ATTENDANCE SYSTEM USING A MOBILE DEVICE: FACE RECOGNITION, GPS OR BOTH?

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Abstract— In every higher education setting in Malaysia, there are concerns about student attendance, as the current process of manual attendance taking is not only time consuming but is also inaccurate. Inconsistent attendance in class may significantly affect students’ overall academic performance. Thus, having a consistent attendance system is important. This paper proposes a mobile attendance system equipped with face recognition and a GPS locator. The face recognition adopts the Local Binary Pattern Histogram (LBPH) algorithm and retrieves the student’s location using GPS services. This project has a high potential to replace the current attendance system, as it is designed for speed and accuracy and is more convenient than the current approach.

Keywords— Mobile attendance, Face recognition, GPS, Local Binary Pattern.

I. INTRODUCTION

As a student, it is necessary to attend regularly all lectures, tutorials and lab sessions listed in the timetable. Doing so enables student to learn effectively across the semester with the designed syllabus. Some might argue that independent learning is the best way for students to learn and that students have the right to manage their own time, even if this means missing class. However, considering the amount of money students are paying for their education, and the fact that lax attendance systems are known to affect particular students’ studies and the university’s reputation [1], attendance records are important to understand student progress and development. In some institutions, without a certain percentage of attendance, students are not allowed to sit for an examination, while in some other institutions, attendance is part of the continuous assessment.

The classic attendance system of calling students’ names and recording their presence on paper is easily manipulated by students [2], who know how to abuse the system and have their friends record their attendance falsely. The system is also time consuming and may adversely affect students’ learning experience [3]. Imagine how long it would take to register attendance in a class of 100–300 students using this method. Further, it would require preparation on the part of the attendance taker, which is tedious, and the lecturer would need to monitor students manually to detect cases of dishonesty. To solve this problem, some universities have introduced the Moodle attendance system, where an attendance link is provided for a short period for students to update their attendance. This method requires students to login to a device using their own account. However, while this method improves efficacy, some problems remain. For example, students can mark their attendance from outside the class or university with the right timing. Therefore, it is essential to find a new approach to overcome the problems of the current methods and to make it more convenient for lecturersto record their students’ attendance. Previous attempts at automated time and attendance systems have used electronic tags, barcoded badges, magnetic strip cards, biometrics (vein reader, hand geometry, fingerprint or facial) and touch screens [4] in place of paper cards. Such attendance systems try to overcome the aforementioned problems by ensuring students are directly interacting with the device and that the device is in the particular class in which the student should be. Conversely, the aim of this project is to create an attendance system that allows students to record their attendance using their own mobile device, with the help of face recognition technology and a GPS locator. Our proposed attendance system does not require any kind of peripheral device other than students’ own smartphones, thereby reducing computational time and avoiding the cost of placing physical devices in classes.

II. PREVIOUS WORK

Several techniques and methods have been accepted to effectively monitor students’ attendance. Shewu et al. [5] proposed a cost-effective computer-based embedded attendance management system that allowed the electric monitoring of attendance using an electronic card. These cards, which contain all necessary information on the individual, are inserted into a machine that records the time and other information to a server. In another example, Cheng et al. [6] designed and implemented a system that applies user identification and a password for authentication. However, the issue with these electronic card or password-based systems is that they allow for the sharing or dishonest use of the cards or passwords. This problem can be addressed by using a biometric recognition system, such as fingerprint or iris recognition. A system was proposed and implemented by the authors in [7] and [8] for using fingerprint scans.
to record attendance and generate reports after a fixed duration. To have their attendance verified, individuals simply had to insert their fingers into a fingerprint reader.

In another attempt to address the problem of misuse of electronic attendance-taking systems, Kadry et al. [9] proposed a wireless attendance management system using an individual’s iris, which is unique, for authentication. In this system, a scanner is used to scan the iris and automatically log in the person. Unlike fingerprints, the iris is more preserved from the external environment. However, both fingerprint- and iris-recognition-based approaches require extra devices and scanners, usually connected to a server.

In radio frequency identification (RFID)-based methods, attendance is recorded in the same way as for the fingerprint reader, with the only difference being the tools used; that is, the RFID card [10]. The RFID card stores user’s information on the card as data. This data is encrypted into the card, which is then used as a key to record when the user arrives [11].

