Development of Students' Attendance Management System using Facial Recognition

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ABSTRACT
Attendance management systems are employed in various organizations, ranging from schools to determine the number of students in a class, hospitals to determine the number of patients in a ward, and companies to keep track of the number of workers present. The issue of attendance management is most prevalent in schools; hence, this paper describes a student attendance management system using facial recognition software. A Raspberry Pi 4 microprocessor was integrated alongside a camera and proximity sensor for object and image tracking to achieve this goal. The system has a database written in MySQL programming language that records and stores the facial structure of each student taken with the camera. Other programming languages used in the development of this system are Python, PHP and JavaScript. A web interface using HTML and CSS was also designed to facilitate easy interaction with the system. To test the system, a total of 990 images were used to train the neural network, and then another 410 images were used to check whether the neural network meets the proposed objectives.

Keywords
MySQL, Raspberry Pi, microprocessor, PHP, JavaScript, Neural Network.

1. INTRODUCTION
Authentication poses a significant challenge in today's information systems environment [1]. Student attendance is critical and it affects the academic performance of students. A positive correlation was found between attendance and the performance of students in final exams [2]. Manual attendance monitoring which involves the use of paper is inefficient and slow [3]. In some workplaces, attendance is used to ensure punctuality; they could also be used to calculate the percentage of salary to be paid to the individual whose attendance is being inspected.

Facial recognition is one of the available means of biometric recognition. The face plays a crucial role in human identity, serving as a key feature that differentiates individuals within large populations [4]. Biometrics denotes the scientific study of physical measurements and calculations, specifically on metrics associated with human traits. [5], since no two humans have all their physical characteristics completely identical, it is a secure means of verification and validation. The prevalence of biometric technologies is rising in various aspects of daily life, encompassing applications that range from safeguarding personal devices to controlling physical access [6].

Biometrics is a prominent field in bioengineering, due to its swift expansion and the rise of new technologies. Image processing encompasses a diverse array of applications, including biometric identification, behavioural assessment, telecommunication, and video monitoring [7]. It is now becoming one of the widely implemented methods of automation for recognizing people based on physical or behavioural features [8]. Several biometric systems already exist in systems that implement features such as signature, fingerprints, voice, iris, retina; geometry of the hand, ear and face. Facial and fingerprint recognition systems have gained worldwide acceptance. A typical facial recognition system takes into account; the shape of the face, the distances between features of the face, the varying sizes of these features etc.

The method of using attendance sheets to take and validate students' attendance has been in use for several years with various limitations. Recording absence in a class having a large population is a difficult task as it increases paperwork and the process is also time-consuming as great effort is required to compute the attendance rates for each student by the staff of the department. Other issues like dishonesty on the part of the student and high errors are also associated with taking attendance manually. These are some of the problems encountered daily by lecturers. To solve these problems, a computerized system has the capability of taking records and managing students' attendance automatically with little or no interference from either the lecturer or the student. Numerous educational institutions mandate a minimum attendance percentage for students to be eligible to sit for examinations; however, this policy is often not rigorously enforced due to the challenges associated with current attendance tracking methods. This paper primarily aims to create an automated attendance system utilizing facial recognition technology, intended for implementation across university departments. The system will streamline the process of tracking student attendance in classes and will also generate reports to assess student eligibility based on their attendance records.

[1] outlined a methodology for identifying individuals in images, including those wearing face masks. The approach employs a MobileNetV2 architecture in conjunction with OpenCV for mask identification and utilizes FaceNet for facial recognition tasks. With a training dataset comprising 13,359 images, the system demonstrates an impressive accuracy of 99.65% in mask detection, 99.52% in recognizing faces with masks, and 99.96% in identifying faces without masks.

[7] created an automated system for detecting and recognizing faces by analyzing images extracted from videos, thereby facilitating the attendance tracking of students through the identification of their unique facial characteristics. This proposed system enhances human face detection utilizing the Viola-Jones algorithm and employs the Fisher Face algorithm

for face recognition, achieving an accuracy rate between 45% and 50%.

[9] developed a system to monitor student attendance, assigning each student a unique identity associated with a barcode that can be scanned using a smartphone app. However, this system presents the risk of one student using another's identification, which could undermine the reliability of attendance records. An alternative biometric approach that could improve the attendance system is iris recognition, which utilizes a framework to capture, store, and match iris images for identification.

