Student attendance based on face detection and recognition with PCA Algorithm using LattePanda

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Abstract. Face is the representation of one's identity. The human face is a complicated multidimensional visual model. Hence, it is very difficult to develop a computational model for recognizing it. Face Recognition, as it is often referred to, analyses characteristics of a person's face image input through a camera. Verification or identification can be accomplished from the distance of two-feet-away or more, without requiring the user to wait for long periods of time. Face recognition is widely used in many applications, such as security system. Traditionally, students' attendance is taken manually by using attendance sheet, given by the faculty member in class. The paper describes how to take students' attendance using face recognition. The face recognition is implemented with the help of Principal Component Analysis (PCA) algorithm. It recognizes the face of students and saves the response in database automatically. The system also includes the feature of retrieving the list of students who are absent in a particular day. Lattepanda is used for image processing using OpenCV.

1. Introduction

Maintaining attendance is very important in education institution to check the students' performance. In most education institutions, students' attendance is manually taken by using attendance sheets issued by the department head as a part of regulation. The students sign in these sheets which are then filled or manually logged in to a computer for future analysis. This method is dull, time consuming and inaccurate as some students often sign for their absent colleagues. This method also makes it difficult to track the attendance of individual students in a large classroom environment [1]. In this project, the writers propose the design and use of a face detection and recognition system to automatically detect students attending a lecture in a classroom and mark their attendance by recognizing their faces.

While other biometric methods of identification (such as iris scans or fingerprints) can be more accurate, students usually have to queue for long at the time they enter the classroom [2]. Face recognition is chosen owing to its non-intrusive nature and familiarity as people primarily recognize other people based on their facial features [3]. This facial biometric system consists of an enrolment

process, in which the unique features of a persons' face are stored in a database, and then they continue to the processes of identification and verification. In these processes, the detected face in an image (obtained from the camera) is compared with the previously stored face captured at the time of enrolment.

The traditional manual methods of monitoring student attendance in lectures are dull as the signed attendance sheets must be manually logged in to a computer system for analysis. Using face detection and recognition system will replace the traditional methods that provides a fast and effective method of capturing student attendance accurately, while offering a secure, stable and strong storage of the system records, in which upon authorization; one can access them for purposes like administration, parents or even the students themselves [4].

2. Literature review

2.1. Digital Image Processing

Digital Image Processing is the processing of images which are digital in nature by a digital computer [5]. Digital image processing techniques are motivated by three major applications mainly:

- Improvement of pictorial information for human perception.
- Image processing for autonomous machine application.
- Efficient storage and transmission.

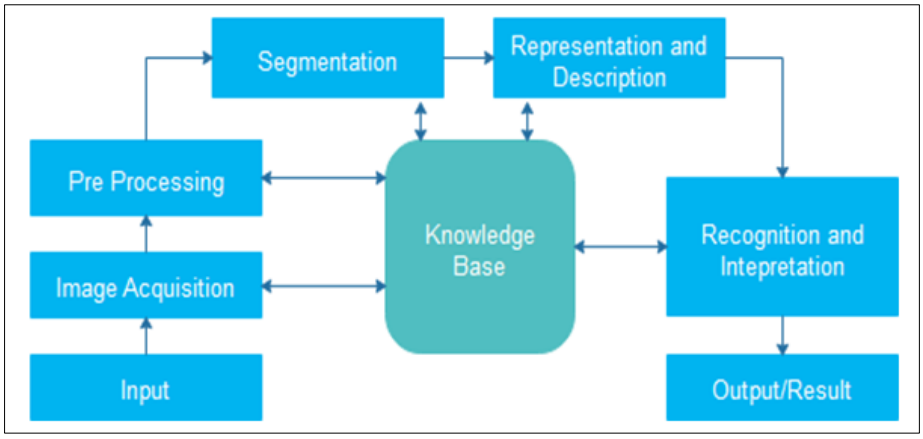

Figure 1. The steps in digital image processing.

An image is a 2-Dimensional light intensity function

$$\mathbf{f}(\mathbf{x}, \mathbf{y}) = \mathbf{r}(\mathbf{x}, \mathbf{y}) \times \mathbf{i}(\mathbf{x}, \mathbf{y}) \quad (1)$$

in which,
r (x, y) is the reflectivity of the surface of the corresponding image point.
i (x, y) represents the intensity of the incident light.

