A Face Recognition Attendance System with GSM Notification

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***Abstract* — Current biometric methods for attendance are too intrusive. This paper presents a stress-free non-intrusive way of taking class attendance using face as the biometric. It also has the added novelty of relaying vital information about class attendance to handheld devices via any available cellular network. During enrollment, a camera was used to acquire facial images that were made into templates using Fisherfaces algorithm. These templates were stored in a database. During verification or attendance taking, facial features extracted from acquired face images and stored picture templates were compared using Fisher Linear Discrimination algorithm for any match within the pre-set threshold. Vital information about collated attendance reports were sent via a cellular network to designated handheld devices. The designed and implemented system had 54.17% accuracy during verification when lighting was varied without any variation in facial expression during enrollment. The system had 70.83% accuracy during verification when facial expressions were varied along with variations in lighting conditions during enrollment.**

***Keywords* — Fisherfaces; feature extraction; enrollment; verification; discrimination; facial recognition; cellular network**

I. INTRODUCTION

Biometrics has an epic range of applications and more innovative ways of using it keeps emerging. A pivotal feature of biometrics is its relative permanence. All biometrics are distinctively unique in features and in individuals [16].

Biometrics has been around for more than a century, with the earliest systematic capture of a hand image for identification purposes recorded in 1858 [1]. In the following years, other methods began to emerge. Including iris pattern recognition, face recognition, speech recognition, signature analysis, gait pattern, palm prints, among others. Biometrics has come a long way since the late nineteenth century and is certainly a constantly developing area of technology [2]. The applications of biometrics are vast and new applications are emerging.

Typically, a good biometric system has two phases; the enrollment phase and the recognition phase. Enrollment involves obtaining the biometric trait of an individual, storing the features in a database as well as an identifier to enable the trait to be associated with the individual. The recognition phase involves acquiring the biometric trait, extracting the identifier and checking the database to see if there is any match [8].

Face recognition has numerous merits above other biometric methods. Most of the other biometric forms need some form of action by the user. However, face recognition can be done without the involvement of the user due to the fact that face images can be acquired from a distance by a camera. In the end, face recognition is totally non-intrusive and so does not expose the user to germs that may be prevalent in a system that has multiple users. Face recognition is non-intrusive [7].

The major aim of this paper is to implement a face recognition attendance system that has the added novelty of relaying outcomes of an attendance taken via a cellular network to designated mobile devices. It also gives a peak into how variations in lighting, facial expression and angles affects the accuracy of the designed and implemented face recognition attendance system.

The objectives of this paper are to design a face recognition attendance system backed by a database, implement the design, add the novelty of being able to send results of attendance taken via a cellular network to designated handheld devices and test to see how variations in face angle, facial expression and lighting affects the accuracy of the designed and implemented face recognition attendance system.

A light-variation, facial expression resistant face recognition attendance system with Cellular network information relay emerged. This could potentially serve as part of a home automation system that notifies home owners of the identity of persons present in their homes regardless of where they are. It can also serve as a deterrent to intentional class absentees whose parents would be notified by the system.

Limitations to this study include partial covering of the face because of hairstyle and glasses, too low or too high image quality that could make analysis more complex or slow down the computer processor's speed respectively. A balance was maintained that did not distort expected results.

I. REVIEW OF SIMILAR WORKS

Akshay N. Patil et al [11] presented the design of a system aimed at providing essential security to homes, banks and for similarly-related control operations and to send security alerts utilising the GSM module. A Raspberry Pi module was used to operate and control the video camera (by capturing images) and turn on a relay that unlocks the door. Six images were captured and used to create a database. The Raspberry Pi module coordinated the comparison between stored images in the database and captured live images. The result of the comparison was sent to the GSM module which in turn relayed the result via a cellular network to the handheld devices of designated persons. The result of the comparison was either positive or negative. If the result was positive, the message sent was "Person Identified!! DOOR OPENS!!" otherwise the message sent was "unknown person is trying to unlock the door".

