Journal of ICT in Education (JICTIE)
ISSN 2289-7844 / 10 / 1 / 2023 / 40-55

The Development of a Face Recognition-based Mobile Application for Student Attendance Recording

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To cite this article (APA): Wan Abdul Rahman, W.F., & Roslan, N.A.S. (2023). The development of a face recognition-based mobile application for student attendance recording. *Journal of ICT in Education*, *10*(1), 40-55. https://doi.org/10.37134/jictie.vol10.1.4.2023

To link to this article: https://doi.org/10.37134/jictie. vol10.1.4.2023

Abstract

Attendance-taking has been practised in most learning institutions, schools, colleges, and universities to monitor the students' commitment towards their studies. The traditional way of attendance-taking is usually performed by passing a piece of paper to be signed by all the students in the class. The main drawback is proxy attendance, whereby a student can sign on behalf of their friend. Students frequently miss classes are at a higher risk of missing important information, discussions, demonstrations, and assignments, leading to knowledge gaps and hindering their overall academic progress. Additionally, traditional attendance-taking takes significant time for the paper to circulate among the students, especially in larger classrooms. This can result in wasted instructional time and disrupt the class flow. The students might be distracted, and their focus on the class material might also be disrupted. Regarding record management, paper-based attendance records can easily get misplaced, damaged, or lost. Retrieving and analysing attendance data becomes time-consuming when papers must be manually sorted. Not only that, considering the post-Covid pandemic nowadays, everyone is still expected to minimise physical contact to reduce the possibility of infection. This, however, is quite impossible if manual attendance-taking is practised because everyone needs to touch the same paper to sign the attendance. Therefore, in this project, a face recognition-based mobile application is proposed to facilitate attendance-taking while minimising the drawbacks of the traditional attendance-taking approach. The main content of this article will be based on the phases involved in the development process. The output interface of the proposed system will be presented from both lecturers' and students' views. Finally, this paper is ended with the system limitations and recommendations for future work.

Keywords: face recognition, attendance-taking, post-Covid.

Received: 1 February 2023; Accepted: 1 April 2023; Published: 1 June 2023

INTRODUCTION

Attendance-taking in school or higher learning institutions is essential to ensure students' commitment to their classes and studies. In manual attendance-taking, the students are usually given the attendance list on a piece of paper and must sign on the specific row next to their names. In most institutions, lecturers or teachers are required to provide an attendance report on a weekly or monthly basis to see the commitment of the students to the class or subject taken. Consistent attendance ensures that students receive a continuous flow of information and instruction, which aids in their overall understanding of the curriculum. The attendance monitoring process by the lecturers/instructors is crucial because when students skip classes, they create gaps in their learning, making it harder for them to catch up later. Regular attendance is often linked to better academic performance. Students who attend classes regularly have more opportunities to engage with the material being taught, participate in discussions, ask questions, and receive clarifications, which enhances comprehension and retention of the subject matter, leading to improved academic outcomes.

Instructors must manually collect and process the attendance sheets before having an accurate attendance record. To accomplish this, the lecturer/teacher needs to go through the attendance list, check line-by-line and key in the data to the spreadsheet to be analysed. However, the process might be tedious and prone to errors, especially when dealing with many students or mass lectures. Retrieving and analysing attendance data becomes time-consuming when records must be manually sorted. This delay in accessing attendance information can hinder timely interventions for students who are absent frequently. Consequently, failure to track and identify students with poor attendance could lead to more significant academic issues or concerns.

Not only the process of transferring the data to the spreadsheet is time-consuming, but the process of manual attendance-taking itself could be more efficient. It takes 17.8 seconds on average for a student to find their name and complete the process of signing the attendance (Shoewu et al., 2014). The impact is even worse when involved with mass lecture classes. Another drawback of taking attendance by passing around a paper during a lecture is that it can result in wasted instructional time and disrupt the class flow (Hoo & Ibrahim, 2019; Tee et al., 2022).

