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Intelligence attendance monitoring system using Real-Time Face Recognition and Raspberry Pi

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Abstract: Recognition technology with Raspberry Pi to transform attendance management practices in educational institutions and workplaces. By harnessing advanced technologies like the Haar Cascade Classifier and Local Binary Patterns (LBP) algorithm, the system exhibits strong performance in accurately detecting and identifying faces across diverse environmental settings. Through rigorous experimental evaluation, the system achieves its highest accuracy in the distance comparison test at 30 cm, with an average accuracy of 92.4%. Similarly, it demonstrates optimal performance in the light comparison test at 100 lux, achieving an average accuracy of 91.3%. These results underscore the system's effectiveness in identifying faces in close proximity and under suitable lighting conditions. Overall, the proposed system offers a promising solution for optimizing attendance management processes while mitigating the shortcomings of traditional recording methods. By providing a reliable and efficient means of tracking attendance, it lays a solid groundwork for enhancing productivity and outcomes in both educational and professional settings.

Keywords: attendance management, face recognition, Haar Cascade Classifier, Local Binary Patterns, Raspberry Pi

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Introduction

Attendance is accumulating data to ascertain the number of students enrolled at a school. Attendance and absence recording is an activity that can never be abandoned. The reason for this is that for students or office workers, during work or lecture activities, the absence record will be a prerequisite for taking the exam as well as a benchmark for the activity of an employee who works and a reflection of the performance of employees or students from companies or educational institutions [1], [2]. Even if students cannot take the exam, they may still receive a failing grade if their attendance or absences are not adequately recorded. When it comes to an employee or employees, things are handled differently; they might be subject to sanctions in various ways, such as having their income reduced or even being fired. Therefore, attendance, or the attendance record, significantly reduces the likelihood of these occurrences.

However, it is essential to note that most student attendance recording during lecture hours is still often carried out traditionally. It involves the lecturer calling out the names of each student individually so that they may be entered on the attendance form [3]. It is a significant problem. In addition to allocating a sizeable budget for things like paper, ink, and other such supplies, hiring specialized specialists to take turns taking attendance requires significant time and money because of the progression of time and advancements in information technology, particularly in software and the internet. The convenience of using mobile or online applications to access and retrieve information is cited as one reason their utilization is deemed more effective and efficient. Because of this, we need to know how important it is to digitize our job to save on expenses, time, and effort.

Information systems are a development in the application of information technology. An information system is an information system that collects, processes, stores, analyses, and disseminates information for a particular purpose [4]. Another definition is a collection of hardware and software designed to convert raw data into usable information [5]. Almost all medium- to large-scale endeavors employ an information system to facilitate operation. Information systems are so helpful for activities that they are frequently used for making decisions.

Traditional attendance recording methods, reliant on manual attendance forms, are plagued by inherent inefficiencies, including time wastage, inaccurate attendance records, and susceptibility to errors such as false attendance or incorrect data entry. Innovative solutions such as Smart Attendance have emerged in response to these challenges, offering intelligent applications designed to mitigate these issues and optimize the attendance management process. By harnessing the power of intelligent attendance systems, organizations can realize enhanced efficiency, flexibility, and accuracy in tracking and summarizing attendance data.

An employee attendance application with additional features, including temperature monitoring for early detection of COVID-19 [6], was developed in prior research. This study proposes a COVID-19 early detection system by integrating temperature monitoring and expert systems into employee attendance systems. Every employee who wishes to participate must input their attendance information into the system. Before recording the employee's presence, the system will analyze employee temperature information from the temperature monitoring and expert systems to determine whether the employee will likely be confirmed with COVID-19. Companies can use the results of this early detection to determine whether an employee can continue working in the office or must work from home [7].

In this innovative employee attendance application, a temperature monitoring system is integrated to enhance workplace safety by detecting potential COVID-19 cases. The system utilizes the MLX90614 temperature sensor, which emits an infrared beam converted into an electric current, generating a voltage subsequently transformed into a digital signal. Complementing this sensor, an Arduino Nano V3 microcontroller processes the sensor data, while a Wi-Fi module facilitates data transmission to a central server. Once on the server, the temperature sensor data is stored and processed, forming a crucial component in the early detection of COVID-19 cases. By combining temperature readings with other indicators within an expert system, the application can identify individuals with elevated temperatures, signaling potential infection risks. This temperature monitoring system is strategically positioned at the office entrance, enabling employees to conveniently measure their temperature and record attendance before entering the premises. This proactive approach promotes workplace safety and contributes to the overall public health efforts in combating the spread of infectious diseases such as COVID-19.