Ashish Choudhary et al [12] proposed a system that solves problems and limitations associated with conventional methods of attendance capture by automating the process of attendance management during exams and lectures thus saving effort and time. The system made use of a camera that processes videos in real time. The faces of students attending a class were captured and stored in a database. The information stored in the database was then used to take attendance. To make the system fool proof, attendance was taken twice, once at the beginning of the class and at the end of the class. Data about face images taken at the beginning and end of the class were used to decide whether a student was present or absent for the day. A student is marked present only if he is recognised in both the images.

Bhange Sourabh Sanjay et al [13] proposed a vehicle security system. As soon as a vehicle is started the identity of the driver is ascertained. This system makes sure only accredited users are allowed to drive the car. If an unauthorised person is identified or an unknown person, the system would prevent that person from driving. The location of the car and an image of the unauthorised person are sent to the system controller which has the ability to prevent the vehicle from moving further.

Sarvesh V. A. et al [14] proposed a system to offer advanced security program in cars, the system was to be enabled with a custom password and a face recognition program, a GSM module and a control platform. The program is mainly used to notice the thief who is trying to steal the car. The FRS (Face Recognition System) is used to detect the face of the driver and recognise it. The GSM plays a very important part in this system. The prototype used a Microcontroller and GSM service [15].

II. RELATED STUDIES

A. Face Detection Technology

The computer application in conjunction with the required hardware must be able detect the presence or absence of a face in any digital image. The resource of any worthy face recognition system must be directed at the face and be able to tell if a face is absent in a digital image. The main means of achieving this is through the process of feature extraction. There are several means of extracting features from a face and some of them are:

- *Feature-based method:* the focus here is on texture and skin colour [1]. It pays no real consideration position, viewpoints and lighting conditions.
- *Knowledge based approach:* the face structure is made into a set of governing rules that is followed by the algorithm performing feature extraction on the face. It was made popular by researchers and their deep knowledge about the structure of the human face. [2].
- *Appearance based approach*: template models are used to extract the features of a face in this approach [2].
- *Template matching:* this method uses patterns that have been designed to describe the face. The input image is compared to the designed pattern and used create the needed face template. This approach is highly affected by variations in scale and pose.

B. Viola Jones Algorithm

The face detection algorithm utilised was the Viola-Jones algorithm, an appearance based method for detecting faces. It detects faces speedily and quite reliably [17]. The processes used by the algorithm to detect faces are detailed below:

- *Haar Feature Selection*: similar features shared by all human faces are used to make the rectangular training pattern used to get a match when trying to detect a face [3].
- *Integral image*: the integral of images captured by the camera are computed to enable fast detection of whether a face is present or absent in an image [1].
- *AdaBoost Algorithm*: Adaptive boosting is the process of taking a few feature from a large pool of potential features in an image that may contain a face [1][4][5].
- *Attentional Cascade*: here attention is directed towards promising parts of an image that may contain a face by using more complex classifiers in a cascade structure [4].

C. Face Recognition Technology

There are several methods used by existing technologies to recognize faces and some of them are:

- *Holistic Approach*: here, all regions of the face are considered when trying to recognise a face. It is a comprehensive approach to face recognition [6].
- *Feature-Based Approach*: here, only a few unique features are used to recognize a face [7][18][19].
- *Appearance based approach*: template models are used to extract the features of a face in this approach [2].
- *Hybrid Approach*: here, combinations of distinct and comprehensive approach are used to recognized faces [8].

D. Fisherfaces

To obtain the template of faces captured, the Fisherface primary goal is to apply the Fisher Linear Discriminant (FLD) [9].

E. GSM

GSM is an acronym for Global System for Mobile Communications. It was introduced in the 1990s as a digital technology based on Circuit Switching and Cellular concept. It is a form of mobile communications [10].

III. METHODOLOGY

A camera served as the input device. During enrollment, Viola-Jones algorithm was used to detect faces and the camera acquired the detected faces. Fisherfaces algorithm was used to create templates of the faces that were captured. A database stored the created templates along with other particulars unique to the users enrolled. During verification, the camera acquired images of faces detected. The acquired images were compared with face templates stored in the database for any match. The number of verified face images formed the basis for attendance taking by the attendance algorithm. Information about attendance taken was relayed via a cellular network to authorized handheld devices. The algorithms used were implemented using C++. The created database had a capacity of twenty (20) persons. Each person had as least Twenty (20) and at most Fifty (50) images of their face stored in the database.

