CHAPTER 6

AUTOMATED ATTENDANCE SYSTEM USING FACE RECOGNITION

Nurul Najihah Nazaraly, Nabilah Filzah Mohd Radzuan

ABSTRACT

Attendance is compulsory in every school or university for keeping a record of the student attending the class. The biometric is applied in the system proposed, which uses face recognition for ease of attendance taking. The automated attendance system uses the proposed face recognition to overcome the weaknesses of manual and traditional attendance systems that cause learning time to be delayed, handwriting that confuses the lecturer and also the concentration of the student to be affected. This paper aims to identify the method used for detection and recognition to develop and evaluate the system. Therefore, the Viola-Jones algorithm is used in detection of student faces and Local Binary Pattern Histogram is used for recognition when it compares the student face with the images in the database. The system flow starts with capturing the image of the student in class, detecting their faces, processing the image for a better image and then extracting the feature. The results have shown the accuracy of face detection is more than 90% because some of the faces cannot be detected due to the different angles, while the accuracy for face recognition varies between 18% to 80% due to the different numbers of images trained for each person.

Keywords Face recognition, detection, attendance system, LBPH algorithm

Nurul Najihah Nazaraly, Nabilah Filzah Mohd Radzuan
Faculty of Computing, Universiti Malaysia Pahang, 26600 Pekan Pahang

Nabilah Filzah Mohd Radzuan (Corresponding Author)
e-mail: nabilahfilzah@ump.edu.my

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INTRODUCTION

The attendance system is widely used in schools, universities and companies to keep track of students attending the class or the time the worker comes and goes back home. Two different types of attendance systems are manual and automated. The manual attendance system is a traditional way for the student to fill in their attendance. The automated attendance system is using advanced technology that involves artificial intelligence and a biometric system that records attendance automatically and accurately.

Biometric is any physical characteristics of a human that can be used to identify a person, which includes facial traits, voice and fingerprints. Human faces are very unique since each facial trait is different, such as the distance between eyes and the shape of the nose (Sanders, 2014). Face detection is one of the computer technologies to identify any face appearance using algorithms and machine learning. It works when the algorithms finding facial features such as eyes, eyebrows, iris and nose, then conclude that it has detected a face. Face recognition, on the other hand, is a way of using their face to verify the person by matching the face with images in the database. Face recognition is widely used nowadays. Delta Airlines in the United States use face recognition for the passenger to check in (Radu, 2019). Steps in face recognition are face detection to locate the face, face analysis about the geometry of the face, converting the image to data based on the individual's facial features and finding a match against the database.

Nowadays, no matter how advanced the technology is, some of the students will take advantage of any weakness of the system. There might be students that will be disguised as their absent friends. Therefore, this study aims to propose an attendance system using face recognition that can verify every student in the class. The contributions of the automated attendance system using face recognition are (i) efficient and fast face detection method using Viola-Jones algorithm, (ii) accurate face recognition method that uses local binary pattern with histogram, and (iii) automatically record the attendance in real time into the excel sheet when face recognition is complete.

Background of the Problem

The traditional attendance system is very inconvenient to implement. Usually, the lecturer tends to call the student's name one by one, which takes almost 4 to 5 minutes, which is time-consuming (Raghunadh, 2013) and shortens the teaching session. Another way is that students need to write down their details on a sheet of paper. The students' concern about the attendance sheet will make them lose their focus in class. Furthermore, the world today was infected with an arising virus called COVID-19 that spreads from an infected person through a sneeze, cough on or touch surface (Coronavirus disease (COVID-19), 2020). Passing papers around the class has a high risk to the students and lecturer to get infected. The inaccuracy of this technique is when some of the students help their friend who is absent in the class, then the attendance of the student is incorrectly taken (Sharanya, 2020). Apart from that, there is a high possibility of human error. For example, during the attendance taken, two students with the same nickname in the class were mistaken as each other and the student's bad writing (Mayur Surve, 2020) caused the lecturer to have difficulty when keying in the data.

Objective and Scope

The main objective of this study is to design and develop an automated attendance system using face recognition. Hence, there are sub-objectives in this study, which are (i) to determine techniques used for detection and face recognition, (ii) to design and develop an automated attendance system using face recognition supported by a database, and (iii) to evaluate the developed automated attendance system using facial recognition application.