The most crucial issue is that manual attendance-taking is exposed to students' cheating attempts (Hoo & Ibrahim, 2019). Sometimes, students less committed to attending their class might ask their friends to sign the attendance on their behalf (Yadav et al., 2022). The lecturer might not realise this or have time to double-check by calling the students names. Finally, considering the pandemic Covid nowadays, passing the attendance paper from one student to another has a high possibility of spreading the virus as everyone in the class keeps touching the paper (Dev & Patnaik, 2020; Zhao et al., 2020).

Various attendance-taking approaches have been proposed, including QR code, fingerprint recognition, Radio Frequency Identification (RFID), and barcode scanning. However, the issue of proxy attendance still could not be addressed accordingly. QR code and barcode scanning, for example, requires randomised or personalised QR codes to make it difficult for students to share their codes with others. Fingerprint recognition, although highly secure and difficult to forge, may increase the chances of virus infection because the students must put their fingers in the same place to get scanned. Therefore, a better attendance-taking system that minimises previously mentioned issues should be implemented (Gawande et al., 2020). Facial recognition has excellent potential to detect and prevent proxy attendance by verifying the identity of each student in real time. The attendance-taking approach should be improvised to enhance active involvement in learning, leading to improved academic outcomes. Not only that, it would also help instil a sense of accountability and responsibility in students. Students learn the importance of punctuality, discipline, and meeting commitments by attending classes regularly. These are essential skills that students carry with them into their professional lives.

PROPOSED SYSTEM

This paper proposes an Android-based mobile application prototype to enhance the manual attendance-taking process. Considering that almost everyone nowadays has smartphones, this could be a more practical approach for attendance.

The essential features of the application are as follows:

a) *can automatically generate the attendance report.*
b) *can take or record the attendance in a less disruptive approach.*
c) *use a biometric-based system to avoid fraud, face, iris, fingerprint, palm print, or other features.*
d) *can reduce contact with a contaminated surface (e.g., the attendance paper).*

A face recognition technology has been decided to be used since it is non-intrusive and only requires a glimpse of the registered facial characteristics to verify attendance. Face recognition is preferable to fingerprint recognition because fingerprint requires the user to touch the sensor. The accuracy of a fingerprint is reduced when the person gets dirt or grease on their fingers or scanner.

Received: 1 February 2023; Accepted: 1 April 2023; Published: 1 June 2023

METHODOLOGY

The general project activities are shown in Figure 1 below.