A. Componets

The main parts of the designed system are:

1) *Hardware:*

a) A Webcam.

b) A Modem.

c) A Personal Computer.

2) *Software:*

a) PostgreSQL was used to create the database.

b) Qt Software Development Kit (SDK) was used to create the graphical user interface application that was used to interact with the database, camera and cellular phone. The graphical user interface created allowed an administrator to access the system with a username and password, enroll users and update user bio-data. For user authentication, the system was accessed using the same username and password.

c) OpenCV library provided the C++ Fisherfaces algoritm.

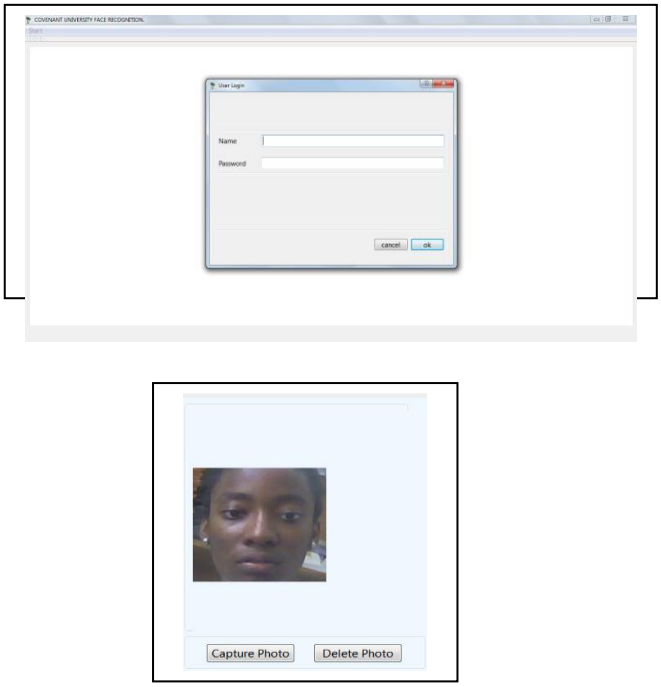


Fig. 2. Sample Face Image

B. Use Case Diagram

The interaction between the user and the software application is shown diagrammatically in Figure 3. The case diagram shows the set of actions that were performed by the system and how it interacts with all users of the system. It displays the different purposes of the system and also relates what the system is capable of and lays the rules of interaction for the required service. It can be referred to as the blueprint of the system.

C. Database

The database held the information of twenty individuals, stored under columns indicating title, surname, middle name, gender, date of birth, nationality, state of origin and local government area. Each entry had provision for the storage of images, with a minimum of twenty and maximum of fifty images per person. The type of database used to implement this system was relational. The interface for enrolling students' bio data is shown in Figure 4 and Figure 5.

