Implementation of Face Recognition Algorithm for Biometrics Based Time Attendance System

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***Abstract*— Face Recognition begins with extracting the coordinates of features such as width of mouth, width of eyes, pupil, and compare the result with the measurements stored in the database and return the closest record (facial metrics). Nowadays, there are a lot of face recognition techniques and algorithms found and developed around the world. Facial recognition becomes an interesting research topic. It is proven by numerous number of published papers related with facial recognition including facial feature extraction, facial algorithm improvements, and facial recognition implementations. Main purposes of this research are to get the best facial recognition algorithm (Eigenface and Fisherface) provided by the Open CV 2.4.8 by comparing the ROC (Receiver Operating Characteristics) curve and implement it in the attendance system as the main case study. Based on the experiments, the ROC curve proves that using the current training set, Eigenface achieves better result than Fisherface. Eigenface implemented inside the Attendance System returns between 70% to 90% similarity for genuine face images.**

***Keywords* - face recognition, opencv, eigenface, fisherface, attendance system, biometrics.**

I. Introduction

Traditionally based on something that *one has* (key, magnetic or chip card) or *one knows* (PIN, password), identity verification has achieved more reliable verification and identification well-known as biometrics [1]-[2]. One of the most natural biometric is face recognition. Mostly developed for surveillance camera in public places, researchers tend to develop biometrics application in order to achieve higher degree of security. Universality, uniqueness, permanence, measurability, and performance are following factors need to be satisfied by biometric identifiers [3]. Face recognition's ability to identify a person without the object's cooperation has made face recognition as one of the most considered biometrics applications despite face recognition lack of uniqueness and performance compare to other biometrics applications.

The purpose of this research is to implement and develop face recognition algorithm provided by OpenCV 2.4.8. Even though all biometrics has its own unique positive value, no single biometric trait has been identified as fully stable or distinctive for now. This is where the multimodal biometric takes its role as the combination of several biometric systems to make it even more secure and powerful. The goal of this research is also to test and develop face recognition as part of future multi-modal biometrics application by taking Attendance System as its case study.

II. PCA and LDA as Face Recognition Algorithm

Principal Component Analysis (PCA) is developed in order to overcome expensive computation and the need of great amounts of storage of older face recognition technique such as correlation methods. Dimensionality reduction of linear projection that maximizes the scatter of all projected samples is chosen by PCA to represent high-dimensional training set into a lower dimensional subspace [4]. While Eigenface uses PCA, the Fisherface method uses Linear Discriminant Analysis. LDA also developed for dimensionality reduction. Eigenface and Fisherface comparison which will be used in this research can be seen in Table I.

Martínez [5] concluded that LDA which deals directly with class discrimination does not always outperform PCA. The small number of samples per class or the non-uniform training data which sample the underlying distribution become the main reasons of this unusual discovery. Therefore, it is recommended that we also perform a comparative analysis on algorithms which are going to be used in our biometric based time attendance system.

Tripathi [6] introduced false match rate (FMR), false non-match rate (FNMR), receiver operating characteristics (ROC) as performance metrics for biometrics system. Receiver operating characteristics or ROC depicted the exchange between FMR and FNMR. While the equal value between accept and reject errors is known as Equal Error Rate (EER). This research will compare the performance of the two algorithms (Eigenface and Fisherface) based on their ROC curve.

TABLE I Comparison between Fisherface and Eigenface

	PCA (Eigenface)	LDA (Fisherface)
Mathematical Comparison	Calculates the Covariance Matrix using the equation $C = XX^T$	Calculates the Between Class Variance $S_B = \sum_{i=1}^{c} N_i (\mu_i - \mu)(\mu_i - \mu)^T$ And Within Class Variance $S_W = \sum_{j=1}^{c} \sum_{y_i=j} (x_i - \mu_j)(x_i - \mu_j)^T$
Algorithm Behaviour	Eigenface maximize the scatter between all face images in the training set	LDA uses class specific linear methods for dimensionality reduction that minimize the within class scatter and maximize the between class scatter [4].