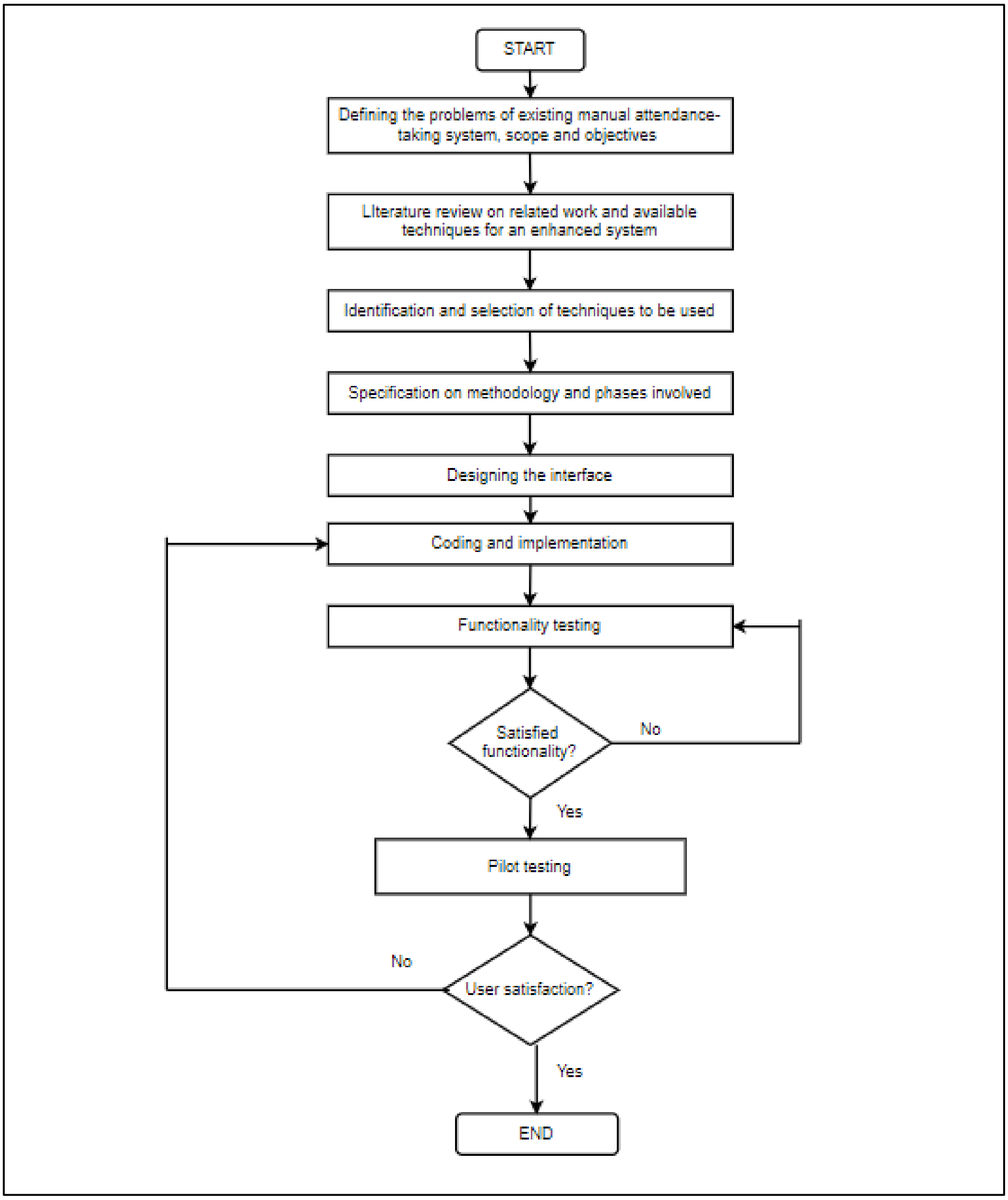

Figure 1: Flowchart of general project activities.

Considering the main idea of the Waterfall Model (Casteren, 2017) of the Software Development Lifecycle, this project started with the analysis part, whereby the problems of the existing manual attendance-taking system have been identified. A survey was conducted by distributing a questionnaire (as shown in Table 1 below) to the lecturers. 88.9% of the respondents agreed with automated attendance-taking deployment in their classes.

Define System Requirements: This project's attendance system scope and objectives have been determined based on the questionnaire findings. The target user group (e.g., students, employees) and their specific needs have been identified. The required features and functionalities of the mobile application, such as real-time attendance tracking, face detection and recognition accuracy, and integration with existing systems, are specified. The application's user interface (UI) design and navigation structure is later defined.

Table 1: Questionnaire for pre-analysis of paper-based attendance-taking

No	Question
1	Would you agree if an automated attendance-taking method is introduced in your class?
2	The traditional way of taking attendance wastes many papers.
3	Paper-based attendance consumes much time and requires more effort from the lecturer.
4	Students tend to cheat in paper-based attendance.
5	The paper-based attendance-taking is efficient and easy to manage, even for large classes or mass lectures.
6	The paper-based attendance-taking can distract the students' attention.
7	The management and analysis task of paper-based attendance-taking has a high chance of human error.
8	The paper-based attendance can be easily misplaced.

A literature review has been conducted to identify related work and available techniques/approaches that can be applied to this project. A proper selection of techniques and tools has then been made based on the suitability and practicality of this project.