In contrast to research [8], which utilized RFID (Radio Frequency Identification) technology, RFID technology enables remote identification. The proposed system utilizes the OpenCV Python library. This library is utilized because it facilitates the development of face recognition systems. Using OpenCV, face detection will occur in real time.

This study addresses the inherent inefficiencies of manual attendance recording systems prevalent in educational institutions and workplaces by proposing an innovative solution: an Intelligent Attendance Monitoring System utilizing real-time face recognition technology integrated with Raspberry Pi. By recognizing the limitations of traditional methods and emphasizing the need for automation and accuracy, this research aims to revolutionize attendance management processes. The proposed system offers a more efficient and secure means of recording attendance by integrating advanced technologies, such as real-time face recognition. It contributes to enhancing workplace safety in the context of the COVID-19 pandemic by facilitating early detection of potential cases. Moreover, by prioritizing data accuracy and security, this study establishes a robust foundation for attendance monitoring systems, ensuring reliable records and safeguarding against unauthorized access.

Methodology
Data Collection

In this research, the Attendance Monitoring System was subjected to comprehensive testing using facial data from ten individuals, seven registered in the database. The testing protocol involved capturing facial images at varying distances of 30 cm, 40 cm, and 50 cm under different light intensities of 20 lux, 100 lux, and 200 lux. Each individual's facial data was sampled 200 times to ensure thorough testing and reliable face recognition performance. Through this rigorous testing process, face detection accuracy was evaluated across different distance and lighting conditions, providing valuable insights into the system's performance and reliability in real-world scenarios.

Face Recognition

Face Recognition is a technological method that can recognize and match human faces with digital images or databases containing input image data from faces; face recognition is also an efficient technique and one of the most preferred biometric modalities for identifying and verifying individuals compared to voice, fingerprints, iris, retina scan of the eye, gait, ear geometry, and hand geometry [9]. Visage Recognition is a system that measures the physiological features of the human visage, such as the eyes, nostrils, and mouth. Face detection, feature extraction, and face recognition are the three fundamental stages of developing a robust facial recognition system. The initial phase, face detection, aims to locate and identify the image of a human face obtained by the system. The feature extraction step involves extracting the feature vector for each human visage identified in the first phase. In the final phase of facial recognition, features extracted from human faces are compared with all facial template databases to recognize human faces [10].

Haar Cascade Classifier

Face detection using the Haar Cascade Classifier is widely used in various applications, including developing an Intelligent Attendance Monitoring System using Real-Time Face Recognition and Raspberry Pi. The Haar Cascade Classifier method, known for its efficiency and speed in detecting faces [11], has been applied in different contexts such as home security [12], [13], government official recognition [14], multimedia applications [15], and even in web-based real-time face detection systems [16].

In attendance monitoring, the Haar Cascade Classifier is crucial in accurately detecting faces. It is noted that the accuracy of face detection using this method can reach up to 75% [12] and 85% [13]. Additionally, the Haar Cascade Classifier effectively detects multiple faces in real-time scenarios [14], making it suitable for applications requiring swift and efficient face recognition processes. Moreover, the Haar Cascade Classifier includes the path to the frontal face Haar Cascade classifier for successful face detection [15]. This method and other trained face detection algorithms have been utilized in various systems, showcasing its versatility and reliability [17]. The consistent improvement of detection accuracy and real-time performance further reinforces its role as a foundational technique in computer vision-based applications. The sequence of image transformations in Figure 1 illustrates how increasing complexity and segmentation in visual patterns may mirror layered approaches in face detection systems.

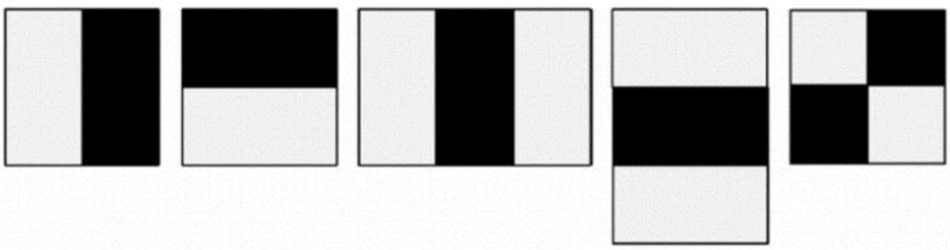


Figure 1. Haar feature

Local Binary Patterns (LBP)

Face detection using Local Binary Patterns (LBP) is widely used in computer vision and image processing. In an Intelligence Attendance Monitoring System Using Real-Time Face Recognition and Raspberry Pi, utilizing LBP for face detection is crucial in accurately identifying and recognizing faces in real time.