The scope for this study is student since it is applied when the face of the student is detected and recognised for their attendance to be taken. Tableau will be used for visualisation to create the table that displays the student images for the lecturer to ensure the student attendance is correctly taken and ease their use.

RELATED WORK

The automatic attendance management systems using real-time computer vision algorithms (Shehu V, 2010) introduce another accurate and detailed method for taking attendance instead of the traditional way, which is an additional tool that is not interrupting the learning process. This system is used by the lecturer in a classroom in the interface of the Learning Management System (LMS), where the digital camera scans, detects and extracts faces from images. This system has three modules, which are image capturing, face detector and face recogniser. Image capturing is where the camera will take the picture until all the faces are detected then it will be sent to the server using web services. Next is face detection using the HAAR classifier, classifying positive face images (wanted object) and negative face images (unwanted object) that are implemented in the Open CV library. Lastly, face recognition between images captured with the student images on the database using eigenfaces algorithm, server-based module, programmed in Python language. The system is deployed in the computer to be used in the classroom.

The study of Implementing Automated Attendance System Using Face Recognition Technique (Nirmalya Kar, 2012) is about a system that records a student's attendance automatically and the administrator can access student's information easily. This system can be used by students and the administrators. The interface of the system is designed with a Light Tool Kit (FLTK). The system works when the web camera captures the image and extracts the frontal face using OpenCV HaarCascade to detect any face. Then, perform the (Principal Component Analysis) algorithm on the training set. PCA is used to find patterns in data, and the similarities and differences between data are highlighted (Liu, 2002). Lastly, it compares the face earlier with the faces in the local database programmed in C language. The automated attendance system using the face recognition technique is deployed on mobile and computer.

Face Recognition Attendance System with GSM Notification (K Okokpujie, 2017) is a system that implements face recognition in an attendance system with notification through mobile devices. This system is used by the student to take their attendance and the lecturer to receive the attendance information. Qt Software Development Kit (SDK) was used to create the interface of the face recognition attendance system with GSM notification. The system consists of the enrolment phase and recognition phase. In enrolment, the camera is used to detect the face with help of the Viola-Jones algorithm. Then, the templates of the faces are captured using the Fisherfaces algorithm and stored in the database created with Postgresql. Next, the verification when the acquired images are detected will be compared to the face templates in the database to verify the images by taking attendance using C++. The attendance details are sent to the authorities. A face recognition attendance system with GSM notification is deployed in computers and also mobile.

Comparative Analysis

As mentioned in the previous section, the automatic attendance management system using real-time computer vision algorithms is a system that offers an accurate method of taking attendance without interrupting teaching sessions. One of the advantages of this system is its high detection rate. From the captured image, more than 70% of the face was detected in that picture and the identification rate is about 56% of the first-year student since the picture of the student in the database is still new. The second advantage of this system is the high speed of face recognition. The algorithm used is very fast since it compares the images with an image in the database of the student enrolled for a certain course only, so there is no need to compare to data of many student. Apart from that, this system also has some disadvantages.

The first disadvantage is that face detection can interfere with many things. The face pose, position, rotation, scale, light and image colours are examples of factors that the face might not be detected. The second disadvantage of this system is the system cannot identify if there are changes in a student's look. Only 30%

of the students were identified, which involve second year and the third year that cannot be identified, because their facial changes when compared to the first-year picture in the database.

Study of Implementing Automated Attendance System Using Face Recognition Technique is a system that is used to automatically record a student's attendance and the student's information can be accessed easily by the administrator. One of the advantages of this system is it has a higher detection rate. The detection rate is up to 98.7% when the face orientation is 0 or frontal since the HAAR classifier is used. The second advantage of this system is a higher recognition rate. On the frontal face, it has a 95% recognition rate. Apart from that, this system also has some disadvantages, which are the recognition and detection rate depending on the face orientation. Both detection and recognition cannot be detected when the side face is captured.

Face Recognition Attendance System with GSM Notification is a system that uses face recognition to take attendance and be sent to mobile devices. One of the advantages of this system is the higher accuracy of recognition with good lighting conditions. The average accuracy of recognition is about 70.83%, where their expressions are varied. Apart from that, this system also has some disadvantages. The first disadvantage is the accuracy of recognition is low under various lighting conditions. When the lighting conditions are not constant but with the same expressions, the average accuracy is only 54.17%, where almost half has not been recognised. The second disadvantage of this system is its analysis is more complicated when the faces are hidden. For example, if the face is covered with glasses or hairstyle, even the quality might have an impact on the face recognition analysis. All of these explanations can be seen in Table 1 and Table 2.