[10] introduced a framework for attendance marking that integrates computer vision and ear recognition techniques into attendance management processes. This system employs a non-intrusive advanced camera installed in the classroom to scan the environment, identifying and extracting ears from the captured images. Once the ears are extracted, they are compared against an existing database of student images, and upon successful identification, an attendance list is generated and stored in a database.

2. MATERIALS AND METHODS

2.1 Hardware

This section includes the necessary hardware required to implement the control system. These hardware components are:

i. Microprocessor
ii. Camera
iii. Passive Infrared (PIR) Sensor
iv. LED Lights

2.1.1 Microprocessor

The microprocessor serves as the central processing unit of the system. It can be implemented in two primary ways: through a personal computer or via a dedicated system. In this context, the dedicated system utilized is the Raspberry Pi 4, illustrated in Fig 1. This device operates on the Raspbian operating system, features 2 GB of dedicated RAM, and allows for expandable internal storage through a memory card.

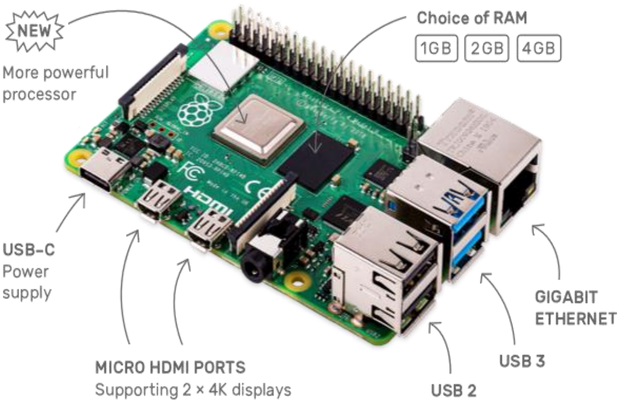

Figure 1. The Processor

2.1.2 Camera

The Raspberry Pi features a specialized camera module called the Pi-Camera, illustrated in Fig 2, which will serve as the camera during Raspberry Pi operations. Conversely, if the program is executed on a personal computer, a webcam will be necessary to capture the required images.

Figure 2. The Camera

2.1.3 Passive Infrared (PIR) Sensor

The sensor designated for proximity detection is the Passive Infrared (PIR) sensor, illustrated in Fig 3. This device functions by identifying the infrared radiation released by warm-blooded organisms. Upon detecting these infrared rays, it activates the output to initiate a pre-programmed action.

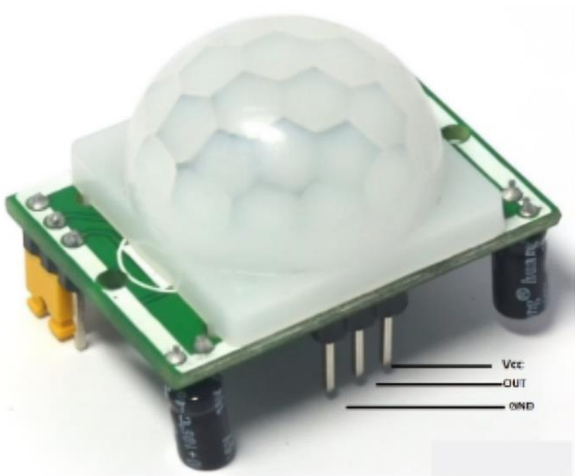

Figure 3. Proximity Sensor

2.1.4 Radio Frequency (RF) Transmitter

LED Lights: The LED works to notify the user of the current operating stage of the entire system. The colours of LED lights will be used. The colours include amber, green and red. Each of these colours represents a varying stage of the operation.

2.2 Software

The programming languages implemented during the development of this system are:

i. Python
ii. MySQL
iii. PHP
iv. HTML5 and CSS3
v. JavaScript

2.2.1 Python

Python is a robust open-source programming language known for its accessibility and ease of learning, making it suitable for both novice developers and seasoned programmers. Its versatility encompasses various applications, including web and mobile development, algorithm creation, and machine learning, as well as data analysis. Development frameworks that complement Python include TensorFlow, Keras, and Anaconda/Miniconda. The neural network training was conducted on the Google Colaboratory platform, utilizing the complimentary GPU resources available.