A digital image **f (x, y)** is discretized both in spatial coordinates by grids and in brightness by quantization [6]. Effectively, the image can be represented as a matrix whose row, column indices specify a point in the image and the element value identifies gray level value at that point. These elements are referred to as pixels or peels.

2.2. Viola-Jones Algorithm

Viola-Jones algorithm, which was introduced by Paul Viola, Michael Jones, is the most popular algorithm to localize the face segment from static images or video frame. It presents an approach for

object detection which minimizes computation time while achieving high detection accuracy. Paul Viola and Michael Jones [7] propose a fast and robust method for face detection which is 15 times quicker than any technique at the time of release with 95% accuracy at around 17 fps. The technique relies on the use of simple Haar-like features that are evaluated quickly through the use of a new image representation.
Based on the concept of an integral image, it generates a large set of features and uses the boosting algorithm AdaBoost to reduce the over complete set, and the introduction of a degenerative tree of the boosted classifiers provides for robust and fast interferences. The detector is applied in a scanning fashion and used on grey-scale images, the scanned window that is applied can also be scaled, as well as the features evaluated. Basically, the concept of Viola-Jones algorithm consists of four parts. The first part is known as Haar feature, second part is in which integral image is created, followed by implementation of Ad-boost on the third part, and lastly cascading process. In general, Viola and Jones method is appropriate for our proposed technique, and was chosen in this paper for its robustness, speed of detection [8], and low false positive detection rate. The four key points in Viola and Jones' technique is Haar features, adaptive boosting, cascading and computing integral images to reduce the computations and get higher accuracy [9-10].

3. Methodology and design

3.1. System design

In this design, several related components in terms of functionality have been grouped to form sub-systems which then combine to make up the whole system. Breaking the system down to components and sub-systems informs the logical design of the class attendance system. From figure 2, it can be observed that most of the components utilized are similar; the image acquisition component for browsing for input images, the face detector and the faces database for storing the face label pairs, only that they are employed at the different stages of the face recognition process.

3.2. Training set manager sub system

The logical design of the training set management sub-system is going to consist of an image acquisition component, a face detection component and a training set management component. These components interact with the faces database in order to manage the training set. These are going to be implemented in a windows application form.

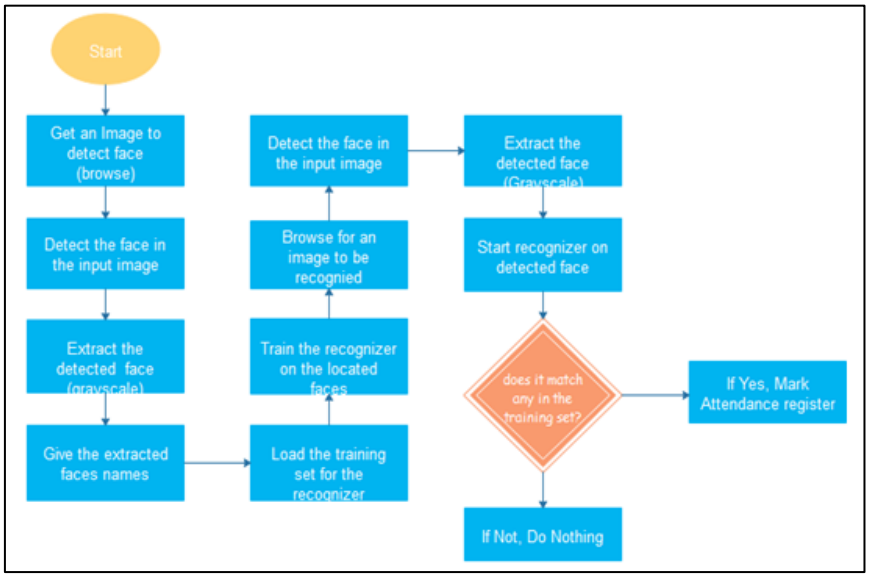

Figure 2. System overview.

3.3. Face recognizer sub system

The logical design of the Face Recognizer consists of the image acquisition component, face recognizer and face detection component, all working with the faces database. In this design, the image acquisition and face detection component are the same as those in the Training set manager sub system, as the functions of them are the same. The only difference is in the face recognizer component and its user interface controls. This loads the training set again so that it trains the recognizer on the faces added and shows the calculated Eigen faces and average face. It should then show the recognized face in a picture box.

3.4. Function of two sub-systems

The functions of the components are depicted in the block diagrams of figure 3. The face recognizer system consists of two major components i.e. the training set manager and the face recognizer. These two components share the Faces database, the image acquisition and the face detector components; as they are common in their functions.