System Development and Integration: The project goals established during the analysis phase are translated into specific system functions and operations while designing the interface. Detailed descriptions of the desired features and operations, screen layouts, process diagrams, and other documentation have been drafted in this phase. This includes the interaction among modules involved, interface design (how interfaces will appear), and data design (what data will be required). While developing the system's user interface (UI) and functionality, factors such as ease of use and intuitive design. This phase is followed by the implementation part, which considers the actual development process. The face-recognition feature involves five main phases: face capturing, face identification, face extraction, face verification, and finally, attendance recording.

The application is designed by using Android Studio (Google & Jetbrains, 2022) and implemented using FaceNet (Zhao, 2020) and Convolutional Neural Network (CNN) algorithm (Isinkaye, 2020).

Received: 1 February 2023; Accepted: 1 April 2023; Published: 1 June 2023

The smartphone must be linked to the laptop via USB to debug the written Android Studio codes. Once Android Studio has been installed, the necessary SDKs (Software Development Kits) and face detection and recognition tools, such as OpenCV or a deep learning framework like TensorFlow, are set up.

The User Interface (UI) design phase includes creating the app's visual design, considering user-friendly layouts, colour schemes, and intuitive navigation, and designing screens for user authentication, attendance tracking, profile management, and any additional functionalities required.

Generally, the face recognition part consists of four main steps: (i) Data collection and preparation, (ii) Model selection and training, and (iii) Evaluation and testing.

Data collection and preparation: At this stage, a sufficient amount of face image data from individuals using the system are collected, considering variations in lighting conditions, facial expressions, poses, and backgrounds. This is to ensure diversity in the dataset. The images are then pre-processed by performing tasks such as face detection, alignment, and normalisation to improve the quality and consistency of the data.

Model selection and training: The dataset is split into training and validation sets. The selected model is trained using the training set by utilising transfer learning (Jin et al., 2020) or fine-tuning (Martínez-Díaz et al., 2021) techniques. The model hyperparameters, including learning rate, batch size, and regularisation techniques, are optimised based on the validation set performance.

Evaluation and testing: The trained model's performance is evaluated using appropriate metrics (e.g., accuracy, precision). Thorough testing uses separate test datasets to measure the system's performance in real-world scenarios and assess the system's robustness against variations in lighting, poses, and expressions.

Deployment and Continuous Improvement: The system is deployed in the classroom once the development has been completed according to the previously designed interface and functions. At this phase, functionality testing ensures that each module gracefully works together without faults and errors and maintains compatibility with the intended platform. A series of rigorous testing is performed by using sample images that have been recorded. The debugging procedure is iteratively done whenever improper functionality is detected. This phase is essential to ensure that the initial plan and users' requirements have been achieved and to ensure system stability, accuracy, and scalability. In some instances, changes to the system can still occur after the prototype is tested by the user, which is commonly related to the system's user-friendliness and improved functionality. The user feedback is incorporated, and system usage is monitored to identify potential enhancements or new features.

IMPLEMENTATION REQUIREMENT

The tools required for this project are Android Studio, Visual Studio (Microsoft Corporation, 2022), Eclipse (Eclipse Foundation, 2022), Flutter (Google, 2022) and Xamarin (Microsoft, 2022). Other related software needed is the FaceNet model, Real-Time Firebase (Tamplin & Jee, 2011), Google ML Kit Face Detection (Google, 2021), CameraX and Google Sheet. The algorithm in Python, supplied by TensorFlow Lite, supports the Android library to implement intelligence and machine learning in the apps. Android Studio does not only support standard data formats for inputs and outputs, such as images and arrays, but it has pre- and post-processing components that can perform image scaling and cropping.

The Firebase Assistant included in the Android Studio lets developers connect any app to a Firebase server. Numerous valuable features, including app statistics, authentication, and notification messages, can later be embedded. Android Studio also aids in the integration of the app with the Google Cloud infrastructure.

