

AUTOMATED ATTENDANCE CAPTURE AND TRACKING SYSTEM

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Abstract

The increasing number of students in colleges or universities is becoming a challenge for the lecturers especially when taking their attendance. Besides that, some students might just come to get their attendance marked and then leave the class. As existing systems do not track the students before marking their attendance, students are able to leave the class once their attendances are taken, resulting in the attendance taken by the system to be not accurate. Hence, in this paper, a tracking algorithm which will ensure that the students were actually present for certain duration of time before having their attendance taken by the system is proposed, resulting in a more accurate attendance capturing system. This system employs the Viola-Jones method for the face detection algorithm and Eigenfaces method for the face recognition algorithm. The tracking was done by allocating points to students who were successfully recognized and then dividing the total point for each student with the system's counter that represents the total time of the lecture. The proposed system was able to achieve a 78% attendance marking accuracy. From the results obtained, it is found that the system is able to verify that the students are present for a set duration of time before marking their attendance which improves the accuracy of the attendance capture system.

Keywords: Attendance system, Image processing, Face detection and recognition, Tracking.

1. Introduction

Capturing the attendance of people is a task commonly performed every day. For example, in the workplace, bosses need to be able to know whether the staff have reported to work while in academia such as schools and universities, the attendance of students are also needed to be taken to track their status. Therefore, it is important that the method for attendance capturing is accurate, convenient and fast so that it does not consume too much time. Traditionally, universities have often used the

conventional method of calling names and signing of attendance sheet to record the attendance of the students. This old method has proven to be very tedious especially for big classes and can easily be compromised through the help of fellow students signing on behalf of their friends. With that, modern methods like biometrics have been proposed as a solution to the problems faced by traditional methods.

Biometric authentication is the process which utilizes unique human traits in order to accurately identify a person. Examples include scanning of fingerprints, retina scan of the eye, voice recognition and face recognition [1, 2]. Biometric authentication is deemed very efficient and accurate in identifying individuals. This is because no two people have the same retina to perform the retina scan or have identical fingerprints. However, each biometric authentication method will have their own strength and weaknesses. Therefore, it is important to identify the suitability of these methods in an attendance capturing system.

The fingerprints of a person are unique and remains the same throughout his or her lifetime [3]. This makes it very reliable compared to other biometric traits. However, an optical sensor, which is used to capture the fingerprints of a person, can only be used by one person at a time. For attendance taking, this can be very time consuming if the class is large. Also, since the optical sensors require direct contact with the student, the risk of it being damaged or getting dirty can be high when used by many people. Retina scanning uses the unique blood vessel pattern of a human's eye for verification. The blood vessel pattern remains the same and is not affected by aging [4]. Again, this type of scanner can only be used by one person at a time and is exposed to the public, making it susceptible to being vandalised. Voice recognition [5], which identifies a person using his or her voice pattern, will also require the person being identified to be in close contact with the capturing equipment.

Therefore, for attendance capturing purposes which can involve a large group of people; it would be more practical to capture the biometric features remotely without the need for each person to have direct contact with any equipment. This reduces the possibility of damage to the equipment as well as it being more hygienic. Face recognition is a type of biometric authentication which uses the unique features of a human's face in order to recognize and identify that person [6]. These features can be captured remotely using a camera placed in a safe location. The process begins with face detection, where faces from an image or video are detected and passed to the recognition stage where the faces are identified by comparison with an existing database of faces [6]. A camera is able to capture the image of a whole classroom, making it suitable for attendance taking and also attendance tracking since the faces of a group of people can all be obtained in one image. Hence, this type of biometric system has been proposed as a suitable automatic attendance capturing system for universities to overcome the flaws in conventional methods.

By applying face recognition for attendance capturing, precious time can be saved as the system will take the attendance of the students automatically without the need for human intervention. Furthermore, it is impossible for another person to fake an attendance as the original person's face is required in order for him to be recognized and marked present. Therefore, many attendance capturing systems that use the face recognition method have been developed over the years.