Table 1: Specification of existing system

SPECIFICATION	SYSTEM			
System Name	Using real-time computer vision algorithms in automatic attendance management systems	Study of Implementing Automated Attendance System Using Face Recognition Technique	Face Recognition Attendance System with GSM Notification	Automated Attendance System Using Face Recognition (Proposed system)
User	Lecturer	Student and administrator	Student and lecturer	Lecturer
Interface	Learning Management System (LMS)	Light Tool Kit (FLTK)	Qt Software Development Kit (SDK)	None
Algorithm	HAAR classifier Eigenfaces algorithm	HAAR classifier (Principal Component Analysis) algorithm	Viola-Jones algorithm Fisherfaces algorithm	Viola-Jones algorithm Local Binary Pattern Histogram (LBPH algorithm)

SPECIFICATION	SYSTEM			
Language	Python	C	C++	Python
Database	University local database	Local database	Local database using Postgresql	The Labelled Faces in the Wild (LFW) Dataset
Database Security	Not available	Not available	Not available	Not available

Table 2: Advantage & Disadvantage of existing system

SYSTEM	ADVANTAGE	DISADVANTAGE
Using real-time computer vision algorithms in automatic attendance management systems	1. High detection rate : It has a 70% of detection rate for each captured image	1. Face detection can interfere with many things: The examples are face pose, position, rotation, scale, light and image colours
	2. High speed of face recognition: The algorithm compares the images with images in a database of student enrolled for a certain course only; hence, there is no need to compare to data of many student	2. The changes in student's look cannot be identified: Only 30% of the second-year and third-year students were identified, since their facial changes when compared to their first-year picture in the database

SYSTEM	ADVANTAGE	DISADVANTAGE
Study of Implementing Automated Attendance System Using Face Recognition Technique	1. Higher detection rate: The detection rate is 98.7% since the HAAR classifier used can make the face detected when the face orientation is 0 or frontal up	1. The recognition and detection rate depend on the face orientation: Both detection and recognition cannot be detected when the side face is captured
	2. Higher recognition rate: It has a 95% recognition rate on the frontal face	
Face Recognition Attendance System with GSM Notification	1. Higher accuracy of recognition with good lightings conditions:	1. Low accuracy low under various lighting conditions: The average accuracy is only 54.17% when the lighting conditions is not
	The average accuracy of recognition is about 70.83% when the expression is varied	constant but with the same expressions
		2. Analysis is more complicated when the faces are hidden: If the face is covered with glasses or hairstyle, even the quality might have an impact on the face recognition analysis

Viola-Jones Algorithm

Viola-Jones algorithm is one of the detection algorithms proposed by Paul Viola and Michael Jones. This algorithm is fast, robust and efficient to be applied in real-time application (Jones P. V., 2004), even if it is slow in training the data (Bramhekar, 2020) as it consists of few steps:

Haar-like Features

Haar-like features as in Figure 1, is one of the ways to extract features from the image that represents the shape of a rectangle divided into black and white that represent dark regions and light regions. All human faces have universal properties such as the bridge of the nose region is brighter compared to the eye region, while the eye region is darker than the cheeks region. These properties help to find out if a human face is in an image. To know which is dark and which is light, the pixel values are summed up and compared. The darker region consists of a smaller sum of pixels compared to the lighter region.

> Value of feature = sum of pixel values in dark regions - the sum of pixel values in the white area
> Value of feature can be used to interpret different parts of a face. The zero value or the same value of pixels indicates that it does not have useful information. To get useful information, the value should be a large number to differentiate regions.