2.2.2 MySQL
MySQL is a structured query language designed for querying servers in web-based applications. As one of several available structured query languages, it is open source and primarily utilized for database management, with its fundamental purpose being to retrieve records from databases.

2.2.3 PHP
PHP, which stands for Hypertext Preprocessor, is a recursive acronym. In the realm of programming, individual files are typically referred to as scripts, positioning PHP as a scripting language particularly advantageous for server-side development. It ranks among the most widely utilized programming languages in web development due to its straightforward implementation. The recent release of PHP7 has notably enhanced processing speed and improved compatibility with various systems.

2.2.4 HTML 5 and CSS3
HTML, or Hypertext Markup Language, serves as the foundational language for developing static websites and is recognized as the standard for web page creation. It employs a collection of elements to outline the webpage's structure and is typically utilized in conjunction with CSS or CSS3. CSS, which stands for Cascading Style Sheets, is a prominent styling language that can be applied directly within HTML or PHP scripts or through the importation of an external stylesheet containing all the design specifications.

2.2.5. JavaScript
JavaScript, commonly abbreviated as JS, serves to introduce diverse functionalities to websites. It plays a crucial role in the development of many responsive websites, and contrary to popular belief, numerous responsive features on widely used sites are achieved through JavaScript.

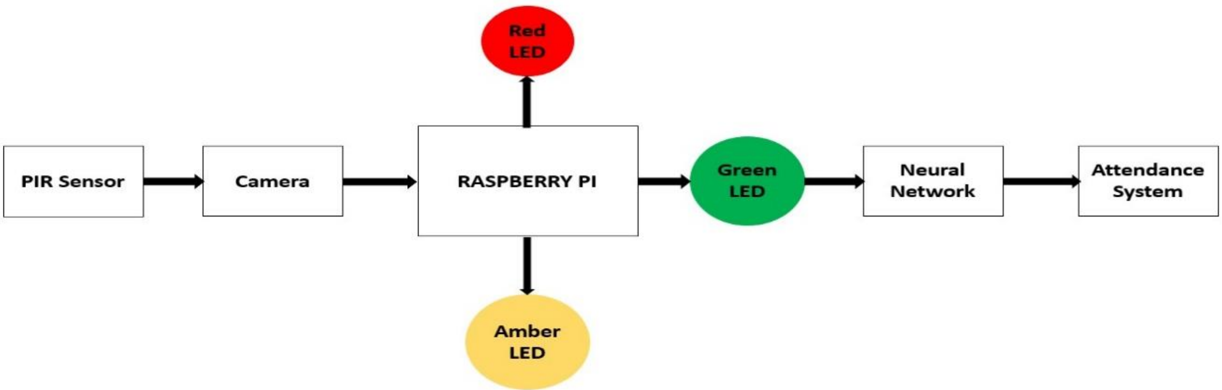