III. METHODOLOGY

The challenge in algorithm comparison can be defined: Given a set of face images labelled with the person's identity (the training set) and an unlabelled set of face images from the same group of people (the face sample), Euclidean distances produced by Fisherface and Eigenface will be recorded. FMR represents an acceptance over a non-legitimate user because the system finds biometric data similar enough to the master template of a legitimate user, and FNMR represents rejection over a lgeitimate user due to the system not finding the user's current biometric data similar enough to the master template. A visual characterization of the trade off between FMR and FNMR known as receiver operating characteristics or ROC will be created. Creating ROC plot for both Fisherface and Eigenface will visually inform researcher about the best algorithm to use for handling a certain training set.

There will be two features created for Attendance System study case; "Collect Face Data" and "Attendance Recognition". Collect Face Data is built in order to collect face images from several students who are going to use this application in a real-time environment and pre-processed all the face images to yield a better similarity result. Users (students) are required to provide their valid student's ID in order to turn on the built-in webcam. In this research, each subject's faces are taken under the same room with moderate lighting condition to get the best training set. Each subject will sit in a chair with black background behind them to minimize the reflection of light. All subjects are cooperated means that they are using the same pose during the process in order to get a good training set. But there is no photometer used during the process. The only problem during the training set acquisition process is the light coming from a window in the room. In order to minimize the lighting effect coming from that window, we tried to take all the training set directly in the same time in hope that the light intensity coming from the window did not change during the process. Facing straight to the camera allowed pre-trained face detection algorithms inside OpenCV 2.4.8 to work. This research uses both haar-cascade and LBP-cascade from OpenCV 2.4.8 for face detection. Haar-cascade on the other hand is used for eye detection. Face detection process in this research will detect the whole face and both eyes. Captured face will be pre-processed and displayed. User is eligible to press "Collect Face" button whenever his/her captured face is displayed correctly. The flowchart depicting the process is shown in Fig. 1.

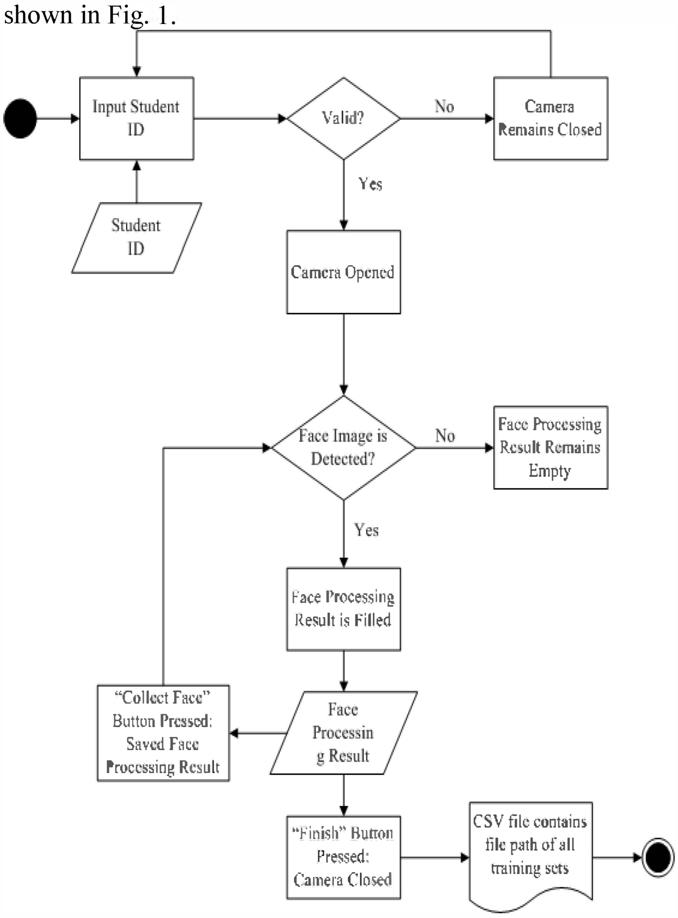

Fig. 1 "Collect Face Data" flowchart

As depicted in Fig. 2, "Attendance Recognition" task began with training the face recognizer against training set. "Attendance Recognition" also allowed its user to set a countdown timer (e.g. 15 minutes) where students must present their face before the countdown ends in order to fill the attendance. Once the "Run" button is pressed, the countdown timer will start and the camera will be turned on. Student's face must be presented in front of the camera and pressed the "Attend" button in order to be marked as "present" during class. While presenting the face in front of the camera, students who inputted their face in the training set will be recognized, while students who did not input their face in the training set using "Collect Face Data" feature will be labelled as "Unrecognized Person".