In our work, we address the problem of the misuse of electronic attendance-taking systems by using the internet connectivity of smartphones to monitor the presence or attendance of an individual. Smartphone-based monitoring systems prevent the expense of additional scanning devices by leveraging on the fact that almost all students own smartphones. In our system, an area is fixed for every student. When he or she enters or exits that area, a time stamp is saved and the system calculates the duration of any particular student residing within the area.

III. AGILE METHODOLOGY

A. Extreme Programming (XP)

Extreme programming (XP) is one of the agile methods that emphasize iterative development and has been very effective in producing high-quality software in real-world projects with strict time constraints. Table 1 maps the XP practices, distinguishing the XP practices which address the software quality and those which address the development process quality. We used this mapping to address the software quality, emphasize technical and code-oriented aspects, whereas the XP practices, which address the development process, emphasize human and social aspects. Needless to say that both aspects are important and there is a synergetic relationship among them [12].

Table 1: XP practices mapping with respect to quality subjects

<table>
<thead>
<tr>
<th>Influence level</th>
<th>XP practices address the software quality</th>
<th>XP practices address the development process quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Simple design</td>
<td>Planning game</td>
</tr>
<tr>
<td></td>
<td>Testing</td>
<td>Customer on-site</td>
</tr>
<tr>
<td></td>
<td>Refactoring</td>
<td>Pair programming</td>
</tr>
<tr>
<td></td>
<td>Continuous integration</td>
<td>Collective ownership</td>
</tr>
<tr>
<td>Normal</td>
<td>Small releases</td>
<td>Merit</td>
</tr>
<tr>
<td></td>
<td>Coding standards</td>
<td>4-hour week (adapted to academic schedule)</td>
</tr>
</tbody>
</table>

B. Testing

We piloted our program first in University of Nottingham Malaysia Campus (UNMC) and Polytechnic Sultan Abdul Halim Mu’adzam Shah located in Jitra, Kedah. We have tested not just in the smallest room in UNMC as well as the largest room in UNMC. We conducted the testing using four devices: Samsung S advance, Oneplus one, Galaxy Mega 2 and Samsung S5. The results are identical. The devices are all similar in their process time which is less than 1 second.

IV. PROPOSED SOLUTION APPROACH

A. How the Program Works

The program needs to be installed on an android device with an active internet connection, GPS, and a camera. Users need to follow some simple steps to enable the program to update their attendance record, including permitting the program to obtain their current location and providing the necessary input to allow the program to recognise the student’s face. This program can only recognise one face at a time.

The primary objective of the program is to be able to take attendance using students’ mobile devices without any accuracy. For the project to succeed, it must employ a location tracker and face recognition to deliver a reliable attendance system. The face recognition requires the student to have direct interaction with the device, while the GPS locator specifies the device’s location. Students also benefit from this system, as they can check their attendance status for their current classes. Since student can use their own mobile device, which they can bring anywhere, the system offers excellent mobility.

To summarise, this program requires the following core functions:

- Face recognition
- A classroom locator
- The ability to register attendance and allow students to access their attendance record.

1) Facial Recognition Technology

A camera is needed to use facial recognition. Before deploying the application to users, it must be initialised with the required dataset images (facial images of the students), which will be processed at the start of the program. To ensure the optimal speed of the program, the dataset images must be minimised. The best way of doing this is by separating the dataset images by course. Thus, every student in each course would use the same application, except it will have been initialised with different images. Once the program has been loaded with the student images, it will be able to recognise students’ faces by using an appropriate algorithm to compare the current frame image with the one that has been initialised. Initialising the images in the program before generating the installer provides much greater reliability because students cannot easily alter the initialised images.
2) Classroom or Location Locator

GPS coordinates are required for the program to instantly determine the student’s current location, based on the coordinates received. Using GPS, we can obtain both x- and y-coordinates up to 6 decimal points with the help of ground and space satellites. The location becomes even more accurate with the help of cellular network providers. To interpret the coordinates, the program must be integrated with Google Maps APIs so that users can view the visual location of the coordinates receive. A credential is required to use the Google Maps APIs service, which can be obtained by placing a request through Google console.

