Automatic Lecture Attendance System Using Face Recognition Techniques

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Abstract **- Face recognition is one of the most important image processing research topics which is widely used in personal identification, verification and security applications.**

Traditionally, student's attendances are taken manually by using attendance sheet given by the faculty members in class. In a large classroom environment, it is very difficult to verify one by one student with distributed branches whether the authenticated students are actually responding or not and which is a time consuming event. The ability to compute the attendance percentage becomes a major task as manual computation produces errors. To avoid these losses, automatic process which is based on image processing is going to be used. The system consists of two stages: face detection and face recognition. In face detection, it differentiates faces from non-faces and is therefore essential for accurate attendance. In face recognition, the predicted image will be searching to the collected student database and marking the student attendance. The Raspberry pi 2 module B is used for face detection and recognition. Using this system, time will be saved. And it is so convenient to record attendance on any time.

Keywords **- Viola Jones algorithm, PCA, LDA, Raspberry Pi 2 Model B, Raspberry Pi Camera**

I. INTRODUCTION

In many institutions and organizations the attendance is a very important factor for various purposes and for students and organization employees to check the performance of students or employees. So maintaining the attendance is also important. Attendance management falls into conventional and automated methods. Every institute has its own method. Some are taking attendance manually using attendance registers, marking attendance sheets or file based approach and some have adopted methods of automatic attendance using some biometric techniques.

Biometric based technologies include identification based on physiological characteristics (such as face, fingerprints, finger geometry, hand geometry, hand veins, palm, iris, retina, ear and voice) and behavioral traits (such as gait, signature and keystroke dynamics). These techniques, which use physical data, are receiving attention as a personal authentication method that is more convenient than conventional methods such as a password or ID cards because it uses data taken from measurements and such data is unique to the individual and remains so throughout one's lifetime in [3].This technology has been applied for controlling access to high-security facilities, but it is now being widespread developed in information systems such as network, e-commerce, and retail applications. In these technologies, face recognition becomes the most mature and popular biometrics technology used in automatic personal identification.

Face recognition appears to offer several advantages over other biometric methods, a few of which are outlined here: Almost all these technologies require some voluntary action by the user, i.e., the user needs to place his hand on a hand-rest for fingerprinting or hand geometry detection and has to stand in a fixed position in front of a camera for iris or retina identification. However, face recognition can be done passively without any explicit action or participation on the part of the user since face images can be acquired from a distance by a camera. This is particularly beneficial for security and surveillance purposes. Furthermore, data acquisition in general is fraught with problems for other biometrics techniques that rely on hands and fingers can be rendered useless if the epidermis tissue is damaged in some way (i.e., bruised or cracked). And also in these methods students have to wait for long time in making a queue at time they enter the classroom.

Many biometric systems are available but the key authentications are the same in all the techniques. Every biometric system consists of enrolment process in which unique features of a person is stored in the database and then there are processes of identification and verification. These two processes compare the biometric feature of a person with previously stored template captured at the time of enrolment .Biometric templates can be of many types like Fingerprints, Eye Iris, Face, Hand Geometry, Signature, Gait, voice and so on. Since Iris and Fingerprints are very short-distance biometrics, but our system requires a person to be at a medium distance from the camera, which is fixed at the centre of the classroom near the black board, so that the view of the camera covers the entire classroom. Hence we go for a medium range biometric such a face.

The system is used face recognition approach for the automatic attendance of students in the class room environment without students' intervention. Face recognition consists of two steps, in first step faces are detected in the image and then these detected faces are compared with the database for verification. The database includes name of the students, their images & roll number. The efficiency of face recognition algorithm can be increased with the fast face detection algorithm. This system is developed in order to avoid the manual drudgery for lecturers in entering the data daily while taking attendance and also to avoid proxy. This system eliminates classical student identification such as calling student names, or checking respective identification cards, which can not only interfere with the teaching process, but also can be stressful for students during exam sessions. And also time will be saved and convenient to record attendant at any time.