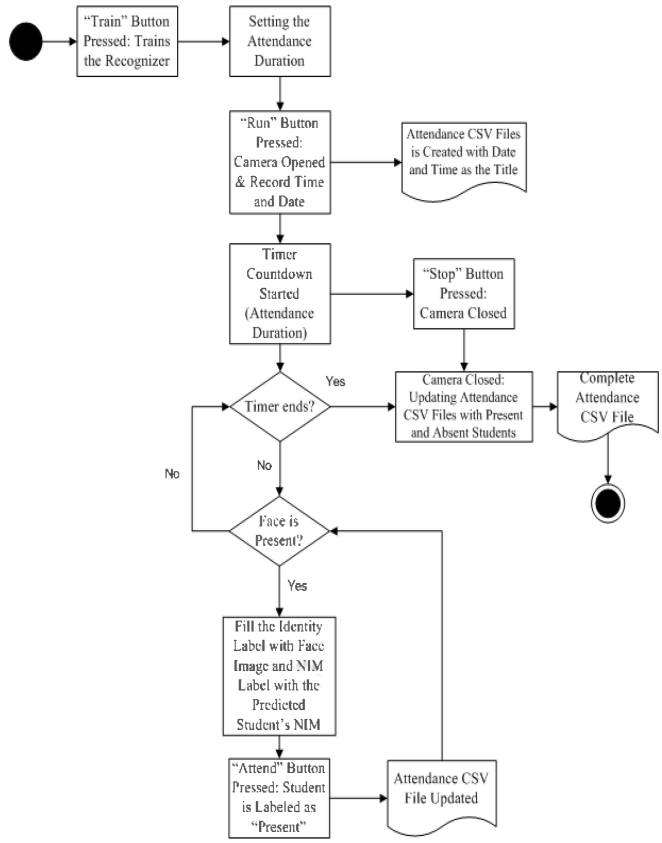

Fig. 2 "Attendance Recognition" flowchart

IV. EXPERIMENTAL RESULTS

The training set used for comparing the two algorithms is taken from Swiss German University's students. Ten students are chosen for this research. Student's face image samples were taken directly using "Collect Face Data" module inside the Attendance System application. Student's face will be taken eleven times. Each student's face will be taken under a steady expression to minimize variation in facial expression and asked to tilt their face a bit to the left and moved their head slowly to the right each time their face is taken. Performing the above training set acquisition process will produce 100 face images for the training set and another 10 face images as samples to test against the training set.

Fig. 3 Face Image Samples

Before we conduct the experiment, all training set (e.g. see Fig. 3) and face sample will be pre-processed using a well-known "preprocessFace.cpp" module [7]. Both Fisherface and Eigenface algorithm successfully recognize each face sample with the correct respective training set. But the similarity percentage is yet to be analysed in the following subsections.

A. *Eigenface*

TABLE II Eigenface FMR and FNMR value at specific threshold

THRESHOLD	FMR	FNMR
0	1.00	0.01
10	0.97	0.22
20	0.81	0.51
30	0.53	0.67
40	0.25	0.77
50	0.10	0.83
60	0.06	0.88
70	0.04	0.91
80	0.01	0.94
90	0.00	0.97
100	0.00	1

FMR obtained its value when a certain threshold set for the recognition algorithm recognize impostor as a genuine match. On the other hand, FNMR obtained its value when a genuine user is blocked to access his own. Table 1 shows how FMR and FNMR behave against each other. Setting the threshold too low will produce FMR result high (near 1) and produce FNMR result low (near 0). But setting the threshold too high will produce FMR result too low (near 0) and produce FNMR result too high (near 1). The ROC graph produced by the Table II is depicted in Fig. 4.