Figure 4. Block Diagram of the Facial Recognition Attendance System

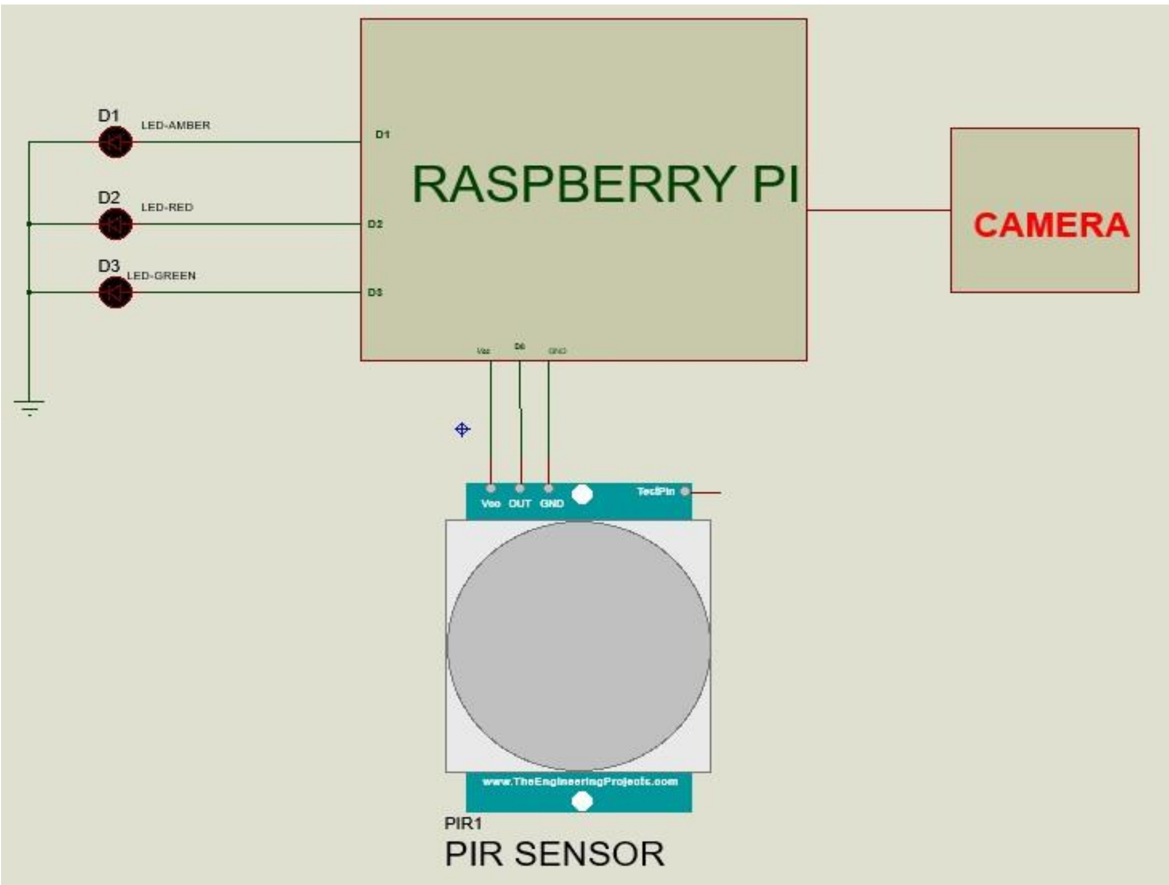

Figure 5. Schematic Diagram of the System

3. RESULTS AND DISCUSSION

3.1 Neural Network Test

To evaluate the software, 14 images not included in the training dataset, representing 7 individuals, were utilized. This approach aims to assess whether the neural network's accuracy remains within acceptable limits. The test seeks to generate both numeric identifiers (matriculation numbers) and non-numeric identifiers (names), followed by the verification of a document listing the individuals recognized by the neural network. Subsequently, this data is integrated into the website, where the list is processed to automatically update the attendance records for the respective class. In this system a total of 990 images belonging to people were used to train the neural network and a total of 410 test images were used to test the neural network created.

The validation images which also contained another set of 410 images previously unexposed to the neural network during its training were also used to test its accuracy over the various learning iterations as shown in Fig 6.

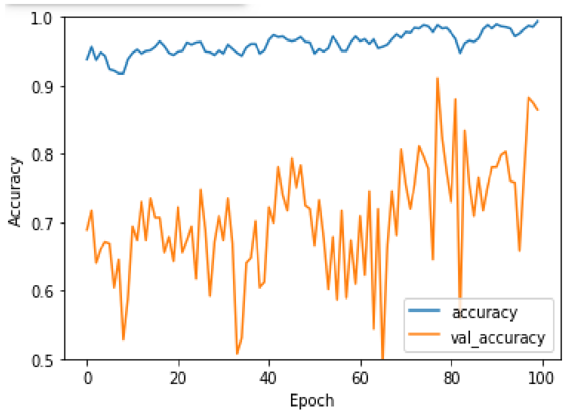

Figure 6. Training Accuracy Plot

3.2 Camera Test

The camera was triggered as soon as the PIR sensor detected the presence of a user whose attendance was to be taken. The LED lights indicated the status of the camera and a standby mode was indicated by all LED lights off. When a user is standing in *front of the camera as detected* by the sensor, the camera comes up and takes an image (expected to be the face of the user). As soon as the image was taken, the amber LED came on to indicate a processing status.