II. Related Works

A. Computerized Attendance System

In 2012, a project was proposed, the students have to register independently using a client server socket program from their device (laptop) in [4]. In this case, student snapshot is taken by the client application. Even though the time wastage is also there, but still it is an improvement on the manual process since attendance data can be stored safely and reports can be easily generated.

B. Bluetooth based Attendance System

In 2013, Vishal Bhalla et al. [5] have proposed the attendance system which can take attendance using Bluetooth. In this project, attendance is being taken using instructor's mobile phone. Application software is installed in instructor's mobile telephone enables it to query student's mobile telephone via Bluetooth connection and through transfer of student's mobile telephone Media Access Control (MAC) addresses to the instructor's mobile telephone, student presence can be confirmed. The problem of this proposed system is that student's phone is required for attendance. In case of students' absent if his mobile is given to his friend then also present is marked. So presence of student is not necessary only phone should be in coverage area.

C. NFC Based Attendance system

In 2014, author presents the implementation of an (AMS) Attendance Management System that is based on Bluetooth and NFC technologies in a multiuser environment in [6]. It uses fingerprint & the Bluetooth address of the NFC enabled phone of the user to authenticate the identity of the user. A Java based desktop application receives the NFC tag IDs, other information associated with the mobile phone and the user and submits them to an analyzer for the interpretation of the user's behavior. But in this case, student must be having NFC enable phone to mark presence in the class room.

D. Fingerprint Based Attendance System

In 2013, Neha Verma et al. [7] proposed system, in which fingerprint recognition based identification system is designed for student identification. In this system, fingerprint template matching time is reduced by partitioning database. In this case problem is the fingerprint device, because it is damaged very frequently. Again, for marking attendance, students have to stand in long line and have to wait for turn for the fingerprint device.

E. Iris Based Attendance System

In 2010, Seifedine Kadry et al. [8] has proposed system. In this paper, RF wireless technique is being used for employee identification. Main problem in this system is it is too expensive and it is very short distance as well as for every class, student has to stand in long line of iris scanner for marking presence. And for universities this is not the best choice.

F. Face Recognition Based Attendance System

Student attendance is being taken using one of the bio-metric techniques .i.e. Face Recognition. Since Iris and Fingerprints are very short-distance biometrics but the application requires a person to be at a medium distance from the camera, which is fixed at the center of the classroom near the black board, so that the view of the camera covers the entire classroom in [9]. The proposed system comprised of using the Viola Jones algorithm for detecting the human faces and then the detected face is resized to the required size, this resized face is further processed by using linear stretch contrast enhancement and finally it is recognized using a simple PCA / LDA. Once recognition is done, automatically attendance will be updated in an Excel Sheet along with his name, date and time. An html file is automatically updated by our system so that a remote authenticated user can access the attendance file.

G. Mobile Based Attendance System

In 2013, student information tracking system is being developed in Android to manage student attendance on mobile. This system allows teachers to take attendance, edit attendance, view student's bunks, send important documents in pdf format such as exam time table, question bank etc. and also helps teachers to inform students about the events that college is going to organize. This system is mobile independent. This system can be installed on any mobile which is having Android as OS in [10]. The problem of this system is that it is developed on for Android platform so it cannot run on iOS or any other mobile OS as well as it is very time consuming to mark student attendance in mobile.

H. RFID Based Attendance System

In 2012, RFID reader was designed with microcontroller, transceiver chip, and serial communication IC, LCD, USB interface, power supply module, etc. as components. When a student touches the reader it sends the data to the microcontroller for comparison with the ID stored in the microcontroller's memory; if ID exist the name, ID and attendance will be displayed on the LCD then transfer the data to PC via RS323 port in [11]. The problem in this research is that there is verification which is not done. So proxy attendance may be marked.

III. BACKGROUND THEORY

For this system we are using a two-step mechanism. First comes to be face detection then followed by face recognition. For face detection we are using Viola Jones face detection algorithm while for face recognition we are using hybrid algorithm from PCA and LDA.