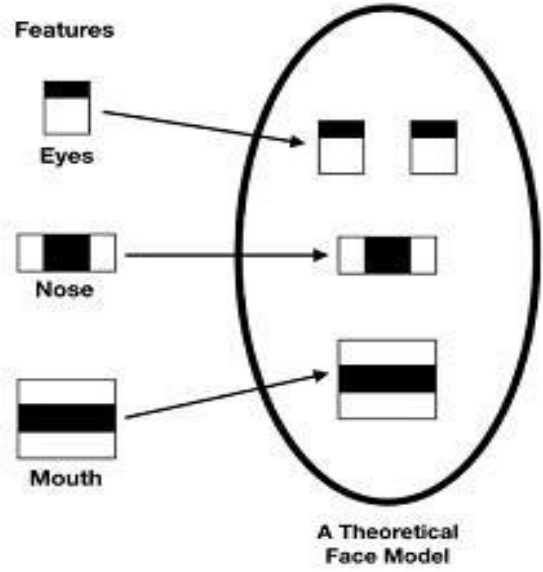

Figure 1: Haar-like features (S.Selvi, 2019)

Integral Images

The Haar-like features take a lot of time. The integral image or summed-area table that calculates the sum of pixel values quickly, as in Figure 2, needs to be used to overcome this problem. The value of each point in the integral image is the sum of all pixels above and to the left, including the target pixel (Rahmad, 2020).

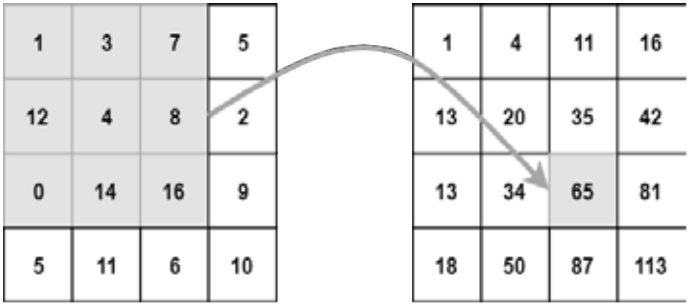

Figure 2: Calculation of an integral image from pixel value (Ivancic, n.d.)

Adaboost Algorithm

Adaboost algorithm is a machine learning algorithm that decides the best features and sizes in finding faces. Adaboost will check the classifiers' performance supplied. The performance of the classifier is calculated by evaluating it on all subregions of training images. Subregions that produce a strong or positive response indicate the image contains a human face while subregions that produce a weak or negative response does not contain a human face. The weak classifier can be found when it has the lowest rate in the iteration. Haar-like features represent a weak classifier. Combination of weak classifiers forms final result, a single strong classifier.

Cascading

The AdaBoost algorithm is still time-consuming to calculate the features of each region. The cascade, as in Figure 3, is to remove non-faces that can save time and computations in real-time face detection. The strong classifier turns into a cascade, where the stages are represented by each weak classifier. Image subregion evaluates as positive and negative evaluation. If the evaluation is positive, it means that it has a face that will give output and will send it to the next stage. This process is repeated until all stages for the human face are detected. If the evaluation is negative, it means that it does not contain a human face at any stage and it will be discarded immediately.

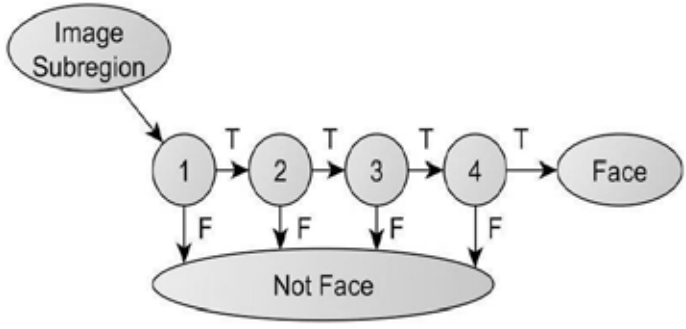

Figure 3: Cascade Classifier illustration (Jones P. V., 2001)

Local Binary Pattern Histogram (LBPH Algorithm)

LBPH algorithm is one of the face recognition algorithms used to recognise the face in the image. This algorithm is efficient, accurate in real time and less computational complexity (SudhaNarang, 2018). The algorithm needs to train with the dataset of facial images and id for each image. LBP operation, as in Figure 4, starts by creating an intermediate image that improves the image after highlighting facial characteristics. To highlight the characteristics, the sliding window concept is applied, where the greyscale facial image is converted into binary and then decimal value. The conversion of value results in a new and better image compared to the original.