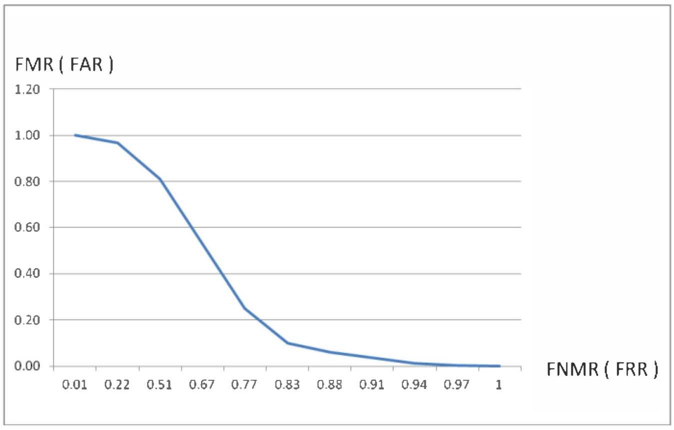

Fig. 4 Eigenface's ROC curve

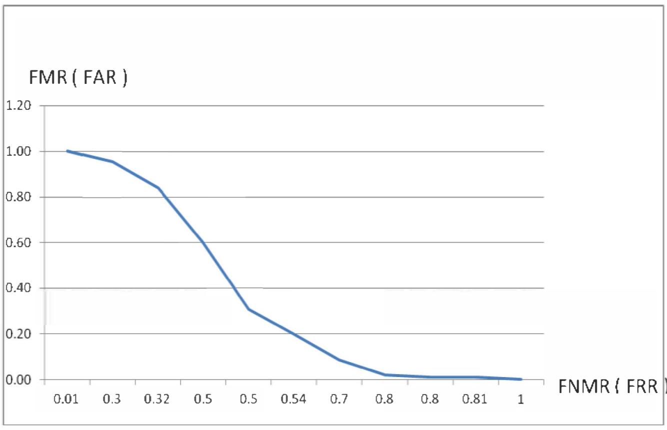

Fig. 5 Fisherface's ROC curve

B. *Fisherface*

TABLE III Fisherface FMR and FNMR value at specific threshold

THRESHOLD	FMR	FNMR
0	1.00	0.01
10	0.95	0.3
20	0.84	0.32
30	0.60	0.5
40	0.31	0.5
50	0.20	0.54
60	0.09	0.7
70	0.02	0.8
80	0.01	0.8
90	0.01	0.81
100	0.00	1

Table III presents the FMR and FNMR value of Fisherface algorithm. From the table above, the graph of Fisherface algorithm is depicted in Fig. 5.

C. *Algorithm Comparison*

By combining both ROC from Eigenface and Fisherface, we will obtain the following graph.

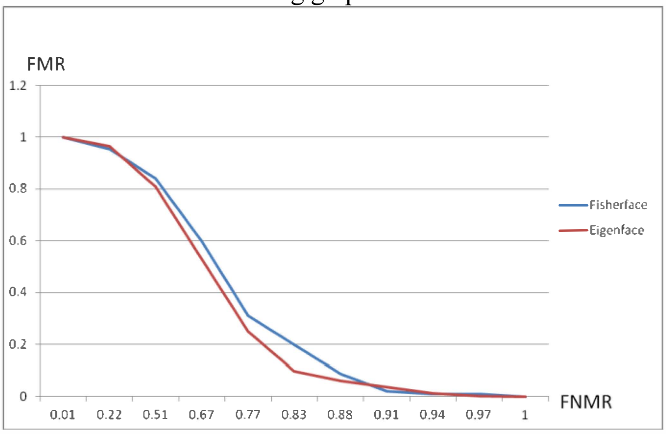

Fig. 6 Eigenface and Fisherface ROC curve

In ROC curves, the closer the curve follows the left-hand border and then the below border of the ROC space, the more accurate the test. Using Fig. 4, we can analyse that Eigtenface's line resides a little bit lower than Fisherface's line. Therefore, using our current training set Eigenface presents better result than Fisherface in this research.

D. *Attendance System Implementation*

"Collect Face Data" module is created to collect student's face image. Using the student's unique ID number, students are allowed to activate the camera and record his/her own face. In this module, the application will activate 3 classifiers to perform face detection over a face image. The whole face image is detected by using the LBP-cascade for frontal face (lbpcascade_frontalface.xml). LBP-cascade for frontal face is believed to be faster than the Haar-cascade counterpart [8]. The other two classifiers used for "Collect Face Data" are Haar-left eye cascade classifiers and Haar-right eye cascade classifiers. The main purpose of these two eye classifiers is to make sure that the subject is facing straight to the camera.

