facial recognition systems built with neural networks and machine learning tools have generated positive results. Some tests recorded as high as 96.2% success rate (correctly recognized faces) [24]. Some artificial intelligence approaches even went as far as including evolutionary pursuit and techniques based on boosting to get the desired facial recognition accuracy even in difficult scenes.

B. Face Recognition system Architecture

Face recognition systems always have a video or image input. Verification or identification of the users is the output of all facial recognition systems. Facial recognition in some systems is carried out in three steps [21]. Sometimes, face extraction and detection could be carried out simultaneously.

The process of getting facial images from scenes is termed Face Detection. In so doing, the system maps out certain regions of a scene as face(s). The system continues to track the face even when the face seems not to be static (the user is moving), gets and crops the facial image to finalize the detection process. The needed facial features are extracted from the facial image in a process called Feature Extraction. Variations in facial regions and angles are some of the features extracted from the facial image. The proposed method used for feature extraction in this paper is the Fisher Discriminant Analysis (FDA). The facial recognition system finally identifies or verifies users by checking for their presence in the database. This phase involves a comparison task, a discriminating algorithm and an accuracy test.

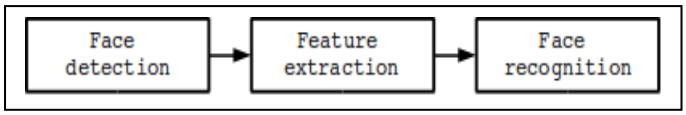

Fig. 1. A basic facial recognition system

C. Face Detection

Face detection is a complex network of tasks. While some systems can carry out detection and location of faces concurrently, other systems separate the two processes by performing one before the other (usually detection before location). Tracking algorithms, if added to the detection and location process, greatly improves the system's accuracy.

Reduction in the data dimension is first done to achieve a good response time. Preprocessing is then carried out to ensure that the image conforms to the algorithm's prerequisites. Relevant facial areas are thereafter extracted by the algorithm. The features extracted are measured and quantified. The weighted, analyzed and evaluated data got from the facial image is used by the system to decide whether it is indeed a face and locate the face. Finally, most of the algorithms used in facial recognition systems have the ability to learn and can be trained with new data models.

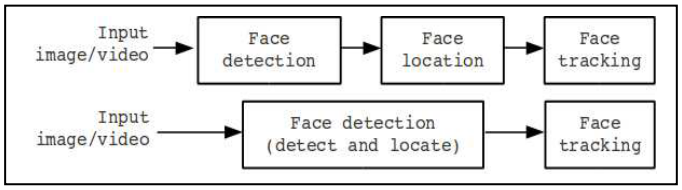

Fig. 2. Face detection process

D. Feature Extraction

The process of extracting specific information from an acquired facial image is called Feature Extraction. Extreme care is usually taken by the system at this stage to ensure that users' facial images are stored with enough discriminating features, thus enabling a very low margin of error during the process of Identification or Verification. The memory size used and computing time for the feature extraction process is made as efficiently as possible. The result should encourage easy

discrimination and classification. The output should also be optimized for the classification step. There are several steps in Feature extraction; some of them include, dimensionality reduction involves several steps - dimensionality reduction, extraction and selection. The result of selection and extraction is usually a reduction in dimension. The algorithm that performs this step usually carries out dimensionality reduction as a compound task of selection and extraction. Dimensionality reduction is an essential task in any facial recognition system.

The goal is always to fix high-dimensional data in a low-dimensional space without any or very minute loss of the information in the original data. Classifiers are built based on the number of images taken and the amount of features to be extracted. The classifier design must be such that it does not cause an increase in the error rate (false positives). The number of training samples must be commensurate with the number of features to be extracted. The benchmark of using training image samples that are at least ten times the number features to be extracted per class is a good design threshold for classifiers. Using too many features to design a classifier will consume too much space and lead to a higher level of false positives especially if there is redundancy in the features extracted. An optimal balance must be struck between too few and too much extracted features in classifier design.

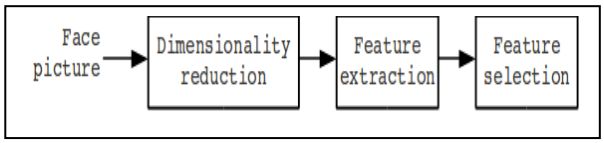

Fig. 3. Feature extraction processce detection process

E. Fisher Discriminant Analysis (FDA)

A very popular means of carrying out dimensionality reduction, it seeks out positions in the original image that can be used to effectively and correctly differentiate between classes as oppose to correctly describe data acquired from facial images. With an assigned number of distinctive features in relation to the data description, the fisher discriminant analysis seeks to linearly combine these two parameters to get the biggest mean difference between wanted classes.