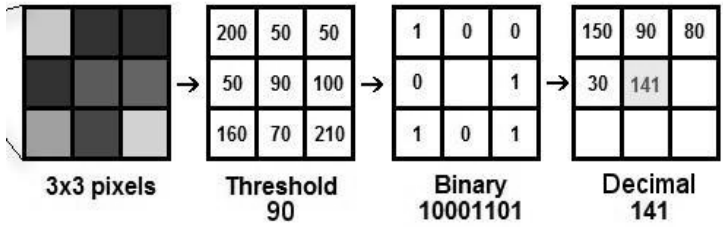

Figure 4: LBP operation (Kehinde, 2020)

The histogram of each region is then extracted. During face recognition, steps are repeated for the input image and compared with a created histogram to find the image with the closest histogram. In comparing the histogram, the distance between both histograms can be calculated using either Euclidean distance, absolute value, or chi-square.

The Labelled Faces in the Wild (LFW) Dataset

The dataset used to train and test for facial recognition is obtained from Kaggle, which is called The Labelled Faces in the Wild (LFW) (Learned-Miller, 2010). This dataset contains more than 13,000 images of 5,749 people taken from different angles and emotions. There are two or more images of 1,680 people in this dataset, as in Figure 5.

Figure 5: Sample images in The Labelled Faces in the Wild (LFW) Datas

METHODOLOGY

System development refers to the waterfall methodology that consists of a few phases, as shown in Figure 6.

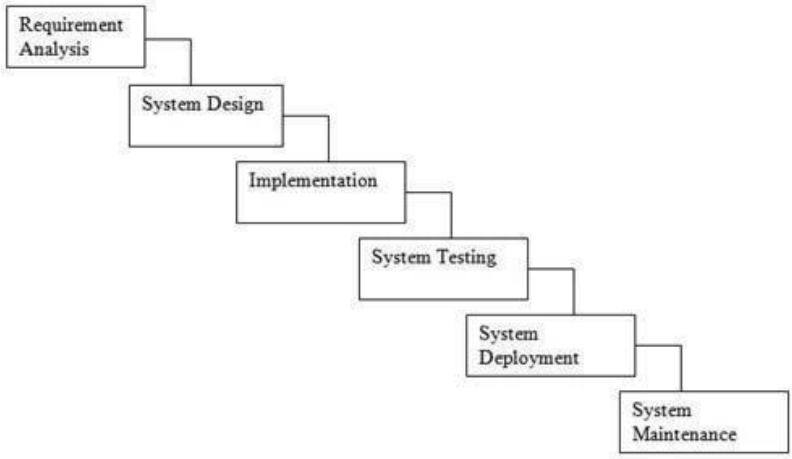

Figure 6: Waterfall model (What Is SDLC Waterfall Model?, 2021)

The requirement analysis is where all the requirements for face recognition and face detection are gathered and analysed to be applied in the system. Next, designing the system on how the automated attendance system using face recognition works with the software, hardware and algorithm used to develop the system. Then, create the code and implement all the algorithms for face detection and recognition. System testing is where all the functions, such as face detection, are tested to ensure it works well. Next, deploy the automated attendance system by using the dataset from Kaggle and lastly ensure that this system is up and running.

The purpose of this study is to propose the automated attendance system using face recognition that can recognise students faces that attend to the class, and record their attendance along with times and identification number. Then, the details can be displayed in the dashboard to identify the student's name and face. The flow of the automated attendance system using face recognition is designed in the flow. The algorithms used are Viola-Jones algorithm for detection and Local Binary Pattern Histogram for recognition. The algorithm will be explained in terms of the process on how the face is detected and recognised in detail. The dataset used in this system is defined for training and testing.

Proposed Design

When the system starts, it will capture the image of students in the class. The image is captured will undergo face detection to detect any face in the image. Then, the image containing the face will be processed for a better image that normalises it before feature extraction starts. Normalisation includes resizing images, conversion of colour images to grayscale and contrast enhancement. Next, feature extraction where all features in the human face such as the location of eyes, bridge of nose and mouth. Then, it continues with feature matching, where it will compare the image retrieval from the testing dataset to verify whether it matches or not. If the feature matches the image in the training dataset, the attendance will be updated in Microsoft word with

their names and times. Otherwise, the system will end. The flow chart is shown in Figure 7.

