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Automated Attendance System Using Facial Recognition System

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Abstract – Traditional manual attendance methods in educational institutions are time consuming, prone to human error and susceptible to fraudulent activities such as proxy attendance. This paper presents an Automated Biometric Attendance System designed to streamline the attendance process using facial recognition technology. The proposed system utilizes a Raspberry pi 4 interfaced with a high - definition USB camera to capture real-time video frames of students entering the classroom. By employing the official Picamera2 library for hardware-optimized capture and Dlib for deep-learning-based feature extraction, the system detects facial landmarks and encodes them into 128-dimensional embeddings. The backend integrates a local SQLite database and a Flask web server to map timestamps to a predefined lecture schedule. This contactless approach eliminates the need for manual name-calling, saving valuable lecture time while ensuring the attendance data is accurate and automatically timestamped. In our testing the system worked accurately in most cases especially in proper lighting conditions, although some challenges were observed in low light. offering a cost effective and secure alternative to RFID or fingerprint-based systems. This project helped us understand practical challenges in real-time face recognition system.

Keywords: Face Recognition, Biometric Attendance, Picamera2, Raspberry Pi, Dlib, Flask, SQLite.

1. INTRODUCTION

The biometric sector has expanded significantly in recent years. As a result, low-cost processing units and high-definition cameras have become more accessible to the public. While biometric systems are utilized in military operations in educational and corporate settings has expanded recently. Having easy access to biometric hardware is not problematic, but some people may misuse manual systems such as fake records.

Traditional attendance methods may pose risks to institutional accuracy and privacy. The need for a detection system to stop unauthorized entries and false attendance has become essential for institutional integrity. While working on project we also noticed that mask wearing and different face angles affected detection so we improved the dataset and adjusted the camera setup. Numerous detection systems are currently available (such as radar, fingerprint, and rfid) yet these have constraints. For instance, visual systems may struggle to identify faces in low visibility. Similarly, in acoustic systems excessive background noise can hinder detection.

In our project we implemented an automated attendance system to make the classroom process faster and more efficient. Unlike traditional methods where teachers must manually call out names consuming up to ten minutes of valuable lecture time our system works automatically in the background without disturbing the class. This allows the academic environment to remain focused on learning while ensuring that the data is collected is accurate and timestamped to the exact second of entry or exit.

2. RELATED WORK

"Smart Attendance System based on Improved Facial Recognition"

From this research paper we learned how deep learning can significantly improve the accuracy and speed of facial recognition systems used for attendance. The authors used an improved Face Net model combined with a MobilNetV2 backbone and SSD for face detection which helped reduce computational cost while maintaining high accuracy. This paper helped us understand that lightweight deep learning models are very useful for real time applications especially when hardware resources are limited. We also learned that optimizing models using depth wise separable convolutions can make the system suitable for embedded devices like Jetson

Nano. This research gave us a strong technical foundation for selecting efficient algorithms for our biometric attendance system.

"Students Attendance System Using Face Recognition"

From this paper we understand the basic structure and workflow of a face recognition-based attendance system. The authors explained how traditional manual attendance is time consuming and error prone and how face recognition can automate the process. We learned about the use of algorithms such as Haar Cascade for face detection and classifiers like KNN, CNN, and SVM for recognition. The paper also highlighted the importance of storing attendance data in Excel format for easy record management. This study helped us to understand how simple machine learning techniques can be effectively applied in classroom attendance systems.

"Intelligent Face Recognition Based Students Attendance System"

This research paper explains we learned how convolutional neural networks (CNNs) can be used to build an intelligent attendance system with higher reliability. The paper explained the complete process including database creation, face detection, face recognition and attendance report generation. It also emphasized how face recognition helps eliminate proxy attendance and reduces manual effort. We understood the importance of object-oriented design and the role of OpenCV in implementing real-time facial recognition. This paper helped me see how such systems can be integrated with mobile and real time databases for better accessibility.

"Student Attendance Using Face Recognition"

This paper helped me understand how a web-based attendance system can be implemented using face recognition. The authors used Haar Cascade classifiers for face detection and LBPH algorithms for recognition which are suitable for group images as well. We learned that attendance can be marked using a single group photograph instead of continuous video streaming which reduces hardware cost. The use of Google Sheets for storing attendance records showed a practical and efficient way of data management. This research helped me understand alternative system designs that are simple, cost effective, and easy to deploy.