3) Register Attendance

The system automatically updates attendance in the database for any faces that the program could recognise. Students’ mobile devices are remotely connected to the local database. The information updated is student name, x-coordinate, y-coordinate, classroom, and timestamp. In addition to registering attendance, the application allows students to access their attendance record. The x- and y-coordinates stored during attendance registration can also be retrieved to show the location on Google Maps. The workflow for this program is outlined in Section B (Fig. 1).

C. Overall Workflow of Program

![Workflow Diagram](image)

D. Local Binary Pattern Histogram

Only a few face recognition algorithms are provided in the OpenCV library, including Local Binary Pattern Histograms (LBPH), Eigenfaces and Fisherfaces. This project uses LBPH, which takes a different approach compared to other methods. In LBPH, characterisation of features is done locally, whereas other approaches process the image as a whole. The LBPH algorithm comes from a visual descriptor for pattern classification mainly used in computer vision. In this project, training images were set to 128 × 128 pixels. It is important to maintain the image size to avoid affecting the face recognition rate. This is because the LBPH algorithm is highly prone to scaled images. That is, once the algorithm extracts a feature, the program can only identify the person when provided with an image at the same scale (in pixels).

The first requirement of the LBPH algorithm or the pre-processing procedure is to convert the image to grayscale mode. Grayscale images are not images in black and white or binary images; instead, grayscale mode is a series of numbers, each of which represents a different intensity level. Having images in grayscale mode represents a significant advantage when using the LBPH algorithm as the image can be treated as a vector to extract valuable information. Next, for each pixel in the grayscale image, we select a neighbouring pixel of size 8 surrounding the centre pixel. The LBPH value is calculated based on the centre value by thresholding it to a 3 × 3 array. The intensity level threshold is set to 8. A more formal description of the LBPH operator can be given as equation (1), where the notation \((P, R)\) denotes a neighbourhood of \(P\) sampling points on a circle of radius \(R\):

\[
LBP_{P,R}(X_c,Y_c) = \sum_{p=0}^{P} S(t_p - i_c) 2^p
\]  

(1)

Formally, given a pixel at \((X_c,Y_c)\), the resulting LBPH can be expressed in decimal form as in equation (1), where intensity \(i_c\) and \(i_p\) are respectively gray-level values of the central pixel and \(P\) surrounding pixels in the circle neighbourhood with a radius \(R\), and function \(s(x)\) is defined as:

\[
s(x) = \begin{cases} 
1 & \text{if } x \geq 0 \\
0 & \text{if } x < 0 
\end{cases}
\]

The operator LBPH \((P, R)\) creates 2\(P\) different output values, matching to 2\(P\) different binary patterns formed by \(P\) pixels in the neighborhood. The basic LBPH operator is invariant to monotonic gray-scale transformations maintaining pixel strength order in the local neighborhoods. The histogram of LBPH labels calculated over a region can be exploited as a texture descriptor. Fig. 2 is an example of calculating the LBPH value with a neighbouring size 8 pixel.
In the above figure, the value 4 is the centre pixel. Note that each of the values represents a colour intensity. The expected output is an 8 binary digit for each pixel LBP calculation. After performing the LBP calculation, the value is stored in a 2D array with the exact same dimension as the input image. With 8 adjacent pixels converted to binary digits, we have a total of $2^8 = 256$ possible combinations of local binary patterns. The stored result in an 8-bit array can be processed to obtain a decimal value. This process is visualised in Fig.3.

For the purpose of illustration, we start at the top right and move clockwise (the blue boxes indicate the sequence) to accumulate the binary string. Note that the sequence of collecting the binary string does not matter provided we use the same sequence for all other Local Binary Pattern (LBP) calculations.

**E. GPS**

Mobile phones equipped with a GPS receiver are readily available on the market. The General Packet Radio Service (GPRS) is currently one of the best and cheapest communication modes available. The attendance system is deployed on this kind of mobile phone, which is supported to perform all required operations. When the application is started on a user’s mobile phone for the first time, they are prompted to register. Thereafter, the user opens the software by entering their username and password. When the user enters their username and password, these are checked for authenticity. If not authenticated, the user is prompted with a message of wrong username and password and may re-enter their log in details.