LBP is effective for feature extraction in facial recognition systems by analyzing pixel intensity patterns in a local neighborhood to capture texture information efficiently [18]. LBP has been integrated into various systems, such as surveillance systems for security applications, where it is combined with the Haar cascade for real-time monitoring of secured areas [19]. Additionally, LBP has been applied in developing robust facial expression recognition systems to address scale variations and texture loss challenges in traditional LBP methods [20].

In conclusion, using Local Binary Patterns (LBP) in face detection for intelligent attendance monitoring systems using real-time face recognition with Raspberry Pi provides a robust and efficient solution. By leveraging LBP's texture analysis capabilities and integrating it with deep learning techniques, researchers have developed accurate and reliable systems for facial recognition and attendance monitoring. As illustrated in Figure 2, the LBP procedure involves comparing each pixel with its surrounding neighbors to generate a binary pattern, which is then converted into a decimal value for texture classification.

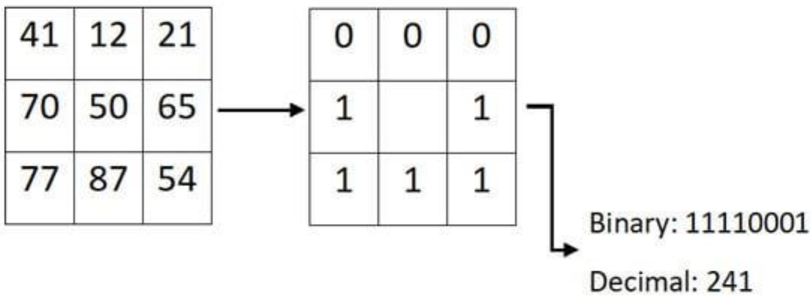


Figure 2. Local Binary Patterns (LBP) procedure

Raspberry Pi

Raspberry Pi is a versatile and portable device that has been extensively utilized in face recognition systems. The Raspberry Pi has been employed in various face recognition applications due to its portability and effectiveness [21]. Researchers have successfully implemented face recognition systems for tasks such as classroom attendance and door security using Raspberry Pi [22]. The use of the Raspberry Pi in real-time monitoring through face detection provided by the OpenCV library has been highlighted in the literature [23]. Additionally, the Raspberry Pi has been utilized in systems for student attendance through face recognition, showcasing its utility in educational settings [24].

Moreover, the Raspberry Pi has been integrated into smart technologies for attendance monitoring, reducing costs and enabling connectivity with diverse devices [25]. The device has also been utilized in the development of autonomous systems, such as self-driving car prototypes, demonstrating its capabilities as a processing unit [26]. Furthermore, the Raspberry Pi has been instrumental in the implementation of various algorithms, including those for text detection and recognition, showcasing its role in advancing computer vision applications [27]. As illustrated in Figure 3, the compact, single-board design of the Raspberry Pi allows for seamless integration into edge-computing solutions for such applications.

Figure 3. Raspberry pi

Design System

Figure 4 is a detailed diagram of a computer data processing process for an attendance system utilizing face recognition technology. The process starts with a camera, likely connected to a Raspberry Pi, capturing images in real time. These images are then processed for face recognition, where the system identifies recognized faces against a database. The diagram also mentions managing face data, including storing and retrieving facial data points for comparison. The attendance system is indicated to serve users such as lecturers and students, suggesting its application in educational settings like offices or lecture halls. Feedback mechanisms and data management processes are highlighted as integral parts of the system, ensuring that the face data is accurately recorded and utilized for attendance.