A. Viola-Jones algorithm

There are three major blocks in Viola-Jones algorithm; Integral Images, Ada-Boost Algorithm and Attentional cascade. The integral image computes a value at each pixel for example (x, y) that is the sum of the pixel values above to the left of (x,y). This is quickly computed in one pass through the image. Viola jones algorithm uses Haar like features. This is nothing but scalar product between the image & some haar like structures. Feature is selected through adaboost. Ada-Boost provides an effective learning algorithm and strong bounds on generalization performance. The overall form of the detection process is that of a degenerate decision tree, what we call a "cascade".

A positive result from the first classifier triggers the evaluation of a second classifier which has also been adjusted to achieve very high detection rates. A positive result from the second classifier triggers a third classifier, and so on. A negative outcome at any point leads to the immediate rejection of the sub-window. The cascade training process involves two types of trade off. In most cases classifiers with more features will achieve higher

detection rates and lower false positive rates. At the same time classifiers with more features require more time to compute. In principle one can use the following stages.

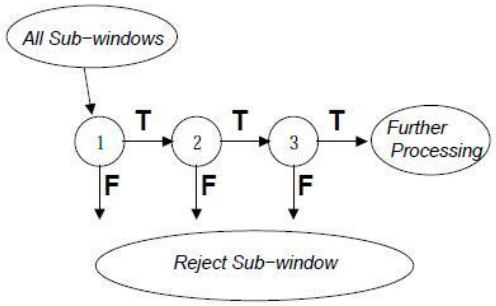

Fig.1 Attentional Cascade

i) the number of classifier stages, ii) the number of features in each stage, and iii) the threshold of each stage, are traded off in order to minimize the expected number of evaluated features. Unfortunately finding this optimum is a tremendously difficult problem. In practice a very simple framework is used to produce an effective classifier which is highly efficient. Each stage in the cascade reduces the false positive rate and decreases the detection rate. A target is selected for the minimum reduction in false positives and the maximum decrease in detection. Each stage is trained by adding features until the target detection and false positive rates are met these rates are determined by testing the detector on a validation set. Stages are added until the overall target for false positive and detection rate is met.

B. Principle Component Analysis (PCA)

PCA was invented in 1901 by Karl Pearson. It involves a mathematical procedure that transforms the 2D image into 1D feature vector in subspace. This subspace is also called eigenspace in which the covariance matrix is obtained as a result of facial features. The subspace formed as a result of PCA conversion makes use of facial feature to characterize different reference images or eigenfaces from the sample dataset. PCA, also known as Karhunen-Loeve (KL) transformation or eigenspace is basically a statistical technique used in image recognition and classification. It is also used for image compression. It provides the linear arrangement of template.

The main advantage of this approach is that it is easy to implement, fast and less expensive than any other feature classifier. But it endows invariance information in the presence of varying lighting and scaling condition.

$$\Psi = \frac{1}{M}\sum_{n-1}^{M}\Gamma_n \quad \Longrightarrow \quad \text{Mean Face}$$
$$\Phi_i = \Gamma_i - \Psi$$

$$C = \frac{1}{M}\sum_{n-1}^{M}\Phi_n\Phi_n^T \quad \Longrightarrow \quad \text{Covariance Matrix}$$

$$\mu_l = \sum_{k-1}^{M}\mu_{lk}\Phi_k \;\; l = 1..,M \quad \Longrightarrow \quad \text{Eigenface}$$

C. Linear Discriminant Analysis (LDA)

LDA is a classification method originally developed in 1936 by R.A.Fisher. It is simple, mathematically robust and often produces models whose accuracy is as good as more complex methods.