Managing XML files is made easier with Android Studio's intuitive drag-and-drop editor. Even developing a whole new app layout is very easy. The Android Studio layout editor, developed with the Constraint Layout API, allows layouts adaptable to different screen sizes to be constructed. This guarantees an efficient design technique appropriate to the device’s needs. Android Studio also has various advanced testing tools and frameworks for multiple purposes, which aid the testing phase using functional UI testing methods.

The latest version of CameraX is used in this project since it is available in the library as a Jetpack extension toolkit. A uniform and simple API interface that runs throughout most Android apps and backward compatibility with previous Android versions make developing camera apps easier. The need to add device-specific code in the code base is removed since it also handles device compatibility. When camera functionality is added to the app, these features decrease the amount of code to be written. The system will compare the image captured (based on similar characteristics) with the previously stored images in the database.

The integration of face detection functionality has been done using the chosen library or framework (e.g., OpenCV). The face recognition feature is executed in this project via the FaceNet model. FaceNet is preferable to developing a face recognition system because of the deep learning approach and CNN features, which enable the creation of highly accurate and robust models (Ghimire et al., 2022). Improved performance can be achieved through effective feature extraction and representation learning from facial images. FaceNet captures a student’s face as input and generates a vector of 128 values representing the most critical features of the face.

An embedding-based representation approach in FaceNet learns a high-dimensional feature embedding space, causing faces from the same person to be close together and faces from different

Received: 1 February 2023; Accepted: 1 April 2023; Published: 1 June 2023

people to be far apart. The discriminative characteristic of the embedding area can capture subtle variations between other individuals' facial features, leading to efficient and accurate face recognition. Even under challenging conditions, FaceNet maintains robustness to variations in lighting conditions, facial expressions, poses, and other factors affecting facial appearance. The Triplet Loss Function employed in FaceNet during training loss ensures that the learned embeddings are discriminative and can effectively differentiate between individuals. It encourages the network to map images of the same person closer together in the embedding space. On the other hand, the images of different people are pushed further apart (William et al., 2019). These face detection and recognition components identified and matched faces against the stored face templates.

The most crucial part is that FaceNet is scalable and can handle many individuals through its embedding-based representation, which supports efficient storage (Qi et al., 2022). A database has been set up to store user profiles, attendance records, and relevant information to quickly and accurately identify or verify individuals.

To ensure a seamless user experience, intuitive user interfaces and responsive design have been designed by developing the necessary screens, buttons, and interactive elements to support the attendance system's functionalities. Finally, the face detection, recognition, and attendance tracking modules are integrated with the UI components.

OUTPUT INTERFACE

The main page (as in Figure 2) shows two options for the users to sign in: STUDENT or LECTURER, according to their roles.

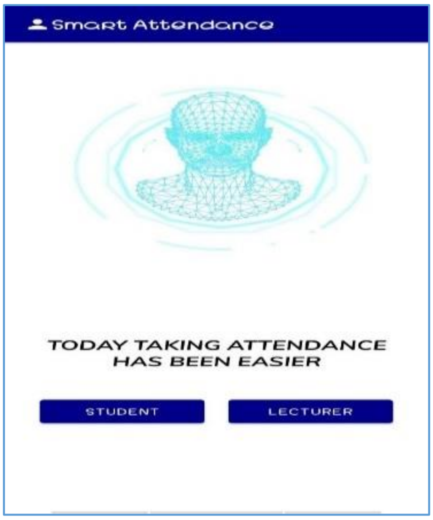

Figure 2: A main page showing two login options for the users.

Journal of ICT in Education (JICTIE)
ISSN 2289-7844 / 10 / 1 / 2023 / 40-55

User Registration – Students' View

As in Figure 3, clicking the STUDENT button will display the following page. Unregistered students can choose to sign up, whereby those who already have the account can directly proceed to log in by filling in the Student ID and password and clicking the log-in button. Once the "DOES NOT HAVE ACCOUNT" button is clicked, the users without an account will be displayed with a sign-up page, as in Figure 4. The students must complete the registration by filling in their student number, name, course code and password.