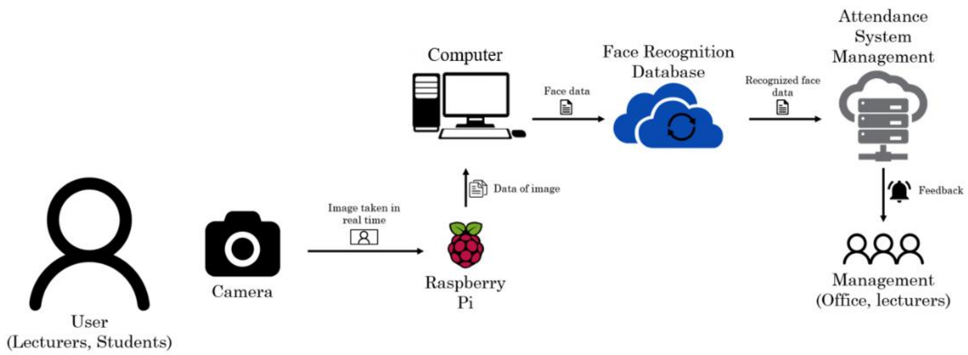


Figure 4. Design system

The Intelligence Attendance Monitoring System, akin to Figure 5, first receives video input from a CCTV camera, capturing real-time footage of individuals. Each video frame is then analyzed to detect faces using facial detection algorithms. Upon detection, the system crops and saves these facial images for further processing. Subsequently, the protected images are compared against a database of known faces to determine if they match any registered students or individuals. Upon identification, the system marks the corresponding student as present in the attendance record. The attendance data is then compiled and securely stored within the system, updating the overall attendance records for the session or class. Feedback mechanisms may provide real-time notifications to administrators and students regarding attendance status. Additionally, a user interface allows administrators to access and manage attendance records, while students may also have access to view their attendance information. This system streamlines the attendance marking process in education by integrating Raspberry Pi and face recognition technology.

Figure 5. Attendance marking process

The block diagram presented in Figure 6 illustrates the sequential steps involved in registering individuals within the system. Initially, the process commences with the CCTV camera capturing video input, which is subsequently processed to generate a dedicated storage folder. Within this folder, the system extracts facial images by cropping them from the frames of the video feed. These cut facial photos serve as the foundational data for creating a comprehensive database, which undergoes training to enable accurate recognition of individuals. During the training phase, basic information about the individuals, such as names or identification numbers, is incorporated into the database. Once the training process is complete, all pertinent data, including the cropped facial images and associated individual information, are meticulously stored within the database for future reference and recognition purposes. This systematic approach ensures the system has the necessary resources to identify and authenticate individuals effectively during subsequent attendance monitoring activities. Establishing a robust database through this registration process lays a solid foundation for facilitating efficient and accurate attendance tracking within educational institutions and workplaces.

Figure 6. Registration block diagram

System Block Diagram

The workflow begins like Figure 7, with the capture of facial images via the USB webcam, which is then processed by the Raspberry Pi 3 using a face recognition algorithm. Successful identifications are logged into the system as attendance entries. Data can be managed remotely over WiFi, and attendance records may be displayed on the monitor for live monitoring or administrative purposes. This intelligent system streamlines attendance management, reducing errors and saving time.