Balcoh et al. [7] proposed the usage of image enhancements on the captured input images before being passed through the face detection, face recognition and attendance stages. The system uses Viola-Jones method for face detection and

Eigenfaces for the face recognition stage. A camera is situated in front of the lecture room which captures the image of the students present in the lecture. Then, the images are sent for image enhancements before being passed through to the face detection; face recognition and attendance management stage. The detected faces are cropped and sent to the face recognition stage which performs a comparison with the database of faces previously taken when the students enrolled. The attendance of recognized students are then recorded and stored in a database where students and parents are able to access and check. The disadvantage of such system is that it does not track how long the student is in class before taking the attendance.

Kawaguchi et al. [8] proposed using continuous observation to determine the attendance of a class. Active student detection (ASD) [9] was used to estimate if a seat is being occupied by a student. This method, which uses background and inter-frame subtraction, depends on the movement of a person to estimate if a seat is being occupied by a student or not [9]. The proposed system by Kawaguchi et al. [8] works by having two cameras where the sensing camera is used to determine where the student is sitting and the capturing camera to recognize the student sitting at that position. The recognition is done one seat at a time. The position and attendance of the student is then recorded into the database. The system runs continuously to ensure that the position of the student as well as the student himself is recognized correctly [8]. A disadvantage of such system is that the system only performs face detection and recognition on one face at a time which results in a waste of time as it would be more practical to perform the detection based on an entire frame. Besides that, the system also does not track the student to ensure that they remain present throughout the lecture before taking their attendance. It only continuously observes the student to determine their seating position.

The system proposed by Shehu et al. [10] utilizes a single camera installed in a classroom which captures the image of the class where it will then perform face detection later on. Faces detected are extracted and recognized by comparing with the faces stored in an existing database. Once recognized, the attendances of the students are marked and an attendance list is generated and stored. The difference between the system proposed compared to the others evaluated is that it performs the face recognition by comparing with the database of the students enrolled in that particular class which saves computational time. It also stores successfully recognized faces into the database along with the date and time so that the system is capable of recognizing the gradual changes of that student in the future, which makes it self-learning. In the case of an extreme change, the system also stores a set of unidentified faces so that the lecturer is able to manually update the database so that the system is capable of recognizing that student again. The disadvantage of such system is that it is unable to ensure that the students are present throughout the lecture before marking their attendance.

All these systems have their advantages but it is found that they share a common flaw which is that the systems proposed repeatedly captures the picture of the students to ensure that they do not miss out a student. Hence, once a student has been successfully recognized, his attendance is taken and he is able to skip the rest of the lecture without worrying about his attendance being mark absent. This shows that current systems proposed are not that reliable as once the attendance of that student is taken by the system, he is able to skip the rest of the class and still be marked present.

Therefore, an automatic attendance capturing system that is able to track the students is proposed in this paper. This system uses existing face detection and face recognition system to accurately detect and recognize the students. Then, it will track each student to ensure that they remain in the class for a certain period of time before taking their attendance. Therefore, the major contribution of this paper is the improvement of the reliability of systems proposed previously by introducing an algorithm that tracks the students to ensure that they are present for a set duration of time before taking their attendance.

The methodology of the proposed attendance capture and tracking system will be discussed in Section 2 while the results and discussion will be shown in Section 3. Finally, the conclusions and future works will be discussed in Section 4.

2. Proposed Attendance Capture and Tracking System

The attendance capture system proposed in this paper introduces a tracking algorithm to track the students before marking their attendance. Figure 1 illustrates the proposed method. During a lecture, a webcam attached to a laptop will capture a video of the class. At fixed time intervals during the lecture, a frame of the video of the class is obtained and passed to the laptop for face detection. Detected faces from each frame are then passed through a filter which isolates false detection. Faces detected are then cropped and histogram equalized before being passed to the face recognition system. Lastly, recognized faces will be sent to the tracking system to determine the attendance of each student. Before the experiment was carried out, a database of faces for students in the lecture was collected to train the face recognition system. The algorithm is divided into several stages, which are Face Detection, Face Recognition, Tracking and Attendance, and packaged into a standalone Graphical User Interface (GUI).