**V. DEVELOPMENT ENVIRONMENT**

The Java-enforced object-oriented programming language developed by Sun Microsystems was chosen for implementing this mobile program. It is designed to enforce object-oriented programming.
to have as few implementation dependencies as possible. We have used Java version 1.7.0, designed for 64-bit operating systems. The reason for choosing Java is the platform’s independence criteria. A Java program can be developed and run on almost any computer that comes with the Java Runtime Environment. Java applications are usually converted into a special byte code so that they can run on any virtual Java machine, regardless of the computer architecture. Moreover, the PHP language is a hypertext processor widely used by web developers, particularly in server-side scripting language. In this project, we implement a short PHP that acts as a translator between the database and the application itself. The PHP script will be placed in the XAMPP local web server.

The developed software required a database to store the data and manage communication between the application and database. XAMPP was the perfect solution. XML stands for Extensible Markup Language, which functions as a set of rules for encoding format. XML is also used in android development for purposes such as defining applications’ user interfaces, describing components of the system and for minor purposes such as replacing hard-coded strings with a single string.

For the development environment, we chose the newest modern integrated development environment, Android Studio, developed by Jet Brains. Android Studio was designed specifically for android development purposes and has taken over end support for Eclipse (another integrated development environment for android) from Google. The official language of Android Studio is Java, as a large part of android is written in Java and its API is intended to be called from Java. Android Studio is a very useful tool because each of its modules is independent and can be run, tested and debugged without affecting another module. Moreover, Android Studio provides improved features for interface design, including drag and drop feature and a delivering mechanism for interaction with resources and multi-tasking. Android Studio also helps developers by adding an external library and providing complete support for Junit and android testing. For this project, Android Studio version 1.5 was used throughout the software development process.

IV. RESULTS AND DISCUSSION

The system proposed is a real-time system. The experimental results showed that the acceptance detection ratio of our suggested algorithm ranged from 75% to 95%. The result of the analysis process is presented below:

F. Main Menu and Login

Fig.5 shows the main menu of our system. We design the interface design in a simplicity way by mainly focusing on user-friendly aspect. The sequence numbered presented in fig.5 illustrate step of taking attendance. However, student can navigate to any other function available such as locating current location, taking attendance with face recognition and accessing attendance log as they want. The enrollment and registration phase is an administrative phase in which the administrator (staff) needs to log in as shown in fig.6. The student’s face photos as well as the other bio-data are stored for the first time into the database for student registration. The student can login to the main menu through the student login.
Fig.7 shows some sample faces captured during the registration phase. There are four different samples of lighting, angle and distance taken.

H. Location detector

The next interface is the location map. Once the student click “Your Location” button, it will directly open google map interface. Refer to fig.8 (left), the maps is programmed to zoom at user’s current location. However, if the student wish to control the range of the map displayed, they able to that with the zoom in and out button. To increase the student understanding of the map, the map has been flagged for each building such as in fig.8 (right).

I. Face Recognition

Next interface is the face recognition mode designed in a landscape mode. As noticed, there is a camera frame in the middle of interface for the purpose of face recognition. Any face detected will then converted into grayscale image and displayed at the top right corner. So basically, the video frame provides the program with lots of static image. This feature provides more odds to be recognized by the program. Once the student has been recognized by the program, a text will be prompted to notify the user their attendance has been marked. Student also has the authority to access face image gallery. However, they cannot add any new image. 

J. Attendance log

Students can navigate to this windows activity by click the “check attendance” button in the main menu. Later, they will need to click again the “check attendance” button in the current interface to see the student attendance record appear in the location. This button will also trigger the connection between application and database. Thus, allowing attendance record to be display. Notice that the interface is divided into 2 sections and both section are scrollable to fit all the information retrieved. The upper part is to list down the entire student along with their details. Meanwhile at the bottom, user can click on the student name to display student’s location in the map and also can print reports of attendance as fig. 11 shows an example.

CONCLUSION

This paper proposed a smart, location-based time and attendance tracking system that runs as a mobile application on a smartphone and uses location and face detection as its core components. The classroom area is set for tracking using GPS, and student coordinates inside the area show that the student is present in the class. The attendance system has been designed to improve the efficiency of the student attendance-taking process and to reduce the rate of errors in managing students’ attendance records.

REFERENCES

Attendance System Using a Mobile Device: Face Recognition, GPS or Both?


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