LDA is based upon the concept of searching for a linear combination of variables (predictors) that best separates two classes (targets). To capture the notion of separability, Fisher defined the following score function:

$$Z = \beta_1\chi_1 + \beta_2\chi_2 + ... + \beta_d\chi_d$$

$$s(\beta) = \frac{\beta^T\mu_1 - \beta^T\mu_2}{\beta^T C\beta} \qquad \text{Score function}$$

$$s(\beta) = \frac{\overline{Z}_1 - \overline{Z}_2}{\text{Variance Z wy groups}}$$

Given the score function, the problem is to estimate the linear coefficients that maximize the score which can be solved by the following equations:

$$\beta = C^{-1}(\mu_1 - \mu_2) \qquad \text{Model coefficients}$$

$$C = \frac{1}{n_1+n_2}(n_1C_1 + n_2C_2) \qquad \text{Pooled covariance matrix}$$

Where:
β: Linear model coefficients
C_1, C_2: Covariance matrices
μ_1, μ_2: Mean vectors

One way of assessing the effectiveness of the discrimination is to calculate the Mahalanobis distance between two groups.

A distance greater than 3 means two averages differ by more than 3 standard deviations.

It means that the overlap (probability of misclassification) is quite small.

$$\Delta^2 = \beta^T(\mu_1 - \mu_2)$$
Δ: Mahalanobis distance between two groups

Finally, a new point is classified by projecting it onto the maximally separating direction and classifying it as C1 if:

$$\beta^T[x - [\frac{\mu_1 + \mu_2}{2}]] > \log\frac{P(c_1)}{P(c_2)}$$

Coefficients vector | Data vector | Mean vector | Class probability

IV. METHODOLOGY

The system consists of a camera which is fixed at the centre of the classroom near the black board that captures the images of the students and sends it to the image enhancement module. After enhancement the image comes in the face detection and recognition modules and then the attendance is marked on the database server. At the time of enrolment, templates of face images of individual students are stored in the face database. Here all the faces are

detected from the input image and the algorithm compares them one by one with the face database.

In this way, a lot of time is saved and this is highly securing process no one can mark the attendance of other. Attendance is maintained on the server. In order to avoid the false detection, the skin classification technique is being used. Using this technique enhance the efficiency and accuracy of the detection process.

Two databases are displayed in the experimental setup. Face Database is the collection of face images and extracted features at the time of enrolment process and the second attendance database contains the information about the students and also uses to mark attendance.

A. Hardware Requirements

1) Raspberry Pi 2 model B: The RPI is a credit card sized single-board computer with 900MHz Broadcom Arm7 Quad Core Processor needs to be installed in the class room where the system is to be deployed. The RPI use about 2W of power.

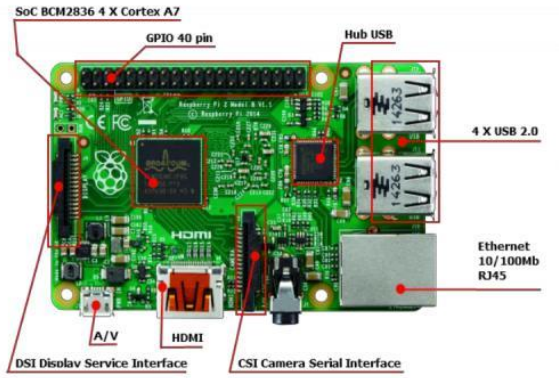

Fig. 2 Raspberry Pi 2 Model B Board

2) RPI NOIR Camera Board: A camera must be positioned in the class room to obtain the snapshots. Optimum Resolution: 512 by 512 pixels.

Fig. 3 Raspberry Pi NoIR camera board and Micro SD card

3) Micro SD card: A SD card preloaded with the official Raspberry Pi NOOBS (New Out of Box Software) package.

B. Software requirements

- MATLAB Version 7.6 (R2008a) or higher
- Windows XP (Service Pack 2) or higher

C. Expenditure

The cost of the entire project will depend simply on the expenditure incurred for the hardware requirements. The software requirements can be easily fulfilled without any cost.

Equipment: Cost:

- Raspberry Pi 2 model B: $35
- RPI NOIR Camera Board: $24

D. System Algorithm

This section describes the software algorithm for the system. The algorithm consists of the following steps

- Image acquisition
- Histogram normalization
- Noise removal
- Skin classification
- Face detection
- Face recognition
- Attendance

1) Image acquisition: Image is acquired from a high definition camera (RPI camera board) that is connected above the white board. This camera is connected to the RPI 2 Model B board. It captures images and sends these images to the board for processing.