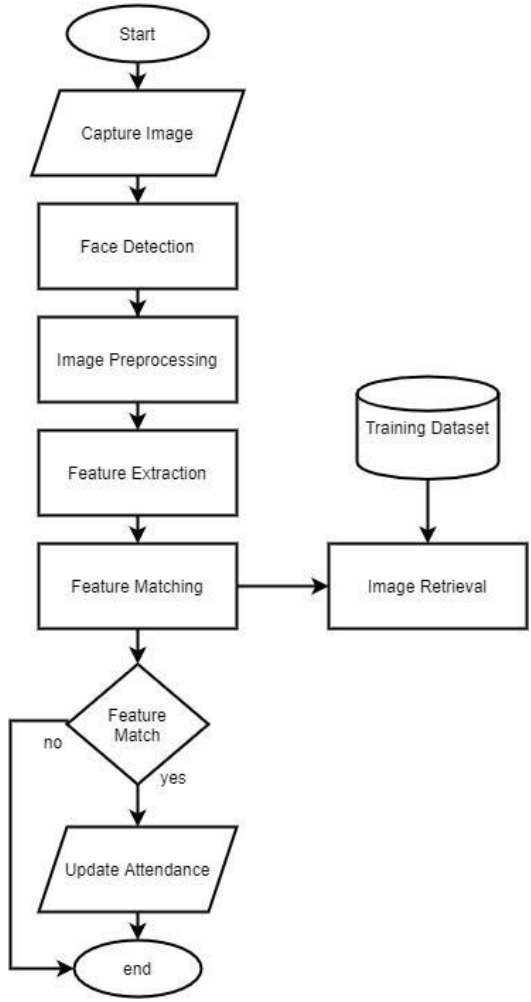

Figure 7: The flow chart of the Automated Attendance System Using Face Recognition

RESULT AND DISCUSSION

The methods are applied for the system development and implementation. There are many stages for developing the automated attendance system using face recognition, including data split into training and testing, detection with their accuracy, recognition with accuracy, and face recognition in real time. Python is used to develop the system and then the result can be customised in the dashboard to show the attendance taken. The goal of the system is it can detect and recognise the student for ease of both student and lecturer during classes.

Pre-Processing Data

The dataset used in this system is obtained from Kaggle, called The Labelled Faces in the Wild (LFW), where the algorithm can be applied to the dataset for training and testing. From the dataset, 14 persons that consist of the highest number of images, which range from 48 to 530, are selected for the training and testing in the automated attendance system using face recognition.

Face Detection

All the images in the selected dataset are run for detection to see if the face detection function works. The system can detect the face in the input image, as shown in Figure 8. Among 1,657 images from the selected dataset, only 24 images could not be detected and the accuracy is 98.55%, as shown in Table 3.

Figure 8: The detection on input image

Table 3: Accuracy of the Viola-Jones Detection

Total images	Face Detected	Face Not Detected	Accuracy of detection (%)
1657	1633	24	98.55

Training and Testing

The dataset is separated into 90:10 ratios for training and testing. Training runs on a training dataset that contains 14 folders of a different person with the time of 2 minutes and 40 seconds. It will detect and recognise the face, give the label for each person and save it in the CSV file for reference when the recognition function is called. The testing starts with the detection of the face and then recognition of the testing dataset as shown in Figure 4.2.
Training and Testing

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Figure 9: The recognition on input image

Face Recognition

Face recognition runs in real time using a webcam. The system automatically opens the camera on the laptop and runs for recognition of the face detected. Figure 10 shows how it displays the name after the face is recognised. The maximum confidence of the system is set until 74, where the value above that cannot be detected or labelled as unknown, because the higher confidence makes the face recognition less accurate. The confidence is printed once the face is recognised to see the accuracy of the face recognition.

Figure 10: The face is recognized

Post-Processing

The name of the face recognised is saved in CSV files along with the time detected and the identification number, as shown in the Figure 11.