When a set of N sample images are considered, $\{x_1, x_2, \ldots\ldots, x_N\}$ each having a value in the assigned n-dimensional space, and belonging to one of c classes, $\{X_1, X_2, \ldots\ldots, X_N\}$. The linear transformational mapping of the original n-dimensional space to a m-dimensional sample space, with m<n. The new sample space vectors $y_k \in \mathbb{R}^m$ can be defined by the linear transformation in Equation one (1):

$$y_k = W^T x_k \qquad k = 1, 2 \ldots N \qquad (1)$$

Where $W \in \mathbb{R}^{n \times m}$ is an orthonormal columned matrix. The vectors in W are selected in such a way that the between-class scatter and within-class scatter ratio is optimized maximally. If the within class scatter matrix is given as:

$$S_W = \sum_{i=1}^{c} \sum_{x_k \in X_i} (x_k - \mu_i)(x_k - \mu_i)^T \qquad (2)$$

The between-class matrix is given by:

$$S_B = \sum_{i=1}^{c} N_i (\mu_i - \mu)(\mu_i - \mu)^T \qquad (3)$$

x_i^j is the i^{th} sample of class j, μ_i is the average image of class X_i, c is the number of classes and N_i is the number of samples In class X_i. S_W is nonsingular, the optimal projection W_{opt} is selected as the orthonormal columned matrix which optimally maximizes the ratio of the determinant of the between-class scatter matrix of the projected samples to the determinant of the within-class scatter matrix of the projected samples:

$$W_{opt} = arg\max_W \frac{|W^T S_B W|}{|W^T S_W W|} = [w_1, \ldots w_m] \qquad (4)$$

Where $\{w_i | i = 1, 2 \ldots\ldots m\}$ is the set of generalized Eigenvectors of S_B and S_W corresponding to the m largest generalized eigenvalues $\{\lambda_i | i = 1, 2, \ldots\ldots, m\}$;

$$S_B w_i = \lambda_i S_W w_i, \qquad i = 1, 2 \ldots. m \qquad (5)$$

There are at most (c – 1) nonzero generalized eigenvalues, the upper bound on m is (c – 1), with c representing the number of classes.

In the face recognition, the challenge is usually the fact that the within-class scatter matrix $S_W \in \mathbb{R}^{n \times n}$ is always singular. This is because the rank of S_W is at the highest, (N-c). Generally, the number of pixels in each image, n far exceeds the number of images in the training set, N. It is therefore realistic to get a matrix W that would give a within-class scatter projection of zero. To beat the challenge of the complicating singular matrix, S_W, a less demanding criterion is proposed. The proposal, Fisherfaces, makes the problem simpler by mapping the original image set to a space of a lower dimension and gets a within-class scatter matrix, S_W that is not singular. This was got by using principal component analysis (PCA) to get a much smaller sample space (N – c). The standard fisher linear discriminant analysis (FLD) is then used to reduce the dimension of the sample space to (c – 1).

W_{opt} becomes;

$$W_{opt}^T = W_{fld}^T W_{pca}^T \qquad (6)$$

Where;

$$W_{pca} = arg\max_W |W^T S_T W|$$

$$W_{fld} = arg\max_{W} \frac{\left|W^T W_{pca}^T S_B W_{pca} W\right|}{\left|W^T W_{pca}^T S_W W_{pca} W\right|}$$

The optimization of W_{pca} is done by carrying out n $\times$ (N-c) matrices with orthonormal columns. The optimization for W_{fld} is done by carrying out (N-c) $\times$ m matrices with orthonormal columns. In solving W_{pca}, we ignored the littlest (c-1) component.

F. The Simple Message Transfer Protocol

SMTP is an email transfer protocol used to relay electronic messages between servers. It is a push technology that uses a store and forward mechanism. A lot of mail transfer agents implement SMTP. Initially, SMTP servers were used by organizations to receive external mails and send mails. It was purely an internal mail transfer protocol. It thereafter grew to become a means through which individuals can send and receive mails. This was made possible by the popularity of the world-wide web. As spam became more widespread, SMTP started implementing authorization and traceability protocols. This well-ordered combination of message relaying and submission is the basics of today's email security practice.

III. METHODOLOGY

A. The Database

The database held the facial images of nine persons. Each person had ten (10) facial images taken with different pose and facial expressions to ensure a very high level of system accuracy in recognizing faces. The particulars of each person are also stored in the database along with their unique facial images.