"Automated Facial Recognition based Attendance System using OpenCV in Python"

we gained practical knowledge about implementing an automated attendance system using Python libraries such as OpenCV, NumPy, and d-lib. The authors explained how face encodings are generated and matched using deep learning-based face recognition techniques. We learned about the importance of face embeddings and how timestamps can be stored automatically when a person is recognized. This research helped us understand how real-time face recognition systems achieve high accuracy and how they can be made portable and scalable for real world applications.

"Facial Recognition Based Attendance System"

This study showed me understand how facial recognition can be a cost effective and reliable alternative to traditional attendance systems like RFID and fingerprint-based systems. The authors explained the four main stages of the system database creation, face detection, face recognition and attendance updating. We learned how Haar Cascade classifiers and LBPH algorithms work together to recognize faces accurately. This paper also highlighted the importance of a user-friendly graphical interface which improved our understanding of combining backend processing with frontend usability.

"Automated Face Recognition Based Attendance System Using LBP Face Recognizer"

We observed how Local Binary Pattern (LBP) algorithms can be used effectively for face recognition in attendance systems. The authors explained the complete methodology including dataset creation image preprocessing training and recognition. We understood the importance of collecting multiple images per student under different lighting conditions and poses to improve recognition accuracy. This research also helped us understand the limitations of other biometric systems and why face recognition is more practical and user-friendly in classroom environments.

"Student Attendance Monitoring System using Face Recognition"

This paper explains the challenges involved in face recognition such as lighting variation pose changes and image quality issues. The authors used Haar Cascade classifiers for face detection and LBPH algorithms for recognition, which are suitable for real time applications. We learned how attendance can be automatically recorded in Excel sheets and later analyzed for performance monitoring. This research helped me understand how facial recognition systems can be made robust and reliable for real-world educational institutions. This was

useful for our project because we are also using similar face recognition techniques

3. ATTENDANCE DETECTION METHOD

There are several methods for detecting individuals each with its own advantages and limitations.

3.1 RADAR/PROXIMITY DETECTION

Radar systems operate by emitting electromagnetic waves and then analyzing the reflected signals to detect the presence of an object. These systems work well for long distance detection and can operate reliably in adverse weather conditions like fog or rain. However, radar struggles to distinguish between specific individuals because small objects often have a limited radar cross section that makes detailed identification difficult. Additionally, the cost of implementing a high-resolution radar system for a classroom environment is often prohibitively expensive compared to other methods

3.2 ACOUSTIC DETECTION

Acoustic detection systems use microphones to detect if a person is present by capturing the sounds it produces. A major advantage of this system is that it is very cost-effective and does not require a direct line of sight to identify that someone is present. Despite these benefits acoustic systems struggle significantly in noisy environments where background sounds can cause the system to miss the target. In a classroom setting, the limited detection range and interference from students talking make it an unreliable choice for precise attendance tracking.

3.3 VISUAL/FACIAL DETECTION

Visual detection systems use cameras and image processing to recognize people based on unique facial landmarks and characteristics. While these systems are non-intrusive and highly accurate, they may struggle to identify students in low visibility or low light conditions. The system requires a clear line of sight and must be positioned carefully to ensure the camera can capture a high-quality frame of each face. Using Conventional Neural Networks (CNN) for classification this method can achieve identification accuracy levels as high as 95% to 99% in well-lit indoor environments. In our project we selected this method because it is more suitable and accurate for classroom attendance systems.

4. DETAILED REVIEW ON FACIAL RECOGNITION ATTENDANCE

4.1 PROCESS

The system begins when a high-definition camera captures a live video feed, which is then converted into individual digital frames for real-time analysis. Each frame is processed to detect features like facial landmarks to identify a human face from the background which are used to distinguish a human face from the background. Finally, advanced machine learning models classify these signals by comparing the extracted features against a pre-defined dataset to identify the specific individual.