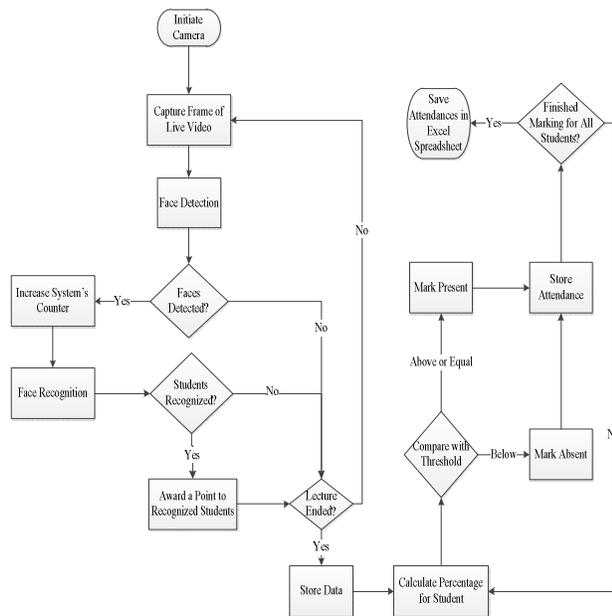


Fig. 1. Proposed attendance capture and tracking system.

2.1. Face detection

The face detection method proposed by Viola-Jones et al. [11] is used due to its high accuracy and low false detection. A video of a class is recorded using a camera located at the center of the lecture room. At fixed time intervals, a frame of the video is extracted out and then converted to grayscale before performing face detection. The Viola-Jones method uses integral images to compute the features which classifies the images and uses Adaboost learning algorithm to select important features from the potential features computed. Efficient classifiers are formed and then combined to form a cascade to eliminate background regions of the image so that computational time is spent on promising face like regions.

After performing the face detection on the converted grayscale frame, boundary boxes are then inserted at the faces detected in the frame. The detected faces are then passed through a filter to determine their size. If the detected faces are found to be between the ranges of 30×30 to 200×200 , the detected faces are cropped and stored for face recognition. Figure 2 illustrates the flowchart of the face detection algorithm. The steps are then repeated until the video has ended.

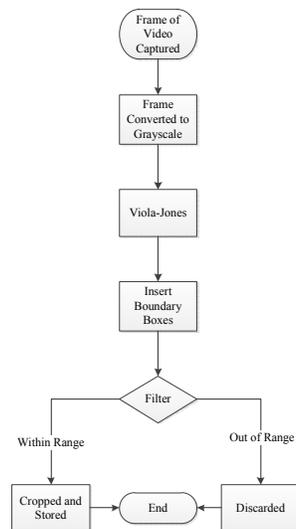


Fig. 2. Flowchart of face detection algorithm.

2.2. Face recognition

The face recognition method used in the proposed system is Eigenfaces [12] as it is able to recognize slightly tilted face which is important as students will be moving their heads from time to time. Eigenfaces works based on principal component analysis. The eigenvectors for the training set of images and its weight is computed and stored. When an unknown image is inputted, its weight is computed and compared with the weights of the training images.

For the recognition process, unknown faces are detected, cropped and resized to 30×30 before being histogram equalized to ensure the recognition of the students, even if they are sitting at the back in the frame of the classroom video. Histogram equalization spreads out the most frequent intensity values of an image which will then increase the contrast of the image. The stored detected faces are then passed through the face recognition system where it will compute the distance between the inputted images to each of the images in the database. If the minimum distance is above a threshold, the system will classify the image as an unknown. If not, the distance is calculated and the average distance of that image to each student in the database is computed. The identity of the unknown face will be the student in the database which has the lowest average distance with the unknown face. Figure 3 illustrates the flowchart of the face recognition algorithm.