A camera was used to acquire facial images in real time. PostgreSQL was used to create the relational database. The Fisherfaces algorithm, written in optimized C/C++ was got from OpenCV, an online library with strong focus on computational efficiency in real-time systems. QtC++ was used to design the graphical user interface for giving and receiving commands such as capture, login, logout, create new student, list all students, configuration etc. and for relaying information to the administrator's e-mail.

B. Enrollment Stage

The required username and password were entered before enrollment began. There are various items on the main menu after logging in, and they are:

1) New student: provides the page through which the particulars of new students can be got. When saved, new pages that enable the taking of facial images come up. The facial images along with the particulars of each new student are stored in the database.

2) List all students: It gives a list of all students in the database of the system. Any student can be selected to see or edit his/her full information, including their images in the database.

3) Configuration: It is where the settings for the email are configured. The email address to receive the identification message can be changed here. Also, an option is provided to use the SMTP.

C. Identification Stage

The required username and password were entered to begin identification of student. After capturing the face, the facial recognition system immediately sends a message to the administrator's email address, detailing the name, time and date the person was identified.

D. Email Message

After identification, a message saying "STUDENT's NAME" was matched by the facial recognition software on "Date Identified" is sent in real-time to the administrator's email address. The name, time and date in the above message varies depending on the individual being recognized and the time of identification respectively. A sample of the e-mail message for the student called 'Oputa Rhema' is show in Figure 6.