If the image taken is valid in terms of the pixels and also the user details have been verified by the neural network and updated by the attendance system, the green LED came on and remained on for five seconds before all LED lights went off. In the other situation when the image taken was invalid in terms of the pixels or clarity or the user details could not be verified by the neural network or updated by the attendance system, the red LED came up blinking for ten seconds before all LED lights went off and the system returned to standby mode. This alerted the user that there was an error and th*e process needed to be repeated.*

3.3 Attendance System Test

The system determined which course required an update by analyzing three parameters: date, time, and the student's level during attendance recording. This analysis was based on the time elapsed between the attendance recording and the class start time, resulting in a grade for the student, which ranged from 0 to 1. At the semester's conclusion, the cumulative grade reflected the overall attendance level within the system. A new class could be created by clicking the plus sign button, while attendance for an existing class was marked by selecting the corresponding class tile. The interface also displayed the lecturer's name, with each tile providing details such as the course name, section, academic year, and the number of classes conducted by the lecturer. The design of the interfaces prioritized user-friendliness while adhering to established standards.

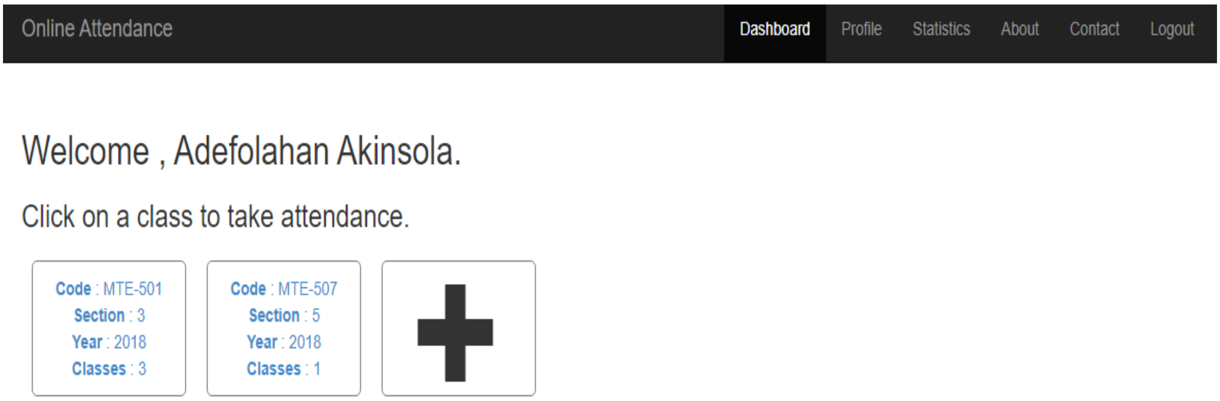

Figure 7. The Home Page of the Attendance System

The information was immediately saved to the database. The database stores the information for each class, the login information with which it retrieves the identity of each user. The database can be updated and all actions carried out on the client side of the system can be reflected in real time.

There were three tables in the database. The three tables labelled Object, Teacher and Temp all store different files. The object table stores information regarding each class, it is updated each time a new class attendance is taken. The teacher table contained the information about the lecturers, it stored their login information and it was used to verify the identity of the user.

Over the period that the attendance was taken, statistical data were created. This statistical data was used to generate graphs which showed the attendance and absenteeism of the students in the class. The graphs were accessible to both the lecturer and the student whose attendance was being checked. This allowed individual students to keep track of their attendance for various classes and for the lecturer to monitor individual students as well as the entire class.

The attendance result generated was a function of the number of classes attended and the number of classes recorded for that particular course; this was dynamically generated once the data was updated. Fig 8 shows the attendance graph generated for a single individual and a graph of the total number of classes with the student's attendance level respectively.