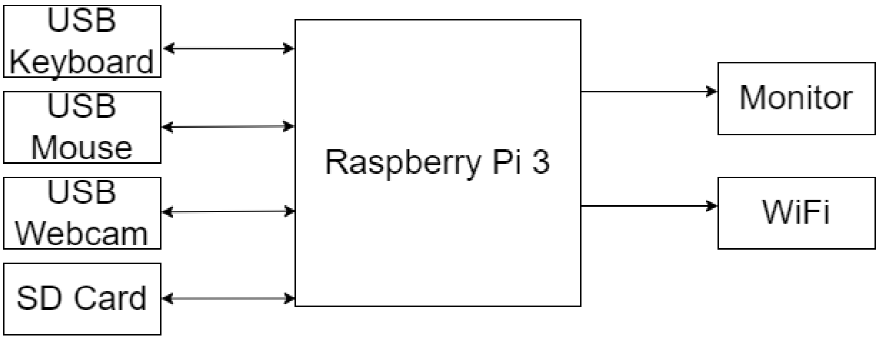


Figure 7. System block diagram

Results and Discussions

System Overview

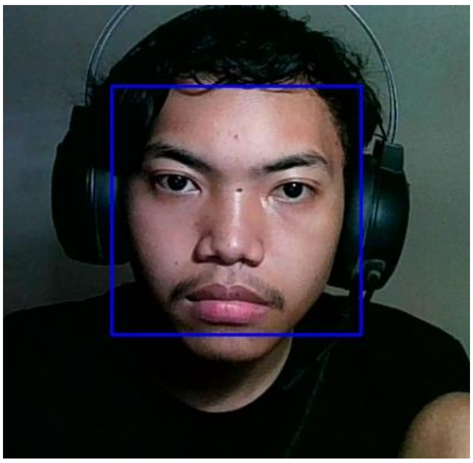
The system begins with the setup of Raspberry Pi, configuring it with necessary peripherals such as a camera module for capturing real-time video feed and a Wi-Fi module for data transmission (Figure 8). Leveraging the OpenCV Python library, the system implements face detection and recognition algorithms, including the Haar Cascade Classifier and Local Binary Patterns (LBP) algorithm, to accurately detect and recognize faces from the captured video feed. Upon successfully recognizing registered individuals, the system marks their attendance in real-time, with feedback mechanisms providing notifications to administrators and users regarding attendance status. Attendance records and facial data are securely stored on the Raspberry Pi or transmitted to a central server for further processing and analysis. Administrators can access and manage attendance records through a user interface, ensuring seamless monitoring and administration.

Figure 8. Rassbery Pi implementation

Implementation Face Recognition

In the initial stages of the registration process, the real-time camera feed undergoes preprocessing to enhance the efficiency of facial recognition algorithms. This preprocessing step involves converting the RGB camera picture to grayscale, a fundamental operation that simplifies subsequent image analysis while retaining essential facial features. Once converted to grayscale, the image is analyzed using the highly effective Haar Cascade technique, renowned for its adeptness in detecting objects within images, particularly faces. Employing this technique, the system scans the grayscale image, identifying and delineating facial features from non-facial items. To facilitate visual comprehension and streamline the identification process, the recognized faces are prominently highlighted with a distinct blue box, as depicted in Figure 9 (a). This visual representation serves a dual purpose, it aids in differentiating detected faces from other objects within the image. It provides a clear indication of successful facial recognition. In instances where successful detection occurs, as illustrated in Figure 9 (b), each identified user's face is meticulously delineated and labeled, showcasing the system's ability to recognize individuals despite varying environmental conditions and facial expressions. This process of repeated identification, spanning 200 iterations per user, not only ensures robustness in recognition but also enhances the system's adaptability to diverse scenarios and user profiles.

Once an item is identified within the captured video feed, the registration process seamlessly transitions to the crucial phase of facial recognition. Leveraging advanced technology, the face recognition system employs the Local Binary Patterns (LBP) algorithm, a robust and efficient method for analyzing facial features. This algorithm meticulously compares each captured face with the comprehensive histogram stored in the database, which encapsulates unique characteristics and patterns associated with each individual's facial structure. Through this meticulous comparison process, the system endeavors to ascertain the individual's identity by matching their facial features with the stored data. This technology is instrumental in accurately identifying the face's owner, enabling precise recognition and authentication within the Intelligent Attendance Monitoring System.



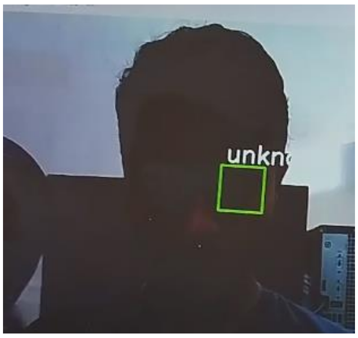
(a)

(b)

Figure 9. Object identification (a), real-time image data from webcam (b)

In Figure 10 (a), the successful facial recognition results are displayed, demonstrating the system's ability to identify individuals based on their facial features accurately. Each recognized face is correctly matched with its corresponding identity from the database, showcasing the effectiveness of the LBP algorithm in facilitating precise recognition and authentication. In Figure 10 (b), a scenario is depicted where the system encounters difficulty in detecting and recognizing a face. Despite the system's best efforts, it fails to match the captured facial features with any entry in the database, failing to identify the individual. This situation may arise due to factors such as poor lighting conditions, occlusion of facial features, or discrepancies between the captured image and the stored data.

(a)



(b)

Figure 10. Success for recognise the face (a), failed for recognise the face (b)

Face Recognition Testing

Distance Comparison

To evaluate the performance of the face detection system, experiments were conducted using three distance settings: 30 cm, 50 cm, and 80 cm, all under a controlled light intensity of 100 lux. These settings were chosen to simulate realistic scenarios where users may be positioned at various distances from the camera during face recognition. The results, summarized in Table 1, provide accuracy percentages for each distance, and the outcomes were categorized as either "Detected" (for registered faces) or "Unknown" (for unregistered faces).

The accuracy for each test case was calculated using the standard formula:

$$Accuracy = \frac{TP + TN}{TP + FN + FP + TN} \quad (1)$$

Where,
TP (True Positive) = Positive data that is correctly classified.
TN (True Negative) = Negative data that is correctly classified.
FP (False Positive) = Negative data that is correctly classified.
FN (False Negative) = Positive data that is classified as unfavorable.