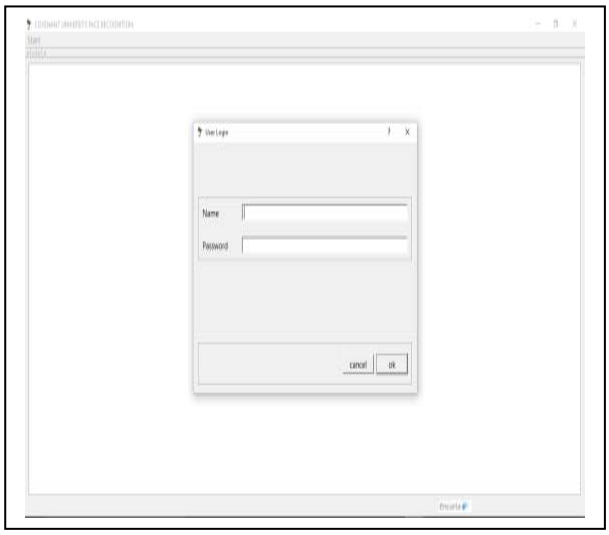

Fig. 4. Login dialogue box

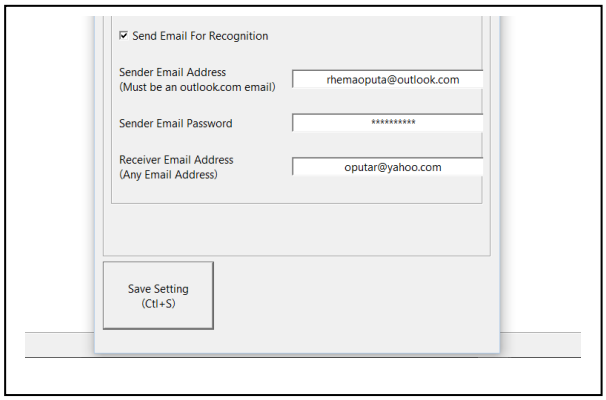

Fig. 5. Configuration settings for sending Email

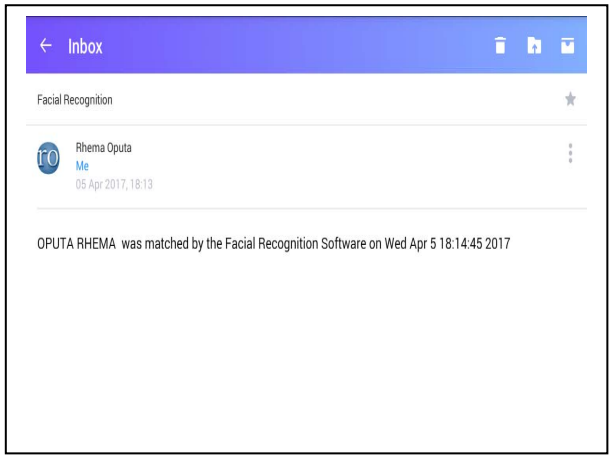

Fig. 6. Identification Email message

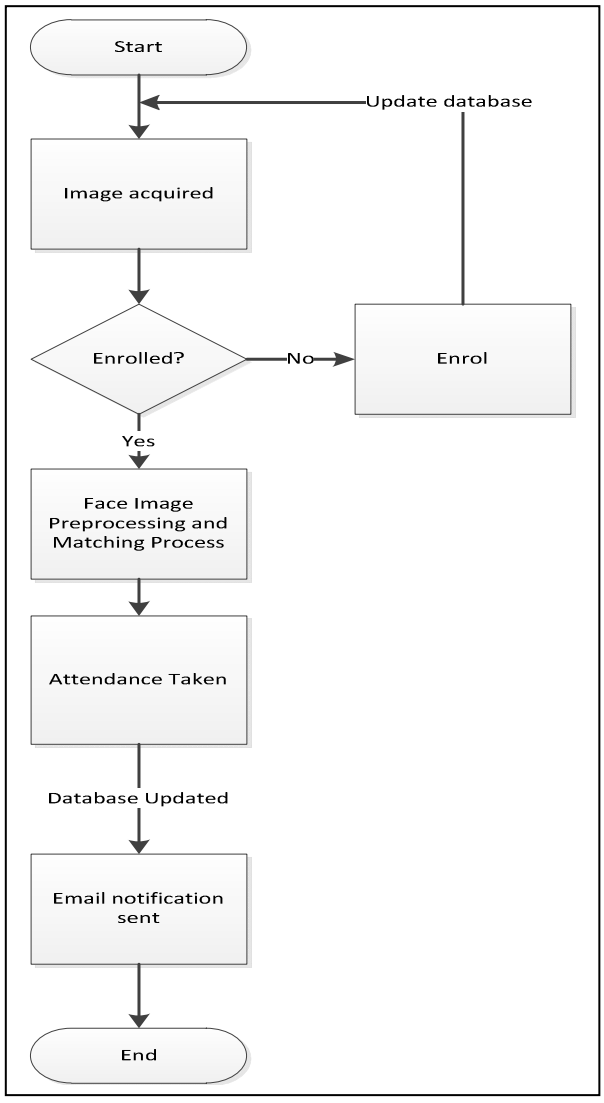

Fig. 7. Algoritm of the designed face recognition attendance system

IV. Result and Discussion

Tests were carried out on the facial recognition system to know its accuracy under varying conditions of illumination. The test was carried out on a database of nine (9) individuals. After the enrolment of each person, identification for each person was done ten (10) times to ascertain the number of times it would identify the person correctly. In the Table I, the number of accurate identifications and false positives of each individual are shown in Table I:

TABLE I. Results from Tests Carried out on Facial Recognition System

Name	*True positives*	*False positives*	*Accuracy (%)*
John	7	3	70
Dan	6	4	60
Joy	9	1	90
Dave	7	3	70
Lily	6	4	60
Max	8	2	80
Bryan	8	2	80
Sonia	7	3	70
Linda	6	4	60

The lowest percentage in terms of accuracy was 70% and the highest accuracy recorded was 90%. This study focused on the development of a facial recognition attendance system with email relay mechanism (using simple mail transfer protocol (SMTP)). The study proposes an attendance system with real-time email relay mechanism. The face recognition process was carried out using Fisherfaces because of its high performance under conditions such as varying pose and different illumination. A programmed graphical user interface (GUI) for interaction with the system was also put in place for taking user details and storing face images in a database created with PostgreSQL. QtC++ programming language was used to develop the facial recognition application.

The problem of face recognition has been an ongoing subject of research for more than 20 years. Although a large number of approaches have been proposed in the literature and have been implemented successfully for real-world applications, robust face recognition is still a challenging subject, mainly because of large facial variability, pose variations and uncontrolled environmental conditions. Fisherfaces algorithm has been implemented for feature matching and recognition. It has shown an accuracy of 71.1% with a database of nine (9) individuals and ten (10) images. Although, Martínez, A. M., & Kak, A. C. in [20] showed that in Fisherfaces approach, the higher the number of training samples, the higher the accuracy obtained.

V. CONCLUSION

Fisherfaces algorithm has been implemented for feature matching and recognition. With a database of nine (9) individuals and ten (10) images for each individual, the designed system showed accuracies as high as 90% and as low as 70%. The accuracy of the designed system can be improved.

The Simple Message Transfer Protocol (SMTP) was successfully used to relay real-time messages regarding the verification and identification of all persons to the administrator's e-mail address.

The real-time e-mail in combination with the good level of facial recognition accuracy can be used to effectively checkmate attendance fraud.

VI. FUTURE WORK

A lot more images, up to forty (40) per enrollee would be used for future studies. This is because the higher the number of images for each individual stored in the database, the higher the accuracy of the facial recognition system.

VII. ACKNOWLEDGEMENT

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