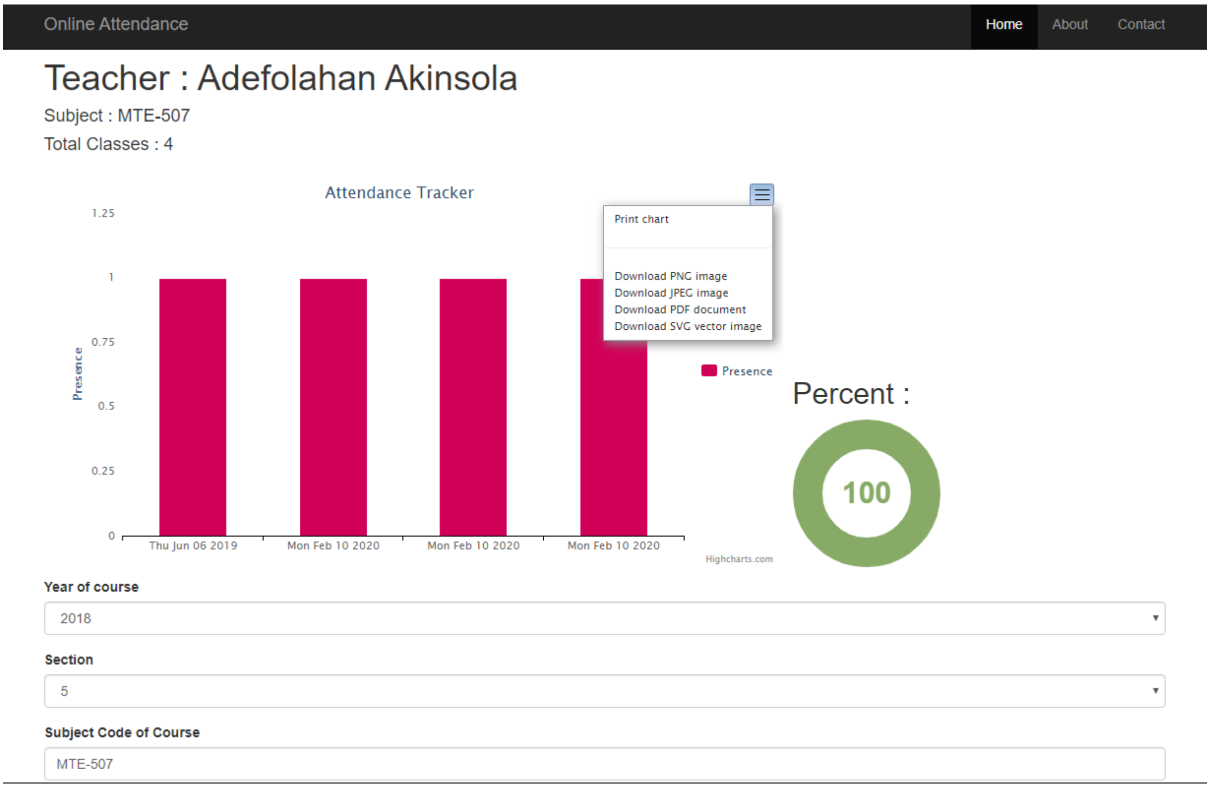

Figure 8. Individual Students Graph

The attendance results were acquired by accessing the chart menu, allowing for the printing of the generated chart or exporting it as a PNG, JPEG, PDF, or SVG vector image through a third-party application. Additional functionalities integrated into the attendance system comprise a profile view and edit section, enabling lecturers to access and modify their information, as well as a statistics tab that displays the attendance records of lecturers along with the average attendance rate for each course they are instructing.

4. CONCLUSIONS & RECOMMENDATIONS

The automated attendance system efficiently optimised the recording of student attendance, significantly diminishing occurrences of fraudulent and proxy attendance while alleviating the administrative workload on educators. This system, which integrates facial recognition technology with a Raspberry Pi microprocessor, camera, and proximity sensor, has shown considerable promise for enhancing attendance management in educational institutions. The decrease in manual record-keeping and the enhanced precision of attendance data signify significant advancements over conventional methods.

To augment the system's efficacy, prospective improvements encompass real-time absence alerts, detailed monthly progress reports amalgamating attendance and academic performance data, predictive analytics for detecting at-risk students, and integration with current learning management systems. These advancements will not only keep students informed but also enhance attendance and academic performance.

Future research directions encompass enhancing facial recognition algorithms for greater accuracy, investigating the long-term impacts on student behaviour, and optimising the system for larger student cohorts to guarantee scalability and sustainability. Through the pursuit of these alterations and research areas, the automated attendance system has the potential to develop into a comprehensive instrument that enhances academic performance, institutional efficiency, and student engagement. The potential to revolutionise educational technology ecosystems is significant, rendering it a crucial focus for future development.

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