4.2 STRENGTHS AND LIMITATIONS

The primary advantage of this is its ability to operate entirely offline on edge computing hardware (Raspberry Pi) without requiring cloud connectivity. Additionally, the system is capable of not only detecting a presence but also identifying the specific type or identity of the target with high accuracy. However, a significant limitation is that real-time AI processing can overheat the Pi`s CPU. To resolve this, a frame-skipping algorithm was implemented, running the heavy mathematical recognition only once every 5 frames while caching the output to maintain smooth video performance. In our project we observed that proper lighting and camera position are important for getting accurate results.

4.3FEATURE EXTRACTION & MATCHING

Deep Metric Learning (Dlib ResNet):

Instead of traditional classifiers, the system uses a pre-trained Residual Neural Network (ResNet) to encode aligned faces into 128-dimensional feature vectors.

Euclidean Distance:

Identity is verified by calculating the Euclidean distance between the live facial embedding and the embeddings stored in the CSV database. A strict distance threshold of 0.5 is used to declare a confident match and prevent false positives.

5. IMPLEMENTATION

5.1 System Process Flow

The implementation is divided into four main functional stages:

1. Frame Capturing: We utilize a Raspberry Pi Camera Module v1.3. To bypass modern libcamera segmentation faults caused by standard OpenCV backends, the system integrates the official Picamera2 Python library to capture raw RGB arrays directly from the motherboard.

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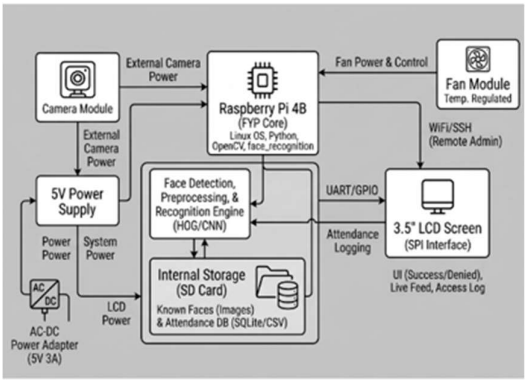
2. Feature Extraction: From each captured signal, the system extracts critical features such as facial landmarks and face features. These features provide insight into the unique characteristics of the face making it easier to distinguish registered students from background noise.

3. Feature Enrolment: Instead of training a new model from scratch, the system extracts 128D facial embeddings from user photographs and stores the mathematical mean of these features into a CSV database for rapid lookup.

4. Classification: Once the model is trained, incoming real-time frames are passed through the classifier to determine whether a match exists in the database.



5.2 Hardware and Software Integration

The system is built using a dedicated hardware-software stack to ensure low latency and reliable data logging:

Hardware Setup:

A Raspberry Pi 4 acts as the central receiver, processing signals captured by the USB camera module.

Software Framework:

We utilize Python and simple processing logic to capture and preprocess signals. For data management, a lightweight SQLite database (attendance.db) is integrated to track real-time IN and OUT timestamps, utilizing a 60-second cooldown logic to prevent duplicate entries.

Web Dashboard Integration:

A Flask-based web server runs in the background, querying the SQLite database to cross-reference a student's raw IN/OUT timestamps against a predefined lecture schedule table. This automatically calculates and displays exactly which subjects the student attended.

5.3 Classification Accuracy

By following this implementation, our system can achieve high accuracy levels similar to established research:

Detection Accuracy:

The system achieves around 95-99% accuracy in detecting the presence of a face within the frame.

Identification Accuracy:

The accuracy for identifying a specific student is approximately 88.4%, though this may vary depending on the number of classes/students registered in the database.

6. FUTURE SCOPE

Integration with AI:

Can improve and reduce false detection by applying machine learning and artificial intelligence. With this we can also make sure that subtle physical changes—such as glasses, facial hair, or varying angles can also detect the face with high precision.

Countermeasures:

Anti-spoofing techniques can be added to prevent fake attendance using photos.

Autonomous Monitoring:

The system can be improved to work automatically with very little to none manual input. We can also make so that automatic synchronization of the local SQLite database with the university's centralized ERP system.

7. CONCLUSION

Automated attendance system is important for improving accuracy and security in institutions. Among different methods facial recognition is better because it is contactless and easy to use. While limitations exist regarding lighting and processing speed future improvements can make the system more efficient and reliable. This project helped us understand the practical implementation of face recognition in real world applications.

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