Table 1. Face recognition result for distance comparison

Data	Face Status	Accuracy (%)			Status Detection
		30 cm	50 cm	80 cm	
1	Registered	98	80	0	Detected
2	Unregistered	100	98	70	Unknown
3	Registered	91	77	20	Detected
4	Registered	82	76	0	Detected
5	Registered	80	88	40	Detected
6	Registered	99	98	30	Detected
7	Registered	89	85	50	Detected
8	Registered	88	60	0	Detected
9	Unregistered	100	80	60	Unknown
10	Unregistered	97	99	99	Unknown
Average		92.4	84.1	52.7	

Each face (both registered and unregistered) was tested 10 times across different distance settings. This repetition allowed for a robust validation of the system's ability to consistently detect or reject faces based on their registration status. By performing the test 10 times, the evaluation ensures statistical reliability and minimizes anomalies caused by brief lighting fluctuations or motion. The average accuracy achieved was 92.4% at 30 cm, 84.1% at 50 cm, and 52.7% at 80 cm, indicating that the system performs best at close range, with detection performance decreasing as distance increases.

Light Comparison

The comprehensive evaluation of the face detection system encompassed varied light intensities of 20 lux, 100 lux, and 200 lux, each meticulously tested at a consistent distance of 30 cm. This methodical approach ensured a thorough exploration of the system's performance under different lighting conditions while maintaining a standardized proximity level. To obtain reliable accuracy values, each face both registered and unregistered was tested 10 times under each lighting condition. The outcomes of these repeated trials were analyzed using a standard accuracy formula, considering true positives, true negatives, false positives, and false negatives. This repetitive testing ensured statistical reliability, minimized anomalies, and provided clear insight into the impact of light intensity on detection performance. As illustrated in Figure 11, the face detection system was evaluated under three distinct lighting conditions 20 lux (a), 100 lux (b), and 200 lux (c) highlighting the system’s ability to respond to variations in illumination.

(a) (b) (c)

Figure 11. Light intensities of 20 lux (a), 100 lux (b), and 200 lux (c)

Table 2. Face recognition result for light comparison

Data	Face Status	Accuracy (%)			Status Detection
		20 lux	100 lux	200 lux	
1	Registered	40	95	84	Detected
2	Unregistered	64	97	88	Unknown
3	Registered	20	85	82	Detected
4	Registered	16	88	65	Detected
5	Registered	28	94	77	Detected
6	Registered	0	84	66	Detected
7	Registered	30	91	65	Detected
8	Registered	0	85	77	Detected
9	Unregistered	50	96	86	Unknown
10	Unregistered	60	98	77	Unknown
Average		38.5	91.3	76.7	

The data analysis concerning face detection accuracy at different light intensities reveals crucial insights into the system's performance. It is evident that light intensity plays a pivotal role in determining the accuracy of face detection, with higher light intensities correlating with improved detection rates. For instance, at 20 lux, the average accuracy is 38.5%, which significantly increases to 91.3% at 100 lux and slightly decreases to 76.7% at 200 lux. This underscores the significance of optimal lighting conditions in ensuring reliable facial recognition outcomes. Moreover, the distinction between registered and unregistered faces is noteworthy, with registered individuals consistently exhibiting higher detection accuracy. This emphasizes the system's proficiency in recognizing individuals whose facial data is stored within the database. Overall, while the system demonstrates commendable performance across various light intensities, there are still opportunities for enhancement, particularly in refining algorithms to better handle varying lighting conditions and improving detection accuracy for unregistered faces. By addressing these areas, the system can further bolster its reliability and effectiveness in real-world applications such as attendance monitoring and identity verification, thereby maximizing its utility in diverse operational settings.

Conclusion

In conclusion, developing an Intelligent Attendance Monitoring System utilizing real-time face recognition technology integrated with Raspberry Pi represents a significant advancement in attendance management processes. This research introduces a groundbreaking solution to enhance attendance tracking in educational institutions and workplaces by addressing the inefficiencies inherent in manual recording systems through automation and accuracy. Leveraging advanced technologies such as the Haar Cascade Classifier and Local Binary Patterns (LBP) algorithm, the proposed system demonstrates robust performance in detecting and recognizing faces under varying environmental conditions.

