Class Attendance System using Unimodal Face Recognition System based on Internet of Educational Things

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***Abstract*—This study presents the design and implementation of an IoT-based class attendance system with face recognition for the high school. The system includes the Open-Computer-Vision (OpenCV) library, Python programming language, and a Raspberry Pi as the main processing unit. The system employs a combination of Haar-Cascades for face detection and Eigenfaces, Fisher faces, and Local Binary Pattern Histograms for face recognition. The methodology for the system is described in detail, including flowcharts for each stage of the system. The experiment results of the system are analyzed and presented, including plots and screenshots. We discussed the challenges encountered during the project, the system's potential applications, and future developments. The system was developed to automate the attendance-taking process, increase the accuracy and security of attendance records, and provide data to improve student performance and progress by recording class attendance in Google Sheets.**

Keywords—Image Processing, Internet of Things, Raspberry pi, Python, OpenCV, Face Recognition, Google Sheets, Class attendance

I. INTRODUCTION

The integration of Internet of Things (IoT) technology has revolutionized the interaction and information exchange between electronic devices [1]. IoT has created a new era of smart devices, including smart grids, homes [2], architectures [3], networks, transportation, and education systems [4] based on the ability to connect and control devices via the internet [5,6]. The development has made it possible for widespread objects such as mobile phones, glasses, watches, and even running shoes to collect and transmit speed, distance, location, and statistical information. Face recognition is used for the identification and verification of an individual's identity based on facial characteristics [7,8]. This technology uses complex algorithms to analyze and compare a detected face to a database of known individuals, verifying their identity through unique characteristics such as the distance between their eyes, nose, and mouth. This technology's high precision has made it applied in numerous industries. The combination of IoT and face recognition technology has improved the usefulness of a variety of applications [9,10]. We propose an IoT-based face recognition system for class attendance using Raspberry Pi and the OpenCV library [11] in this prototype. This system employed the Python programming language and a depth resolution of 1280 x 960 to confirm class attendance via teacher verification and Google Sheets storage [12]. This system can be used to educate and demonstrate the real-world applications of IoT and Raspberry Pi [13].

The proposed system is intended for use in educational institutions such as schools and universities, where class attendance [14,15] is essential to student performance and advancement. As the primary processor, the system employs a Raspberry Pi, a low-cost and compact computer ideal for IoT applications. The face recognition algorithm is implemented using the OpenCV library and image processing tool. The system is designed to be intuitive and user-friendly to capture and process images in real-time [16]. As students enter the classroom, the system captures an image of their faces and compares it to an existing database of known individuals. The system then analyzes the composition and identity of the face by checking for unique characteristics such as the distance between the eyes, nose, and mouth, to confirm that the detected face matches up with the individual in the database. The system records the student's attendance for the specified class after a successful match.

II. RESEARCH OBJECTIVES AND QUESTIONS

The objective of this study is to design, implement, and evaluate an IoT- and Raspberry Pi-based face recognition system for class attendance. In addition, the research is carried out to educate on the potential applications and benefits of employing this technology in real-world situations, particularly in educational institutions. To accomplish these aims, the following research questions are formulated.

RQ1: How well does the system detect and identify single and multiple faces, and can it accurately differentiate between individuals?

RQ2: Is it possible to optimize the system's performance by reducing the image resolution, frame rate, and distance while maintaining the system's ability to recognize faces accurately and send attendance records to Google Sheets?

III. FACE RECOGNITION CLASS ATTENDANCE SYSTEM

The proposed IoT-based face recognition for class attendance checks is conducted by capturing an image of a student's face as they enter the classroom by comparing it to a database of previously identified individuals. The system then analyzes the composition and identity of the face, examining unique characteristics such as the distance between the eyes, nose, and mouth to confirm that the detected face corresponds to the person in the database as shown in Fig. 1. The overview architecture of the system also describes the following.

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1) The user inputs their scanned faces to the system. When the students approach the camera, the system captures their faces.

2) The USB camera captures the image as students enter the classroom, and the USB camera connected to the Raspberry Pi takes a picture of their faces.

3) The system receives input from the USB camera. The Raspberry Pi receives an image of the student's face from the USB camera using a USB cable and a compatible driver.

4) The system detects and recognizes faces. The Raspberry Pi uses the OpenCV library to process the image of the student's face and perform face detection. Using Local Binary Pattern Histograms algorithms, the system then performs face recognition by comparing the detected face to a database of previously known individuals.

5) The system sends and records class attendance in Google Sheets. If the match is successful, the system records the student's attendance for that class and sends the data to a Google Sheet. In the Google Sheet document, the attendance record is stored and managed.