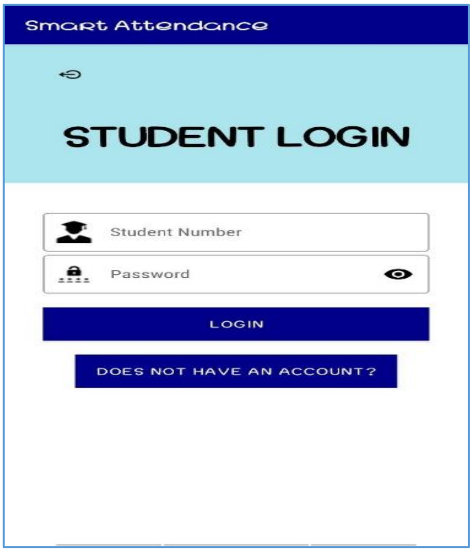

Figure 3: Student login page.

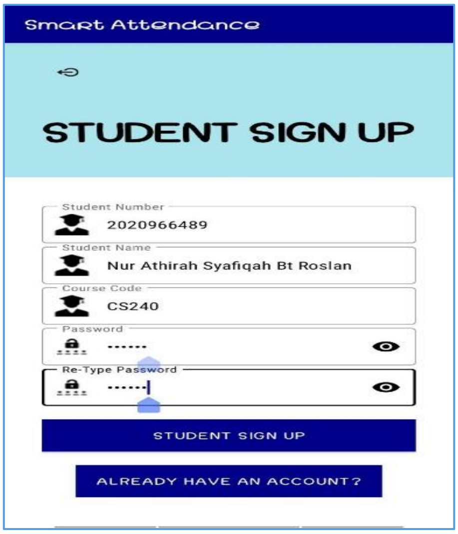

Figure 4: Student sign-up page.

User Authentication and Attendance-taking Process – Students' View

Upon creating an account, students access the system's login page, as depicted in Figure 3. Once successfully logged in, students can seamlessly navigate to the attendance-taking section by selecting the 'ATTENDANCE' icon, as demonstrated in Figure 5. Upon tapping the 'ATTENDANCE' icon, students are directed to the face-scanning page, shown in Figure 6. The frame automatically captures and records the image when a face is detected. Students can use the front or rear camera by pressing the camera button. If no face is detected, a helpful notification (Figure 7) promptly appears, guiding on maintaining an appropriate distance and angle.

Received: 1 February 2023; Accepted: 1 April 2023; Published: 1 June 2023

Figure 5: A successful student login.

Figure 6: Face scanning attempt.

Figure 7: Failed face detection.

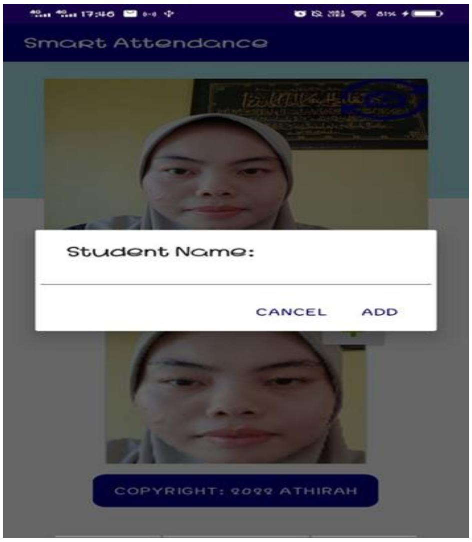

Figure 8: Successful face detection.

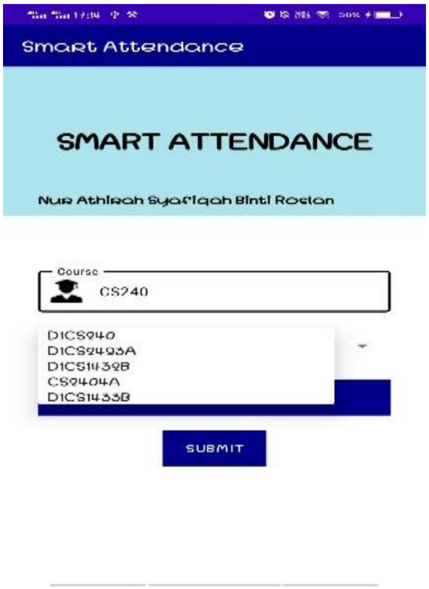

Figure 9: List of classes enrolled by a student.