The experimental evaluation of the face detection system provides valuable insights into its performance across different scenarios. In the distance comparison test, the system exhibits an average accuracy of 92.4%, showcasing its effectiveness in identifying faces at varying distances from the camera. Despite fluctuations, the system maintains impressive performance overall, with noticeable differences in accuracy between registered and unregistered faces.

Similarly, the light comparison test highlights the pivotal role of light intensity in determining detection accuracy. The system demonstrates optimal performance under adequate lighting conditions with an average accuracy of 91.3% at 100 lux. However, there is a slight decrease in accuracy to 76.7% at 200 lux, indicating the need for further refinement to ensure consistent performance across different light intensities.

Overall, the Intelligent Attendance Monitoring System presents a promising solution for streamlining attendance management processes while addressing the challenges posed by traditional recording methods. This system lays a robust foundation for enhancing workplace productivity and educational outcomes by prioritizing automation, accuracy, and efficiency.

Through continued refinement and optimization, it has the potential to revolutionize attendance-tracking practices and facilitate seamless integration into diverse operational settings, ultimately maximizing its utility and effectiveness.

As a suggestion for future research, exploring the integration of additional biometric modalities, such as iris recognition or voice recognition, could further enhance the system's capabilities and security features. Additionally, investigating the feasibility of continuously implementing machine learning techniques to adapt and improve the system's performance over time could contribute to its long-term success and reliability.

References

[1] E. Mulyadi, A. Trihariprasetya, and I. G. Wiryawan, "Penerapan sistem presensi mobile dengan menggunakan sensor GPS (Klinik Pratama X di Jember)," *J. Nas. Pendidik. Tek. Inform. JANAPATI*, vol. 9, no. 1, pp. 11–20, 2020, doi: 10.23887/janapati.v9i1.23174.

[2] Y. Wulandari and H. Sulistiani, "Rancang bangun aplikasi presensi SMS gateway berbasis web dengan framework codeigniter pada SMKN 1 Trimurjo," Jurnal Informatika dan Rekayasa Perangkat Lunak, vol. 1, no. 1, pp. 43–50, 2020, doi: 10.33365/jatika.v1i1.152.

[3] A. Y. Ananta, N. Noprianto, and V. N. Wijayaningrum, "Desain sistem smart attendance menggunakan kombinasi smart card dan sidik jari," Jurnal Sistemasi, vol. 9, no. 3, p. 480, 2020, doi: 10.32520/stmsi.v9i3.874.

[4] G. Ginting, F. Fadlina, A. Karim, C. F. Sianturi, and E. R. Siagian, *Sistem Informasi*. Yayasan Kita Menulis, 2022.

[5] K. Rukun and B. H. Hayadi, *Sistem Informasi Berbasis Expert System*. Deepublish, 2018.

[6] B. Etikasari, T. D. Puspitasari, A. A. Kurniasari, and L. Perdanasari, "Sistem Informasi Deteksi Dini Covid-19," *J. Tek. Elektro dan Komput.*, vol. 9, no. 2, pp. 101–108, 2020.

[7] M. R. Mufid, S. Mawaddah, D. Aditama, A. Basofi, M. J. Ulul Albab, and A. Fiyanto, "Sistem monitoring suhu pada aplikasi absensi pegawai untuk deteksi dini COVID-19," Jurnal Teknologi Informasi dan Terapan, vol. 8, no. 1, pp. 43–51, 2021, doi: 10.25047/jtit.v8i1.200.

[8] S. Patel, P. Kumar, S. Garg, and R. Kumar, "Face recognition based smart attendance system using IoT," International Journal of Computer Science and Engineering (IJCSE), vol. 6, no. 5, pp. 871–877, 2018, doi: 10.26438/ijcse/v6i5.871877.

[9] M. O. Oloyede, G. P. Hancke, and H. C. Myburgh, "A review on face recognition systems: Recent approaches and challenges," *Multimed. Tools Appl.*, vol. 79, no. 37–38, pp. 27891–27922, 2020, doi: 10.1007/s11042-020-09261-2.

[10] Y. Kortli, M. Jridi, A. Al Falou, and M. Atri, "Face recognition systems: A survey," *Sensors (Switzerland)*, vol. 20, no. 2, 2020, doi: 10.3390/s20020342.

[11] S. Anwar *et al.*, "Automatic security system architecture for smart greenhouse using face recognition approach," *IOP Conf. Ser. Earth Environ. Sci.*, vol. 980, no. 1, 2022, doi: 10.1088/1755-1315/980/1/012058.