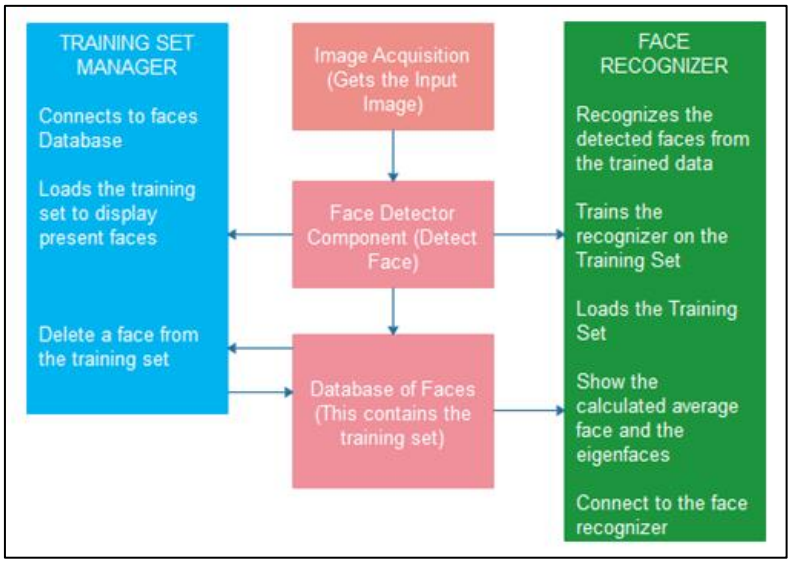

Figure 3. The function of the components.

This article is going to break the system down into two subsystems and have their detailed logical designs to be implemented.

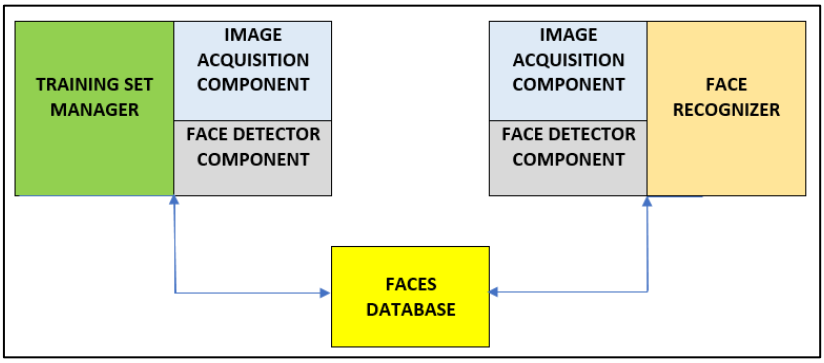

Figure 4. A logical design of the whole system.

3.5. Tools

The tools consist of two components; hardware and software that are going to be utilized in the actual development of system. They also connect to the class attendance register which is implemented as a database management system. In this paper, it uses LattePanda for the computer. LattePanda is the first development board that can run a full version of Windows 10. It is turbocharged with an Intel Quad Core processor and has excellent connectivity, with three USB ports and integrated Wi-Fi and Bluetooth 4.0. It also includes an Arduino co-processor that enables to master the physical world by controlling interactive devices using thousands of plugs and play peripherals. LattePanda is different from the Raspberry Pi and other development boards as it supports a complete Windows 10 system. With abundant software resources and a mature Windows ecosystem, LattePanda gives ideas more accessibility and power [11].