6) The system sends the instructor a notification. Additionally, the system sends an attendance notification to the instructor.

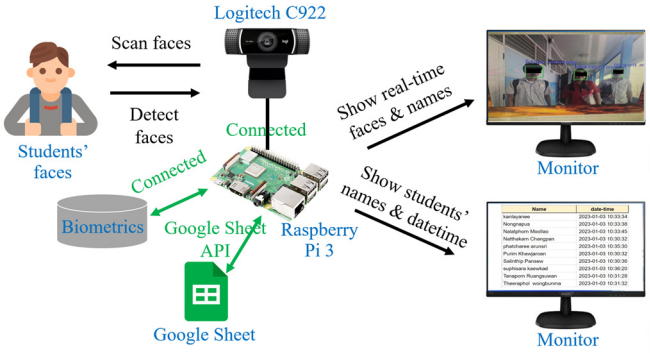

Fig. 1. Architecture of IoT-based Unimodal Class Attendance System.

The process is repeated for each student who enters the classroom, and attendance records are updated in real-time. Additional components can be added to the system to increase its functionality. The system analyzes the attendance data stored in Google Sheets to generate reports and statistics, including attendance percentages and absenteeism rates. The system supports remote monitoring being integrated with a web interface, allowing the teacher or administrator to monitor class attendance in real-time remotely. Additionally, the system enables the integration of attendance tracking with a calendar or schedule to track attendance over a specific period and identify absenteeism patterns. In addition, the system can be integrated with other systems, such as Learning Management Systems (LMS) and Student Information Systems (SIS) to provide a more comprehensive view of student performance and development. Overall, the proposed IoT-based face recognition for class attendance system offers a simple, efficient, and secure solution for automating the process of recording attendance in educational institutions. It improves the accuracy and security of attendance records and provides valuable information that can be used to enhance student performance and progression.

IV. Software Required

The proposed face recognition for the class attendance system needs a variety of software components such as a Raspbian operating system, Python, OpenCV library, Google Sheets API, and other libraries to perform diverse tasks such as image processing, data analysis, and communication with external systems. The software components are designed to work together to provide a robust and efficient solution for automating the process of taking attendance in educational institutions.

A. Raspbian OS (Operating System)

The Raspbian operating system is a Debian-based OS designed to run on the Raspberry Pi. It is compatible with Linux commands and provides the system with a stable and efficient platform. The Raspberry Pi Imager can be utilized to transfer images to an SD card for use with the Raspberry Pi.

B. Python Programming

Python is a popular programming language that is effective, simple to learn, and compatible with multiple platforms. It is employed in web development, software development, scientific research, and machine learning initiatives. Python is available for free download and offers a vast selection of libraries and frameworks for creating web applications quickly and easily. Python is useful for authoring server-side code because it contains multiple libraries with pre-written code for complex back-end functions. Python frameworks allow developers to construct web application structures in a matter of seconds and test them using the framework's test tools without the need for external test tools.

C. OpenCV

OpenCV (Open-Computer-Vision) is a powerful computer vision and image processing library. It provides a wide range of image and video analysis functions, including object detection and recognition, image filtering, and feature extraction. The OpenCV library is open-source to integrate with the Raspberry Pi and Python programming languages and perform face detection and recognition tasks.

D. Google Sheets API and Other libraries

The Google Sheets API provides developers to access and manipulate data stored in Google Sheets as well as programmatically update attendance records in real-time. It is a cloud-based platform accessible from any location with an internet connection. The API provides tools and libraries that can be integrated with the Raspberry Pi and Python programming languages to send attendance data to Google Sheets. Additional libraries, such as NumPy, Pandas, and Matplotlib, can assist the system's data analysis and visualization. They are commonly used in projects involving data science and machine learning.

E. System Implementation and Algorithm

A comprehensive description of the system's implementation and algorithms is as follows.

Face Detection: The initial step in implementing the system is to identify faces in the image captured by the camera. The Haar-Cascade algorithm is used to detect faces in an image. Haar-Cascades are trained classifiers that use characteristics such as a face's edges, lines, and patterns to detect the presence of a face in an image.

Face Recognition: After detecting a face, the system employs various algorithms to identify and match it with a database of known individuals. The system recognizes faces using the Local Binary Pattern Histograms (LBPH) algorithm. The LBPH algorithm recognizes a person based on the texture of their face. It compares the detected face's texture to the textures of known individuals in the database to identify the closest match.

Face Verification: After the face is detected and recognized, the system verifies the face by comparing it to a database of known individuals. If the detected face corresponds to a known person, the system logs the student's attendance for that class and sends the attendance data to a Google Sheet for further analysis and storage.