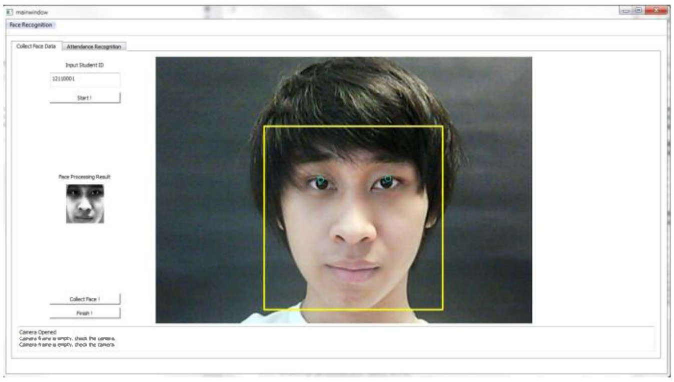

Fig. 7 'Collect Face Data' module in Attendance System

The result application of "Attendance Recognition" feature can be seen in Fig. 6. The graphical user interface shows several functionalities such as training the recognizer, setting the attendance duration, identity identification, and attend button.

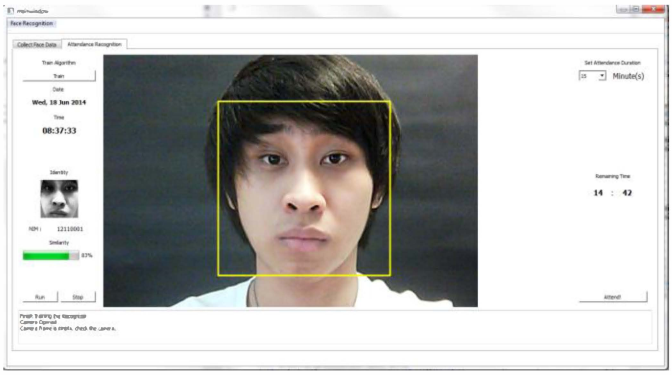

Fig. 8 'Attendance Recognition' module in Attendance System

After the attendance duration timer (top-right) is set and "Train" button is pressed (top-left) by the user. User is allowed to press the "Run" button to turn on the camera. Student must begin to present their face in front of the camera before the remaining timer (sets at the beginning of the process) ends. Student face captured will be pre-processed and showed along with its corresponding student's NIM. Student who found their data correct can press the "Attend" button to verify his/her attendance for specific subject. After the remaining time ends or a user press the "Stop" button, the camera will be closed by the application and a CSV file will be auto-generated. This CSV file will record all students who press the "Attend" button during the attendance recording time. CSV file generated by the "Attendance Recognition" feature can be seen at Fig. 7.

12110001;present
12110003
12110004
12110007
12110011
12110012
12110013
12110020
12110025
14210030

Fig. 9 CSV file generated by "Attendance Recognition" feature

On the same environment as where the face image training set is collected, the Attendance System application can recognize a genuine matching face with similarity percentage around 80% to 90%. On contrary, when the Attendance System application is running under different environment (room with different lighting condition and without the black background) from where the face image training set is collected, the similarity percentage produced by the face recognition algorithm is reduced to 60% to 80% (Fig. 10).

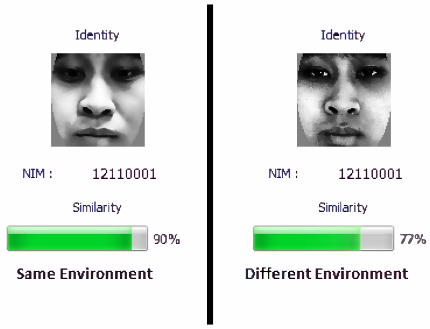

Fig. 10 Recognition result of a same person under different environment

V. CONCLUSIONS

Despite face recognition low accuracy compare to other advance biometrics such as iris and fingerprint. Face recognition can be an assistive system aiming to support multi-modal biometrics application as one of the most natural and "easy-to-collect" biometrics.

Eigenface is the final face recognition algorithm to be implemented in Attendance System application. As seen in Fig. 6, ROC curves of Eigenface algorithm's performance outclassed the Fisherface algorithm's performance using the current training set.

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