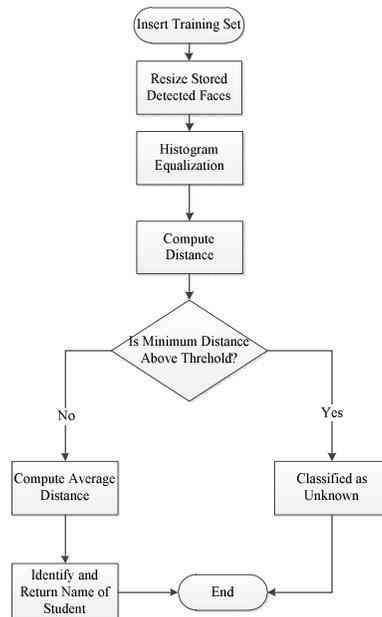


Fig. 3. Flowchart of face recognition algorithm.

2.3. Tracking

Tracking is done based on the number of times the student is recognized by the system. At this stage, both face detection and face recognition algorithm are completed and combined. The system's counter is increased each time a face is detected which represents the total time for the video. Each time a student is recognized, the system will award that particular student with a point. For example, if 100 frames were captured from the video, the system's counter would be 100 and if Student A was recognized 80 times out of those 100 frames, Student A would have received a total of 80 points. The steps are repeated until the video has ended. Once the video has ended, the data is stored for the attendance stage. Figure 4 shows the flowchart for the tracking algorithm.

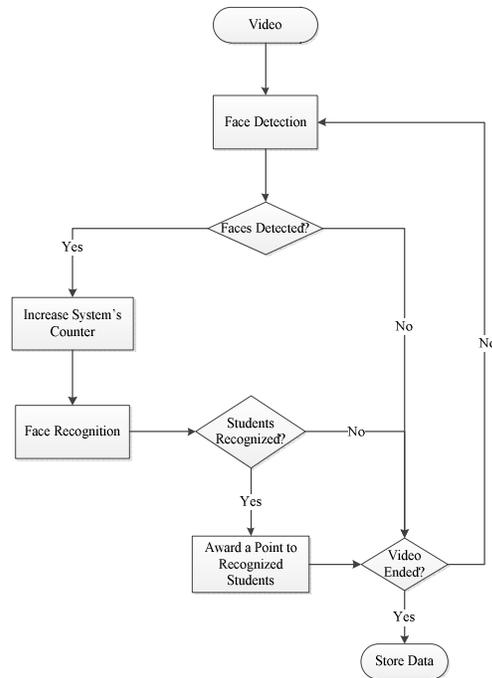


Fig. 4. Flowchart of tracking algorithm.

2.4. Attendance marking

Once the video has ended, the stored data is analysed by the system. The total percentage of which the student was present for the lecture is computed by dividing the points received by that student over the system's counter. After computing the percentage, the result obtained is compared with a set threshold. For example, if it is desired that the students be present for 80% of the total lecture time, the threshold is set to 80. If the percentage is above or equal to the threshold, the student is marked as present.

After that, the system checks if it has finished computing the attendance for all the students. If it has not, the system repeats the process, starting by computing the percentage for the next student. Once all the attendance of the students have been computed, the attendances are recorded and saved into an excel spreadsheet. Figure 5 illustrates the flowchart for the attendance algorithm.

2.5. Graphical user interface (GUI)

After completing the face detection, face recognition, tracking and attendance algorithm, the algorithms were combined to form the overall attendance capture system which was packaged into a standalone GUI. This enabled a simple prototype to be built which consist of a computer connected to a camera.

The GUI has a drop down menu allowing users to select the class which the system would be used to capture the attendance. A live video from the camera is

shown so that the user knows where the camera is facing. The system will begin taking the attendance of the class once the user has selected the class and pressed the “Start” button. The system then continues to track the attendance of the class until the “Stop” button is pressed, where an excel spreadsheet is then generated containing the attendance of the students. The GUI interface created is shown in Fig. 6.