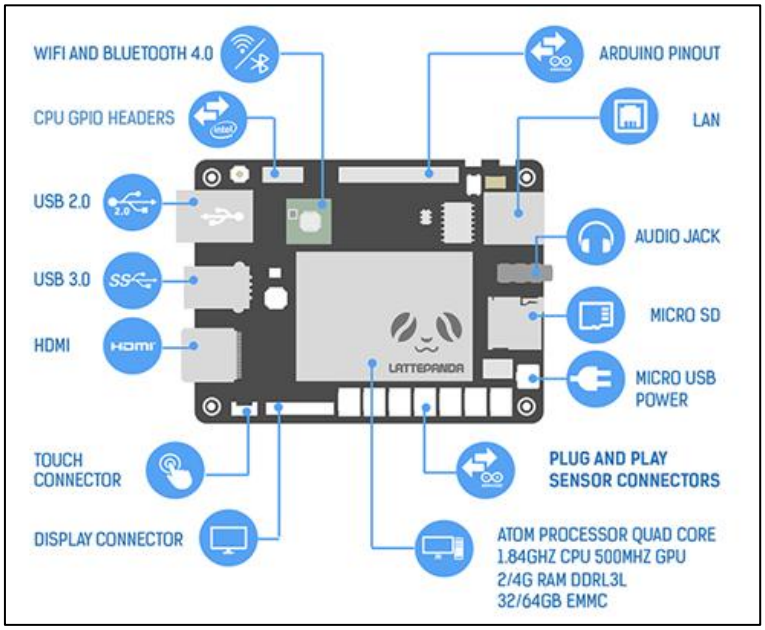

Figure 5. LattePanda Structure.

LattePanda is not only low-cost regular Windows computer, but it also includes an Arduino co-processor, which means it can be used to control and sense physical world when sensor and actuators are added. The image processing uses OpenCV software. OpenCV (Open Source Computer Vision Library) is an open source computer vision and machine learning software library. OpenCV was built to provide a common infrastructure for computer vision applications and to accelerate the use of machine perception in the commercial products [12]. Being a BSD-licensed product, OpenCV makes it easy for businesses to utilize and modify the code.

The library has more than 2500 optimized algorithms, which includes a comprehensive set of both classic and state-of-the-art computer vision and machine learning algorithms. These algorithms can be used to detect and recognize faces, identify objects, classify human actions in videos, track camera movements, track moving objects, extract 3D models of objects, produce 3D point clouds from stereo cameras, stitch images together to produce a high resolution image of an entire scene, find similar images from an image database, remove red eyes from images taken using flash, follow eye movements, recognize scenery and establish markers to overlay it with augmented reality, etc. OpenCV has more than 47 thousand people of user community and estimated number of downloads exceeding 14 million. The library is used extensively in companies, research groups and governmental bodies.

Visual Studio is a widely popular integrated development environment (IDE) used all over the development landscape for business and personal needs, and it includes a vast number of features and plugins to assist developers in their day-to-day work and collaboration [13]. According to a Microsoft developer blog, there are over 1.5 million developers (as of October 2016) writing C++ in Visual Studio alone. Current developers often experience build failures due to problems in their code from recent changes or issues with refactoring. The aim of this project is improving developers' efficiency and output by analysing these issues they are having and providing insight into their session-by-session timelines. Over time, Visual Studio has seen many new features added, both for efficiency and utility.

4. Results

4.1. User interface of the system

The faces database editor adds faces in the training set. It consists of 5 steps.
Step 1: The image is acquired from the highlighted box.
Step 2: Display the image acquired.
Step 3: Extracted grayscale face from the image.
Step 4: Modify the face label pairs.
Step 5: Prepare for the recognition stage.

The desktop module utilizes the OpenCV library in Visual Studio 2017 to implement the two sub-systems (Training set manager and Face recognizer) together with face detector in windows form. The MS Access database is designed in MS Office Suite 2016.

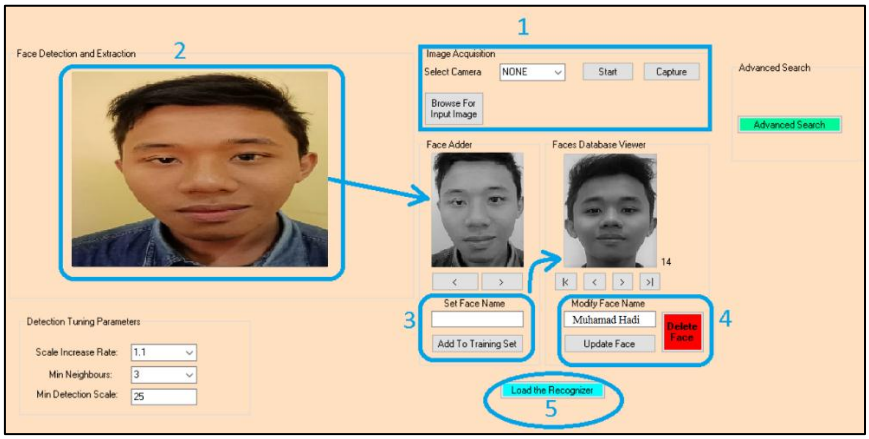

Figure 6. Training set editor.

4.2. The face recognizer

The face recognizer compares the input face in the image captured with the faces captured during enrolment. If it is a match it then retrieves the name associated with the input face.