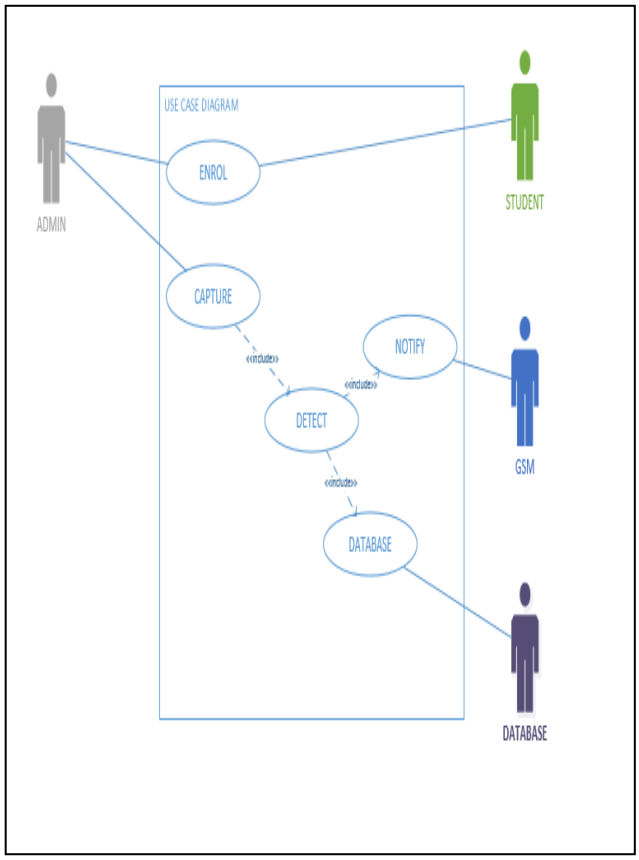


Fig. 3. Use Case Diagram

D. User Identification Portal

After enrollment, verification was carried out through the user identification portal and when a match is found the user is marked present for the day.

E. Information Relay System

After attendance was taken, a set of codes enabled the automatic extraction of vital information about attendance from the database. The application portal relayed the information got to the modem. The modem then transfers the information through a cellular network to the designated handheld device.

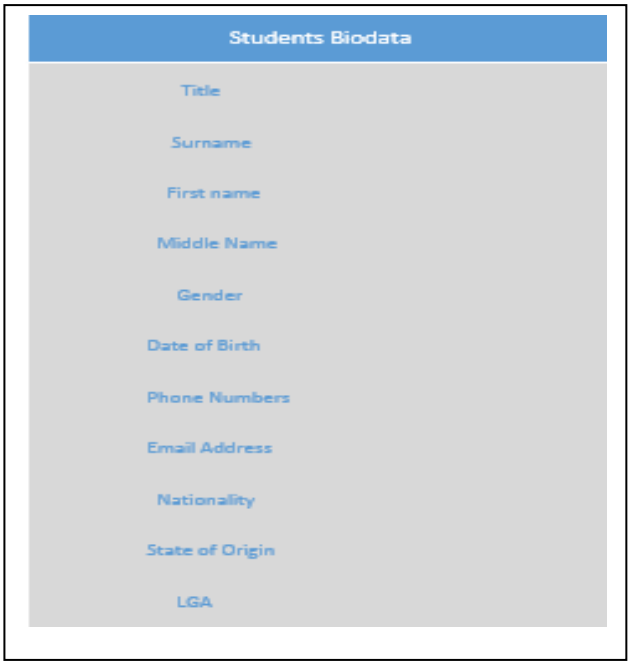
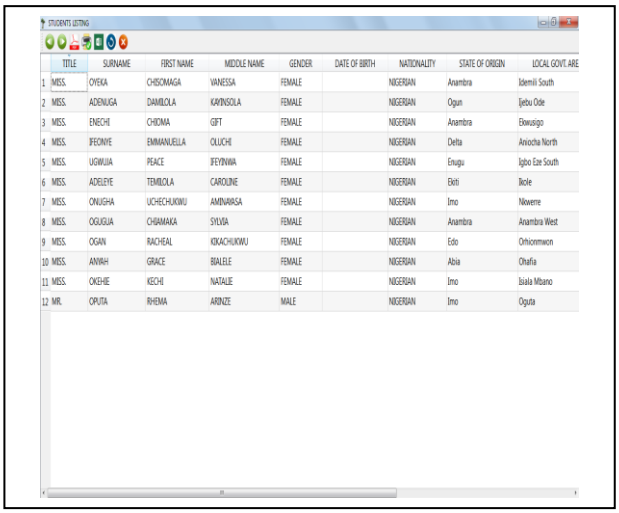