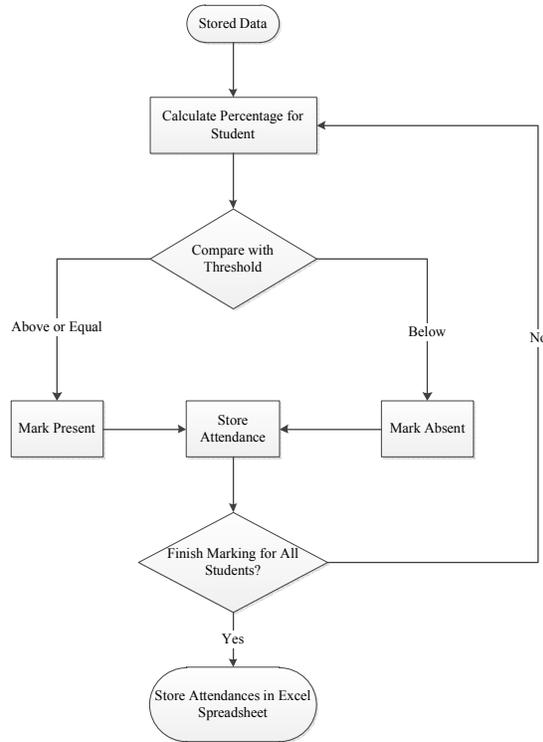


Fig. 5. Flowchart of attendance algorithm.

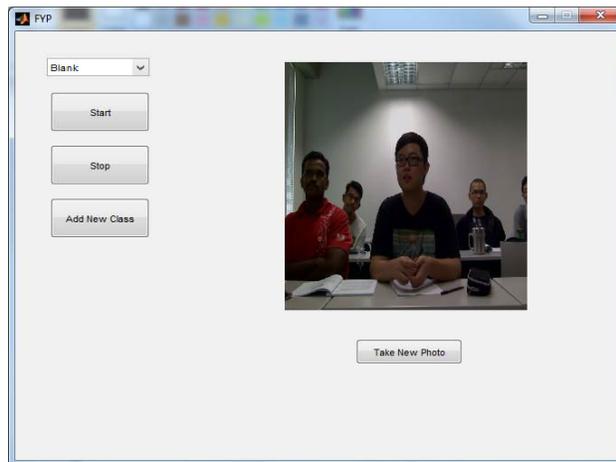


Fig. 6. GUI of attendance capture system.

3. Results and Discussion

The proposed attendance capture and tracking system was tested for a classroom, as shown in Fig. 7. Initially, ten students from a semester had photos of their faces taken and compiled into a training set to train the system so that it is able to recognise their faces. A total of 60 samples, which consists of six photos per person, were used. Then, a video during lecture for that particular semester of students was recorded for 22 minutes and 58 seconds. The video had a frame rate of 30 fps and a resolution of 1280 x 720. From this video, 344 frames, which is 1 frame taken every 4 seconds, were extracted and then sent to the detection, recognition, tracking and attendance system. This video consists of 9 students who are identified as Student A to I, as shown in Fig. 8. The results obtained from each section are further discussed below.



Fig. 7. Frame grab from video of the classroom.

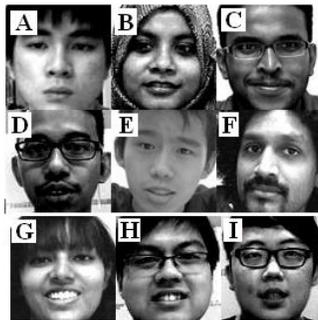


Fig. 8. Photo of students.