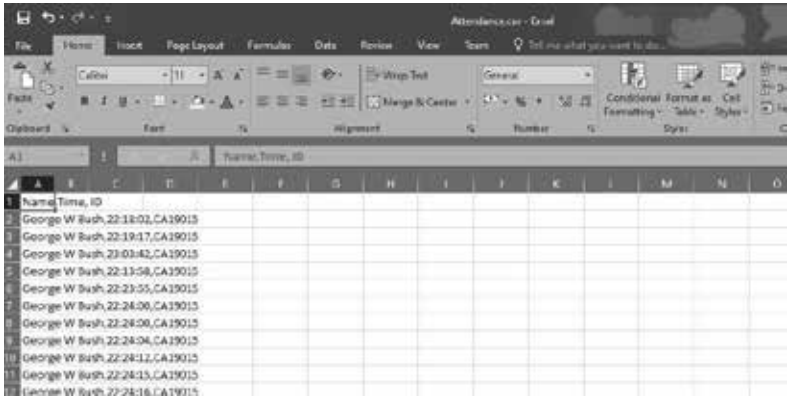

Figure 11: The name, time and id of face recognised

The attendance can be visualised by using Tableau. The duplication of name is removed by returning a minimum of time when the face is recognised. Then, the name, id and minimum

times are added to the row along with measure names. Measure names consist of shapes of the different names that can display the image, as shown in Figure 12.

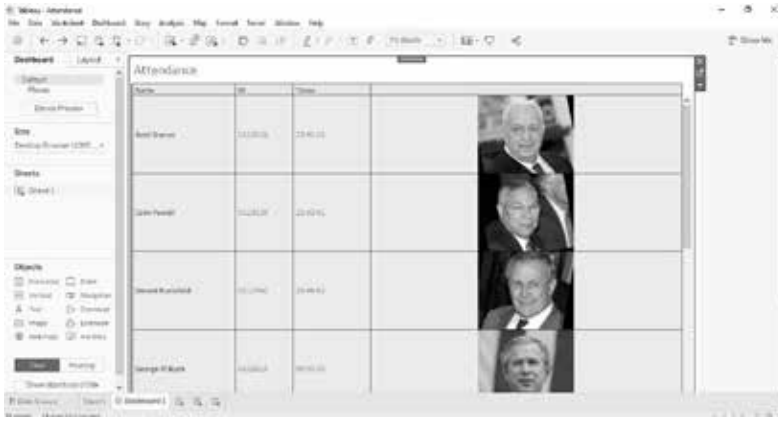

Figure 12: The attendance displays with the image in Tableau

Validate

In order to validate the face detection and recognition function, the accuracy on testing dataset is calculated. The accuracy of the detection can be obtained by how many faces are correctly detected per image input to the system. The accuracy of the recognition is calculated by the number of faces correctly recognised per image input, where the name of person tested is compared to the name of the file. The result of the accuracy is shown in Table 4 below.

Table 4: Accuracy of the Viola-Jones Detection and LBPH algorithm on the tested dataset

Total images	Face Detected	Face Not Detected	Accuracy of detection (%)	Face Recognized	Face Not Recognized	Accuracy of recognition (%)
172	170	2	98.83	147	38	85.47

The system can be validated by obtaining the accuracy of face recognition in real time. The number of faces correctly recognised in the testing dataset, which is obtained from the Kaggle and split in pre-processing, is calculated, as shown in Table 5 below.

Table 5: The result of face recognition in real-time that is affected by lighting, angle of the face, number of training images and camera quality

Name	Face Recognised	Face Not Recognised	Accuracy (%)
Ariel Sharon	6	2	75.00
Colin Powell	13	11	54.17
Donald Rumsfeld	7	6	53.85
George W Bush	43	10	81.13
Gerhard Schroeder	2	9	18.18
Hugo Chavez	5	3	62.5
Jacques Chirac	1	5	16.67
Jean Chretien	3	3	50.00
John Ashcroft	2	4	33.33
Junichiro Koizumi	4	2	66.67
Luiz Inacio Lula da Silva	3	3	50.00
Serena Williams	4	2	66.67
Tony Blair	7	8	46.67
Vladimir Putin	1	4	20.00

CONCLUSION

Few faces from the database cannot be detected since some of the faces are on the side, where both of the eyes cannot be tracked. The accuracy result from face recognition is caused by different numbers of images trained for each person. The face recognition is not very accurate because it is not enough to identify the tested image. The highest accuracy belongs to George W Bush, since the image trained is 530 images, while the lowest, Gerhard Schroeder images less than 100 in the dataset, which is 48. The lighting of the environment hardens the image to be detected. The image from the cell phone is shown to the webcam, so any reflection may interrupt the recognition. The angle of the face from the side is not detected and recognised because the eye's location cannot be tracked, and in the dataset, there are not enough images from a different angle.

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