2) Histogram Normalization: Captured image sometimes have brightness or darkness in it which should be removed for good results. First the RGB image is converted to the grayscale image for enhancement. Histogram normalization is a good technique for contrast enhancement in the spatial domain.

3) Noise Filtering: Many sources of noise may exist in the input image when captured from the camera. There are other techniques like low pass filter for noise removal and smoothing of the images. Low pass filtering in the frequency domain may be a good choice but this also removes some important information in the image. In this system median filtering is used for the purpose of noise removal in the histogram normalized image.

4) Skin classification: In this process first the skin is classified and then only skin pixels remains and all other pixels in the image are set to black, this greatly enhances the accuracy of face detection. This is used to increase the efficiency of the face detection algorithm. Voila and Jones algorithm is used for detection. The images of faces then applied on the class room image for detection of multiple faces in the image.

5) Face detection: Haar classifiers have been used for detection. Initially face detection algorithm was tested on variety of images with different face positions and lighting conditions and then algorithm was applied to detect faces in real time video. Algorithm is trained for the images of faces and then applied on the class room image for detection of multiple faces in the image.

6) Face recognition and attendance: After the face detection step, the next is face recognition. This can be achieved by cropping the first detected face from the image and compare it with the database. This is called the selection of region of interest. In this way faces of students are verified one by one with the face database using the eigenface and fisherface methods and attendance is marked on the server. From the server, anyone can access and use it for different purpose. This system uses a protocol for attendance. A time table module is also attached with the system which automatically gets the subject, class, date and time. Teachers come in the class and just press a button to start the attendance process and the system automatically gets the attendance without even the intensions of students and teacher.

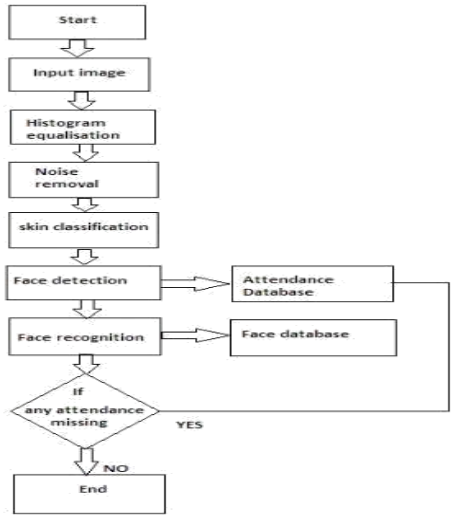

Fig.4 Data Flow Diagram

V. Expected Results

This system will work in a real time. It works best when the face is sufficiently illuminated and the person is frontal w.r.t. the camera. The system is user friendly and easy to use. This system will record the attendance of the students in a class room environment automatically and it will provide the facilities to the faculty to access the information of the students easily and a better security and privacy than manual attendance system. The system will provide accurate results and more detailed reporting system which shows student activity and attendance in a classroom.

VI. Conclusions

In this system we are implementing an attendance system for a lecture by which lecturer or teaching assistant record student's attendance. It saves time and effort, especially if it is a lecture with huge number of students. The excel sheet used to update attendance is overwritten every time the program is executed. The complete system is implemented in MATLAB. This attendance system shows the use of facial recognition techniques for the purpose of student attendance and for the further process using this record of student in exam related issues. The experimental prototype of the embedded image capturing system with Raspberry Pi 2 module is designed in this system. This system is smaller, lighter and with lower power consumption and low cost. So it is more convenient than the PC-based face recognition system. Because of the open source code, it is free to do software development on Linux.

This system is flexible, which means that it may be extended by adding more modules and making some updates or changes for the future work. Furthermore, the possibility of using some additional tools is GPS, GSM and etc. We plan to use GPS and GSM technologies in educational system. SMS option will be provided that student present or absent status will be sent. This system will save time, reduce the amount of work the administration has to do and will replace the stationery material with electronic apparatus. And also the system will provide a better security and privacy than manual attendance system.

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