3.1. Face detection

Each frame extracted from the video of the lecture recorded was first sent to the face detection system. This system uses the Viola-Jones et al. [11] method to detect a face in an image. Figure 9 demonstrates the detection results of the system. As seen in Fig. 9, boundary boxes were placed around the detected faces. Table 1 shows the results obtained from the face detection system. The face detection rate was computed by taking the number of times a student's face is detected over the number of frames the student is actually present in. As

seen in Table 1, the system is capable of achieving a face detection rate of up to 93% which means the face detection system is very efficient. The reason for some faces not to be detected in some frames is due to the blocking by other students and also the positioning of their heads. As seen in Fig. 9, when the heads are rotated to a certain angle or facing down, like Student B, D and H, the system is unable to detect them. Although in a lecture the students should mostly be facing forward, this issue can still slightly affect the attendance accuracy. Therefore, it is suggested that a method to ensure students will look to the front be identified so that the camera is able to always capture a frontal view of their face. The height of the camera should also be increased to overcome the blocking of other students.

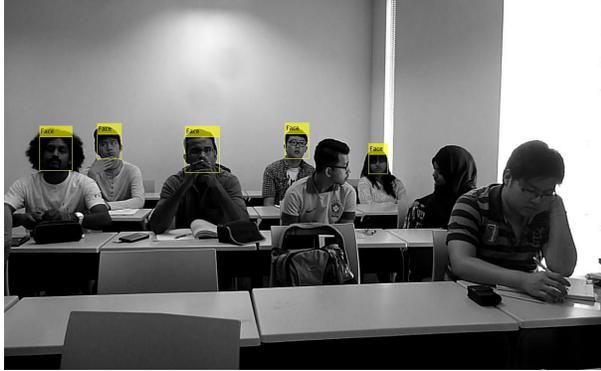


Fig. 9. Example of face detection results.

Table 1. Results of face detection system.

Student	No. of Frames Actually Present in	No. of Times Detected	Face Detection Rate (%)
A	161	115	71
B	344	282	82
C	344	234	68
D	322	206	64
E	270	217	80
F	270	250	93
G	344	103	30
H	344	108	31
I	344	219	64

3.2. Face recognition

Next, after the face detection process, each frame was sent to the face recognition system to determine the identity of each person in the frame. This system uses the Eigenfaces [12] method. Table 2 shows the results obtained from the face recognition system. The rate is calculated based on how many times a detected face is recognized and has his or her identity determined throughout the whole lecture session. For example, Student E's face was detected as a face 217 times

and for 205 times, the identity of the face was determined as Student E. Hence, the recognition rate for Student E is 94%. As seen in Table 2, the face recognition rate is very high with the lowest being 84% for Student H. This shows that the face recognition using Eigenfaces is very reliable. However, some false recognition has also occurred, resulting in some students being recognized more than the amount of times his face is being detected. This is due to some students having almost similar features, causing that student to be wrongly identified as his friend. Hence, it is suggested that the size of the training set be increased to help improve the recognition rate. To overcome the false recognition issue, the face recognition rate was computed by subtracting the false recognition from the number of times recognized and then divided by the number of times detected. As seen, the average face recognition rate is above 90% which means that the face recognition system is efficient.

Table 2. Results of face recognition system.

Student	No. of Times Detected	No. of Times Recognized	False Recognition	Recognition Rate (%)
A	115	138	23	100
B	282	293	16	98
C	234	240	20	94
D	206	189	9	87
E	217	205	0	94
F	250	250	5	98
G	103	111	8	100
H	108	96	5	84
I	219	205	3	92

3.3. Tracking and attendance marking

Table 3 gives the results obtained from the tracking and attendance system. The total time in class (%) refers to the percentage in which each student are present throughout the 344 frames and is computed by taking number of times recognized divided by the system's counter. As there are faces detected only in 316 out of the 344 frames, the system's counter is 316. Student A initially sat in front of the camera for the first 161 frames before shifting out of the camera view to simulate leaving the lecture. As seen in the results, the system has computed that he was present for only 44% of the lecture. As seen in Table 1 earlier, Student E and F were only present for 270 frames and the system has computed their total time in class as 65% and 79%. This shows that the system is capable of tracking the students. From the results, it can be seen that the attendance system depends on the face detection and face recognition system. Since for each frame, both detection and recognition of faces will be performed, hence the location of the student does not affect the attendance system. Therefore, even if the student changes places, his attendance will not be affected. However, positioning of the face will affect the attendance system. Due to the low face detection rate for Student G and H because of blocking of her head and the positioning of his head respectively, the system was not able to accurately calculate their total time in class percentage. As the threshold set

was 60%, students who were present for 60% and above were marked present as seen in Table 3. Hence, the accuracy of the attendance marking is 78% since 7 out of the 9 student's attendance was marked correctly.