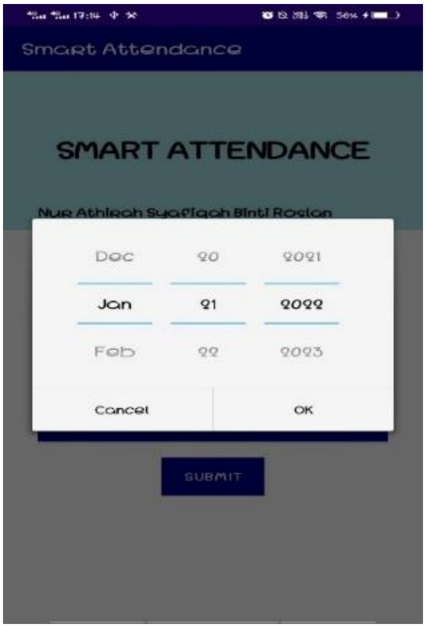

Figure 10: Date selection.

Once the face has been captured by the camera (as shown in Figure 8), the student must enter their name, and then choose the course and class. The list of courses and classes will be displayed to the students based on the extracted data from the database depending on the result of the face scanned and

Received: 1 February 2023; Accepted: 1 April 2023; Published: 1 June 2023

name entered. The students finally need to choose the correct date for attendance. When the student clicks the 'SUBMIT' button, the data will be sent to and kept in the database accessible to the lecturers.

Viewing the Attendance Record – Lecturers' View

The signup or login page for the lecturers is the same as the one implemented for the students. Once successfully logged in to their accounts, the lecturers can access two main menus: 'ATTENDANCE' and 'DOWNLOAD'. They may view and save the list of students by pressing the 'DOWNLOAD' button. The 'ATTENDANCE' button allows lecturers to view, edit, and update their students' lists.

Figure 11: Main menus for lecturers' view.

Figure 12: E-mail verification to access the spreadsheet.

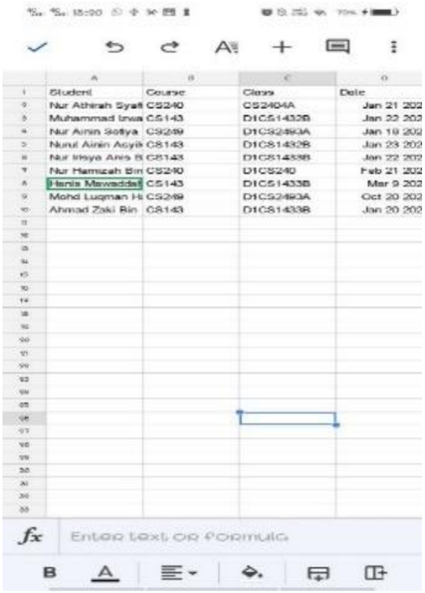

Figure 13: Sample of attendance list in the form of a spreadsheet.

The list of students with successfully submitted scanned faces and data will appear in the lecturers' view. Typing into the search box allows the lecturers to filter the attendance based on the course or class enrolled by the students. The attendance record for specific students can also be filtered by typing their student numbers.

The lecturers can access the attendance list as a spreadsheet by signing in with their email. The list can be viewed and downloaded via the 'save' and 'export' options. As shown in Figure 12, the attendance list can be extracted and displayed in Excel.

DISCUSSIONS

In terms of effectiveness, this face recognition-based attendance system is more accurate than paper-based methods. Manual entry errors, such as illegible handwriting or incorrect transcriptions, can be minimised, reducing the chances of data inaccuracies. With proper implementation, a high level of accuracy in recognising and verifying individuals' identities (based on unique facial features) for attendance purposes can be achieved.