Fig. 4. Bio Data Table



	TITLE	SURNAME	FIRST NAME	MIDDLE NAME	GENDER	DATE OF BIRTH	NATIONALITY	STATE OF ORIGIN	LOCAL GOVT. ARE
1	MISS.	OYEKA	CHISOMAGA	VANESSA	FEMALE		NIGERIAN	Anambra	Idemili South
2	MISS.	ADENUGA	DAMILOLA	KAYINSOLA	FEMALE		NIGERIAN	Ogun	Ijebu Ode
3	MISS.	ENECHI	CHIOMA	GIFT	FEMALE		NIGERIAN	Anambra	Ekwusigo
4	MISS.	IFEONYE	EMMANUELLA	OLUCHI	FEMALE		NIGERIAN	Delta	Aniocha North
5	MISS.	UGWUJA	PEACE	IFEYINWA	FEMALE		NIGERIAN	Enugu	Igbo Eze South
6	MISS.	ADELEYE	TEMILOLA	CAROLINE	FEMALE		NIGERIAN	Ekiti	Ikole
7	MISS.	ONUGHA	UCHECHUKWU	AMINAWSA	FEMALE		NIGERIAN	Imo	Nkwerre
8	MISS.	OGUGUA	CHIAMAKA	SYLVIA	FEMALE		NIGERIAN	Anambra	Anambra West
9	MISS.	OGAN	RACHEAL	KIKACHUKWU	FEMALE		NIGERIAN	Edo	Orhionmwon
10	MISS.	ANYAH	GRACE	BIALELE	FEMALE		NIGERIAN	Abia	Ohafia
11	MISS.	OKEHIE	KECHI	NATALIE	FEMALE		NIGERIAN	Imo	Isiala Mbano
12	MR.	OPUTA	RHEMA	ARINZE	MALE		NIGERIAN	Imo	Oguta

Fig. 5. Application Database for Enrolled Students

IV. RESULT AND DISCUSSION

A. *Testing*

To determine the accuracy of the recognition system, tests were carried out:

1) Under various lighting conditions and varying facial expressions.

2) By varying facial expressions and angles along with lighting conditions.

3) The tests were carried out on the particulars of twelve individuals stored in the database.

4) The identification process was carried out ten (10)times to obtain the probability of an accurate match.

The table below indicates the number of times an individual was identified correctly [Number of Positives (NOP)], and the number of times there was a false negative match [Number of False Negative Match (NFN)].

Table I. Results from Tests carried out by Varying Facial Expressions and Angles along with the Lighting Conditions.

S/N	Name	NOP	NFN	Accuracy
1	Jane	7	3	70
2	Grace	6	4	60
3	Nkechi	7	3	70
4	Damilola	6	4	60
5	Gift	9	1	90
6	Uche	8	2	80
7	Chiamaka	8	2	80
8	Temilola	7	3	70
9	Jonathan	6	4	60
10	Chisom	6	4	60
11	Ajulibe	7	3	70
12	Kusimo	8	2	80

The average accuracy (by varying facial expressions and angles along with the lighting conditions):

$$Accuracy = \frac{70+60+70+60+90+80+80+70+60+60+70+80}{12} = 70.83\%$$

Table II. Results from tests carried out under various lighting conditions but unvarying facial expressions.

S/N	Name	NOP	NFN	Accuracy
1	Jane	5	5	50
2	Grace	4	6	40
3	Nkechi	5	5	50
4	Damilola	5	5	50
5	Gift	7	3	70
6	Uche	6	4	60
7	Chiamaka	8	2	80
8	Temilola	4	6	40
9	Jonathan	3	7	30
10	Chisom	6	4	60
11	Ajulibe	7	3	70
12	Kusimo	5	5	50

The average accuracy of the system (under various lighting conditions but unvarying facial expressions):

$$Accuracy = \frac{50+40+50+50+70+60+80+40+30+60+70+50}{12} = 54.17\%$$

The results showed that the system responds better to face expression variation than to lighting variation.

CONCLUSION

The designed and implemented face recognition system worked with varying levels of accuracy. A combination of lighting, facial and angular factors were responsible for the variations in accuracies got from the tests carried out on the implemented design.

Results obtained showed clearly that the face recognition attendance system performs better in terms of accuracy when facial expressions and angles are varied along with lighting conditions during enrollment (at least twenty (20) face images for each enrollee).

As a requirement, the designed face recognition attendance system is used only under good lighting conditions.

FUTURE WORK

1) Embedded systems would be incorporated into the attendance system to make it fully autonomous.

2) The system would be adapted for transmission of attendance information via local area networks and WIFI to designated nodes on a network.

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