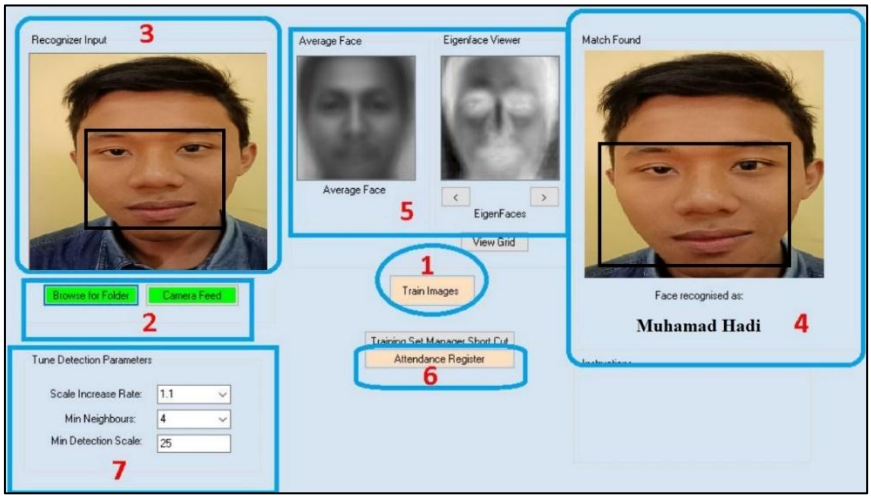

Figure 7. The face recognizer.

Step 1 is to train the recognizer to be able to identify a face as either known or unknown. Step 2 selects the source of the image with the face to be recognized. This could be from a live camera feed or a folder with captured images. The input image with the face will display in the recognizer picture box 3 as shown in Figure 7.

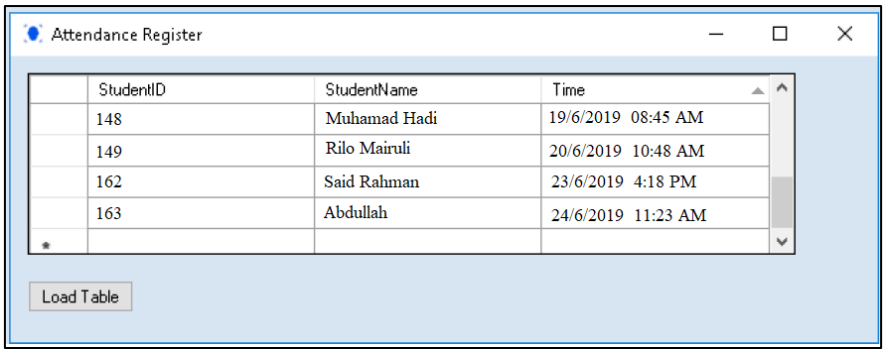

Figure 8. The attendance register.

The name of the input face in the image will display as shown in box 4. The returned name on the input face, date and time are utilized in populating the records in the attendance register database. Clicking the button in box 6 displays the register as shown in figure 8. The highlighted that show in box 5 displays the computer average and eigen faces.

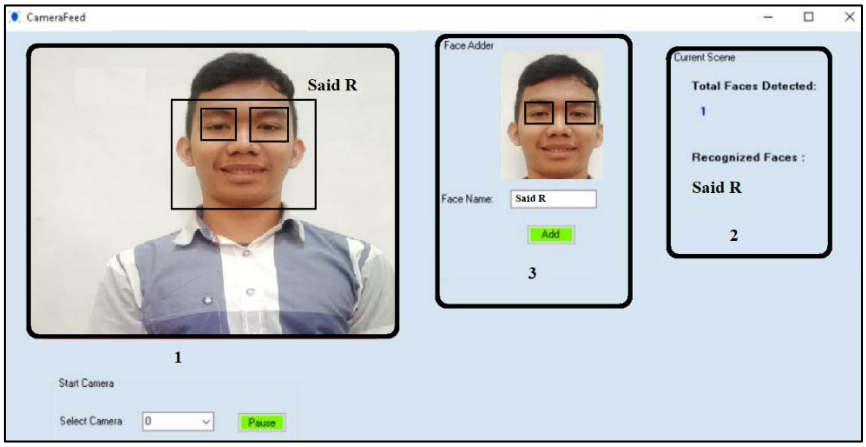

Figure 9. The camera feed.