Face recognition systems can provide real-time monitoring of attendance. They can quickly capture and process facial data, allowing for instant identification and recording of attendance without causing delays or disruptions. Real-time updates on attendance allow instructors or administrators to have

Received: 1 February 2023; Accepted: 1 April 2023; Published: 1 June 2023

instant access to attendance data and help them monitor student participation.

Further, reports can be generated, and data analysis can be easily performed on attendance records. This can provide insights into attendance trends, identify patterns, and help monitor student progress and engagement. Such research is typically more time-consuming and challenging than traditional paper-based methods.

Since the system matches the person's face with a pre-registered image or template, it becomes difficult for someone else to impersonate another individual. The issue of proxy attendance, where one person marks attendance on behalf of another, can be significantly reduced with face recognition systems.

Regarding efficiency, face recognition-based attendance takes less time than manually noting attendance on paper, especially for large classes or events. Its scalability feature can efficiently handle attendance for large groups of individuals simultaneously by processing multiple faces quickly, making them suitable for crowded environments such as classrooms or workplaces.

Compared to paper-based attendance, which can be space-consuming and prone to damage or loss, digital attendance records are easily accessible and stored securely in digital formats. They can be retrieved and analysed from anywhere with an Internet connection.

Finally, the developed attendance systems can be integrated with other software or platforms, such as learning management systems (LMS) or student information systems (SIS), for seamless data exchange and automation, which later will reduce administrative work and facilitate a more holistic approach to managing student information.

LIMITATIONS

First, the accuracy of this application mainly depends on its facial-recognition algorithms which are influenced by the image quality. Scanning a video's visual quality could be better than a digital camera. The scanning is affected by variations in brightness density. Even high-definition video has a standard rate of 720 pixels; the best is 1080 pixels.

Second, storing the detected image data demands the database to retain the face features derived by the algorithm. The challenging part is connecting the scanning feature to the database to extract the recognised face information and store the data for later retrieval. Although the Firebase itself can adapt to any data, this process requires time to be linked with the Firebase Database since it involves a real-time database. Further, Firebase's mobile area concentrates on the Android operating system and does not support iOS apps, resulting in handling Android data only.

Another critical component is the facial detection reader. FaceNet is utilised for this purpose due to its available model and library, as well as an algorithm that allows the user to interpret and extract the face acquired by the camera. However, it takes around a few seconds to remove and detect images using FaceNet due to the unavailability of files in the folder and sources to refer to the face that has been seen. The following limitation is that the face scanning process requires the students to be within 30 cm between the camera and their beginning to ensure the face can be detected appropriately and framed.

FUTURE WORK

The central aspect to be improved in future is the security of this application. Security and privacy protect stored data from illegal access and alteration. Privacy also ensures that the personal information of students and lecturers is kept private. Specific policies and authorisation to utilise personal data and information collected in the database while using the apps are examples of privacy and security that may be applied in facial recognition-based attendance.

In terms of versioning, this face recognition-based attendance could be enhanced to be compatible with Android, iOS, and web applications. This effort is expected to guarantee the adaptability of the application to various platforms as well as the ability for users to use it from their preferred devices without any doubt.

CONCLUSIONS

The output of this project has been found to pave the way for ease in attendance-taking. It is beneficial in eliminating proxy attendance and reducing the human error often occurring while manual attendance is keyed into the computer for the institution's record purposes. It not only can be accomplished within a few seconds but offers great flexibility in taking attendance compared to the traditional approach, whereby the students, as well as the lecturers, manage to access the system anywhere, anytime, just by having their smartphone in hand, without the risk of being misplaced or lost. Finally, during the post-Covid pandemic nowadays, whereby everyone is expected to reduce physical touch among others, face recognition-based attendance can prevent the students and lecturers from touching the same attendance paper as practised before. Despite its limitation, it is hoped that this project's proposed face recognition-based attendance system could benefit other researchers in developing better mobile applications.

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