Table 4 shows the attendance results obtained from the proposed system compared to other systems. The method proposed in this paper tested the algorithm with a class of 9 people while Kawaguchi et al. [8] tested their algorithm with 12 students and Shehu et al. [10] tested their algorithm with 147 people. From the results obtained, it can be observed that the accuracy of the proposed attendance capture system that utilises a tracking algorithm is comparable to other systems that just consider a person present as long as that person is recognised by their system. Hence, this shows that the tracking algorithm added to the proposed automatic attendance capture system is able to provide an accurate attendance list and did not negatively affect the performance of the attendance capture system.

Table 3. Results of attendance system.

Student	No. of Times Recognized/Tracked	Total Time in Class (%)	Attendance
A	138	44	0
B	293	93	1
C	240	76	1
D	189	60	1
E	205	65	1
F	250	79	1
G	111	35	0
H	96	30	0
I	205	65	1

Table 4. Comparison of attendance marking accuracy.

Method	Attendance Marking Accuracy
Proposed attendance capture and tracking system	78%
Method proposed by Kawaguchi et al. [8]	70%
Method proposed by Shehu et al. [10]	30%

3.4. GUI

A simple prototype of the proposed attendance capture and tracking system was built using a computer and camera, as shown in Fig. 10. This was used to test the GUI, previously shown in Fig. 6, which was packaged into an executable file. When the start button is pressed, the GUI will enter a loop which continuously captures a frame from the live video every 4 seconds and perform the face detection, face recognition and tracking algorithm until the stop button is pressed. Once the stop button is pressed, the GUI will then stop the loop, compute the attendance of the students and save the attendance in an excel spreadsheet as well as a .mat file containing the stored data. This is so that

when the GUI is started and stopped for the same class next time, the GUI is capable of saving the attendance in the same excel spreadsheet without overwriting the previous attendance saved, as shown in Fig. 11. This will help a lecturer keep track of the entire student's attendance for the whole semester.



Fig. 10. Hardware setup.

	A	B	C	D	E	F	G	H	I	J
14					Lecture_2					
15					Name	Attendance				
16					A	0				
17					B	1				
18					C	1				
19					D	1				
20					E	1				
21					F	1				
22					G	0				
23					H	0				
24					I	1				
25										
26					Lecture_3					
27					Name	Attendance				
28					A	1				
29					B	1				
30					C	1				
31					D	1				
32					E	1				
33					F	1				
34					G	1				
35					H	1				
36					I	1				
37										
38					Lecture_4					
39					Name	Attendance				
40					A	0				
41					B	1				
42					C	1				

Fig. 11. Example of attendance marking spreadsheet.

4. Conclusions and Future Works

The proposed attendance capture and tracking system is able to track the students to ensure that they are present for a set duration of time before taking their attendance, as seen from the results shown in the results and discussion section. The attendance system relies on the face detection and recognition system in order to track the students present in the class. The results for the face detection and face recognition system show that both systems are accurate with high success rates. The tracking and attendance marking results show that the attendance can be marked correctly for students that are mostly in class as well as for students who leave half way during the class. Hence, this will help prevent students from skipping classes halfway through the lesson and also provides lecturers with an accurate attendance list. For future works, a method which ensures that students look towards the front should be identified, the height of the camera should also be increased to overcome blocking by students and multiple cameras could be used so that the system can be implemented in a bigger classroom.

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