From Figure 9, the highlighted box 1 shows the current camera view. The faces and eyes in the image are automatically detected as indicated by the rectangular boxes around them. The detected face is extracted and compared with those in the database. When the image is successful match, the name associated with the face will display on the upper edge of rectangular box. The number of faces in this scene as well as their corresponding names are also shown on the highlighted box number 2. The face adder box number 3 can also be used to add faces to the database.

4.3. Face detection

For group photos with Minimum Neighbours detection tuning parameter of 3 yield is the best overall performance as indicated in figure 9 where the physical count is 10.

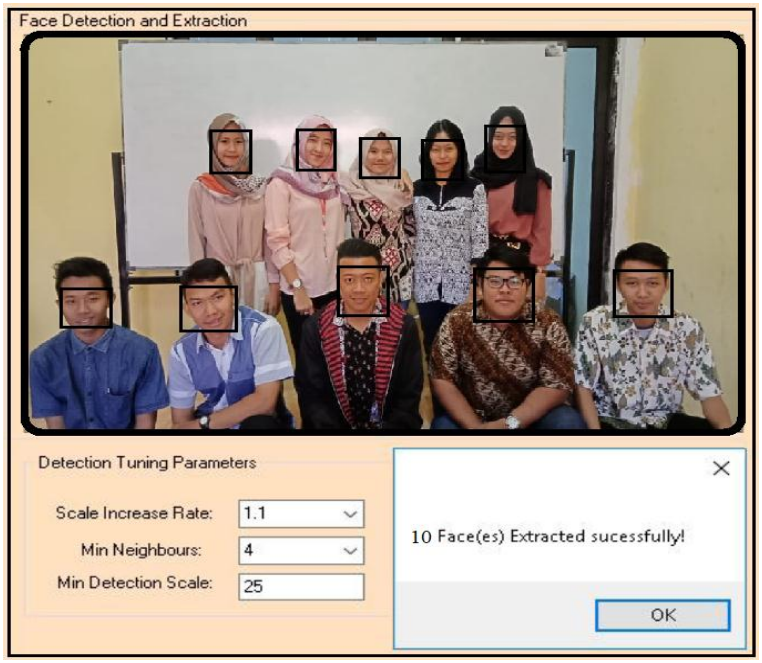

Figure 10. The face detection and extraction.

The faces marked by black hexagon is detected in the Max Neighbors' setting of 4. Here, the faces can be fully displayed. Fur is the highest setting which strictly returns frontal images. The face detector

only works with frontal images. When using a minimum neighbors setting of 1.0 and 2.0, tuning it to 1 returns the number of faces in the images as 8, different from the physical count of 5. This is because the detector returned the slightest resemblance to a face as an actual face and hence the face detection can't detect it correctly.

4.4. Latte panda processing

The Lattepanda is an incredible bit of gear. It's fully featured microcomputer that runs Windows 10 with impressive performance features for its size. It's got a built-in Arduino co-processor in the shape on an ATmega32u4 baked right into the board. In this application, Lattepanda is used because everyone is familiar with windows, and being able to use it exactly like a regular desktop. Image processing need higher speed to process the image. It has 1.8 GHz Quad Core Intel Atom Cherry Trail and 4 GB memory. Besides that, Lattepanda offer GPIO pins for both the Intel CPU which gives a huge amount of flexibility for integrated with discrete hardware and sensors. By using Lattepanda, we need less time to get the face recognition and detection result.

4.5. PCA algorithm

Principal Component Analysis or PCA is a dimensionality-reduction method that is often used the large data sets, by transforming a large set of variables into a smaller one that still contains most of the information in the large set. Reducing the number of variables of a data set naturally comes at the expense of accuracy, but the algorithm in dimensionality reduction is to trade a little accuracy for simplicity. Because smaller data sets are easier to explore and visualize and make analysing data much easier and faster for the algorithm without extraneous variables process.

5. Conclusion

It can be concluded that a reliable, secure, fast and an efficient class attendance management system has been developed replacing a manual and unreliable system. This face detection and recognition system will save time, reduce the amount of work by the administration and replace the stationery material currently in use with already existent electronic equipment. There is no need for specialized hardware for installing the system as it only uses a computer and camera. The camera plays a crucial role in the working of the system hence the image quality and performance of the camera in the real time must be improved. Future work could also include adding several well-structured attendance registers for each class and the capability to generate monthly attendance report and automatically email them to the appropriate staff for review.

6. References

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