[12] N. Muhammad, E. Ariyanto, and Y. A. Saloko Yudo, "Improved face detection accuracy using Haar Cascade Classifier method and esp32-cam for IoT-based home door security," *Jipi (Jurnal Ilm. Penelit. Dan Pembelajaran Inform.*, 2023, doi: 10.29100/jipi.v8i1.3365.

[13] A. A. Kurniasari, M. F. I. Sudirman, A. M. Ramadan, F. Firmansyah, and N. H. Damayanti, "Face Recognition untuk Smart Door Lock menggunakan Metode Haar-Cascades Classifier dan LBPH," *Angkasa J. Ilm. Bid. Teknol.*, vol. 15, no. 2, pp. 141–148, 2023.

[14] U. Aditiawarman, D. Erlangga, T. Mantoro, and L. Khakim, "Face Recognition of Indonesia's Top Government Officials Using Deep Convolutional Neural Network," *J. Resti (Rekayasa Sist. Dan Teknol. Informasi)*, 2023, doi: 10.29207/resti.v7i1.4437.

[15] P. K. Mishra and G. K. Bharti, "Efficient face detection for distinct multimedia using object-oriented programming," Advances in Transdisciplinary Engineering, vol. 32, pp. 639–644, 2023, doi: 10.3233/ATDE221325.

[16] M. Arora, S. Naithani, and A. S. Areeckal, "A web-based application for face detection in real-time images and videos," *J. Phys. Conf. Ser.*, 2022, doi: 10.1088/1742-6596/2161/1/012071.

[17] A. Pratiwi, E. B. Nababan, and Amalia, "Detection of the use of mask to prevent the spread of COVID-19 using SVM, Haar Cascade Classifier, and Robot Arm," *Data Sci. J. Comput.*

Appl. Informatics, 2022, doi: 10.32734/jocai.v6.i2-9289.
[18] D. Canedo and A. J. R. Neves, "Facial expression recognition using computer vision: a systematic review," *Appl. Sci.*, 2019, doi: 10.3390/app9214678.
[19] N. Rathour, R. Singh, A. Gehlot, N. Priyadarshi, and B. Khan, "KlugOculus: A vision-based intelligent architecture for security system," *Comput. Intell. Neurosci.*, 2022, doi: 10.1155/2022/3722527.
[20] S. Yasmin, R. K. Pathan, M. Biswas, M. U. Khandaker, and M. R. Iqbal Faruque, "Development of a robust multi-scale featured local binary pattern for improved facial expression recognition," *Sensors*, 2020, doi: 10.3390/s20185391.
[21] K. M. Hosny, A. Y. Hamad, O. M. Elkomy, and E. R. Mohamed, "Fast and accurate face recognition system using MORSCMs-LBP on embedded circuits," *Peerj Comput. Sci.*, 2022, doi: 10.7717/peerj-cs.1008.
[22] G. I. Hapsari, G. A. Mutiara, and H. Tarigan, "Face recognition smart cane using Haar-like features and eigenfaces," *Telkomnika (Telecommunication Comput. Electron. Control.*, 2019, doi: 10.12928/telkomnika.v17i2.11772.
[23] M. Abirami, K. Saundariya, R. S. Kumaran, and I. Yamuna, "Contactless temperature detection of multiple people and detection of possible corona virus affected persons using AI enabled IR sensor camera," Proceedings of the 2021 International Conference on Wireless Communications, Signal Processing and Networking (WiSPNET), pp. 166–170, 2021, doi: 10.1109/WiSPNET51692.2021.9419439.
[24] A. S. Hasban *et al.*, "Face recognition for student attendance using Raspberry Pi," Proceedings of the 2019 IEEE Asia-Pacific Conference on Applied Electromagnetics (APACE), 2019, doi: 10.1109/APACE47377.2019.9020758.
[25] A. S. Nadhan *et al.*, "Smart attendance monitoring technology for industry 4.0," *J. Nanomater.*, 2022, doi: 10.1155/2022/4899768.
[26] L. Helshani, J. Qarkaxhija, and B. Prevalla, "Sensor based algorithm for self-navigating robot using Internet of Things (IoT)," *Int. J. Interact. Mob. Technol.*, 2022, doi: 10.3991/ijim.v16i23.36213.
[27] T. M. Alanazi, "Embedded system based Raspberry Pi 4 for text detection and recognition," *Intell. Autom. |& Soft Comput.*, 2023, doi: 10.32604/iasc.2023.036411.