V. Recognition Results

The proposed face recognition for the class attendance system was implemented and tested on a sample of 25 students with a resolution of 1280 x 960 and a distance range of 0.5−3 m. A total of 100 students' faces were collected and used to train the system, as shown in Fig. 2.

Fig. 2. Biometric datasets.

Fig. 3. Real-time Face Recognition System.

The system was tested by scanning both single and multiple faces as shown in Fig. 3. When the detection and recognition system is successful, it records the student attendance date and time in Google Sheets as shown in Fig. 4.

The testing results revealed that the face recognition class attendance system could detect and recognize all 30 students' faces. However, the system's accuracy was found to vary depending on the distance between the camera and the student. At close distances (0.5 m), the system's accuracy was higher (85% for single faces and 82% for multiple faces) than at longer distances. As the distance increased, the system's accuracy decreased as shown in Table 1.

TABLE I. Results Accuracy of Face Recognition Class Attendance System at Different Distances

Distance	Face Recognition				Recording In Google Sheets
	Single face		Multi faced		
	Detection	Accuracy	Detection	Accuracy	
0.5 m.	✓	85 %	✓	82 %	✓
1.0 m.	✓	81 %	✓	80 %	✓
1.5 m.	✓	70 %	✓	69 %	✓
2.0 m.	✓	60 %	✓	58 %	✓
2.5 m.	✓	49 %	✓	50 %	✓
3.0 m.	✓	45 %	✓	42 %	✓

The test results show that the proposed face recognition system for class attendance can detect and identify faces. However, its accuracy decreases as the camera and student distance increase. This suggests that the system would be most effective in classroom settings where students are close to the camera. In addition, the system could be enhanced by increasing the resolution and implementing additional algorithms to improve the precision of face detection and recognition at greater distances.

Name	date-time
kanlayanee	2023-01-03 10:33:34
Nongnapus	2023-01-03 10:33:38
Nalatphorn Moollao	2023-01-03 10:33:45
Natthakarn Changpan	2023-01-03 10:30:32
phatcharee arunsri	2023-01-03 10:35:30
Purim Khawjaroen	2023-01-03 10:30:32
Salinthip Pansew	2023-01-03 10:30:36
suphisara kaewkad	2023-01-03 10:36:20
Tanaporn Ruangsuwan	2023-01-03 10:31:28
Theeraphol wongbunma	2023-01-03 10:31:32

Fig. 4. Google Sheet Contained Student Class Attendance.

The system can be enhanced by incorporating robust data validation and error-handling mechanisms to ensure that it can accurately detect and recognize faces under challenging conditions, such as lighting and pose variations. In addition, the system can be integrated with other systems such as Learning Management Systems (LMS), Student Information Systems (SIS), multi-language user interfaces [17], and attendance tracking systems to provide a more comprehensive view of student performance and development. Furthermore, the system security can be improved by implementing secure communication protocols, such as HTTPS, to encrypt the data transmitted between the system and Google sheets and by implementing access controls to restrict who can access the data stored in Google sheets.

In conclusion, the proposed Internet of Things-based face recognition for class attendance system is a promising solution for automating the process of taking attendance in

educational institutions. However, the system's accuracy still needs to be enhanced by increasing the resolution, incorporating additional algorithms, and more robust data validation and error-handling mechanisms. In addition, the system can be improved by integrating it with other systems and implementing security measures to safeguard the transmitted and stored data.

VI. Conclusion

The proposed face recognition system for checking class attendance on the Internet of Things is a promising solution for automating the attendance-taking process in educational institutions. The system uses a combination of different algorithms and techniques to perform face detection, recognition, and verification, which is implemented and tested on a sample of 25 students with a resolution of 1280 x 960 pixels at a distance range of 0.5−3 ms. The testing results revealed that the face recognition for class attendance system detects and recognizes all 30 students' faces. However, the system's accuracy varied depending on the distance between the camera and the student. The system can be improved by increasing the resolution and implementing additional algorithms by raising the accuracy of face detection and recognition accuracy at longer distances. In conclusion, the proposed face recognition for the class attendance system on the Internet of Things has the potential to improve the attendance-taking process. It provides more accurate data, enhances the system's security and accuracy with the integration with other systems, and adds more robust data validation and error-handling mechanisms. Furthermore, the system can also be improved by including more robust data validation and error handling mechanisms to ensure that the system can accurately detect and recognize faces even in challenging conditions such as lighting and pose variations. Additionally, the system security can be enhanced by implementing secure communication protocols such as HTTPS to encrypt the data transmitted between the system and the Google sheets and by implementing access controls to limit who can access the data stored in the Google sheets.

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