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Attendance Management System using Face Recognition

Gaurav Khadilkar[1], Himanshu Sharma[2], Pratik Khairwar[3], Piyush Raipure[4], Prof. Minakshi Getkar[5]
Students, Department of Computer Science and Engineering[1,2,3,4]
Professor, Department of Computer Science and Engineering[5]
Rajiv Gandhi College of Engineering, Research and Technology, Chandrapur, India
gauravkhadilkar25@gmail.com, himya1365@gmail.com
pratikhairwar843@gmail.com, piyush.raipure1234@gmail.com, minakshi.getkar@gmail.com

Abstract: *The main purpose of this project is to build a face recognition-based attendance monitoring system for educational institution to enhance and upgrade the current attendance system into more efficient and effective as compared to before. The current old system has a lot of ambiguity that caused inaccurate and inefficient of attendance taking. Many problems arise when the authority is unable to enforce the regulation that exist in the old system. The technology working behind will be the face recognition system. The human face is one of the natural traits that can uniquely identify an individual. Therefore, it is used to trace identity as the possibilities for a face to deviate or being duplicated is low. In this project, face databases will be created to pump data into the recognizer algorithm. Then, during the attendance taking session, faces will be compared against the database to seek for identity. When an individual is identified, its attendance will be taken down automatically saving necessary information into a excel sheet. At the end of the day, the excel sheet containing attendance information regarding all individuals are mailed to the respective faculty.*

Keywords: Smart Attendance System, NFC, RFID, OpenCV, Numpy

I. INTRODUCTION

This is a project about **Facial Recognition-Based Attendance System for Educational Institutions.** In this chapter, the problem and motivation, research objectives, project scope, project contributions and the background information of the project will be discussed in detail.

1.1 Problem Statement and Motivation

According to the previous attendance management system, **the accuracy of the data** collected is the biggest issue. This is because the attendance might not be recorded personally by the original person, in another word, the attendance of a particular person can be taken by a third party without the realization of the institution which violates the accuracy of the data. For example, student A is lazy to attend a particular class, so student B helped him/her to sign for the attendance which in fact student A didn‟t attend the class, but the system overlooked this matter due to no enforcement practiced. Supposing the institution establish an enforcement, it might need to waste a lot of human resource and time which in turn will not be practical at all. Thus, all the recorded attendance in the previous system is not reliable for analysis usage. The second problem of the previous system is where it is **too time consuming**. Assuming the time taken for a student to sign his/her attendance on a 3-4 paged name list is approximately 1 minute. In 1 hour, only approximately 60 students can sign their **attendance which is obviously inefficient and time consuming**. The third issue is with the **accessibility of those information by the legitimate concerned party**. For an example, most of the parents are very concerned to track their child‟s actual whereabouts to ensure their kid really attend the classes in college/school. However in the previous system, there are no ways for the parents to access such information. Therefore, evolution is needed to be done to the previous system to improve efficiency, data accuracy and provides accessibility to the information for those legitimate party.

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1.2 Research Objectives

In order to solve the drawbacks of the previous system stated in 1.1, the existing system will need to evolve. The proposed system will reduce the paperwork where attendance will no longer involve any manual recording. The new system will also reduce the total time needed to do attendance recording. The new system will acquire individual attendance by means of facial recognition to secure data accuracy of the attendance.

The following are objectives of the project:

- To develop a portable Smart Attendance System which is handy and self-powered.
- To ensure the speed of the attendance recording process is faster than the previous system which can go as fast as approximately 3 second for each student.
- Have enough memory space to store the database.
- Able to recognize the face of an individual accurately based on the face database.
- Allow parents to track their child‟s attendance.
- Develop a database for the attendance management system.
- Provide a user-friendly interface for admins to access the attendance database and for non-admins (parents) to check their child‟s attendance by mailing the attendance.
- Allow new students or staff to store their faces in the database by using a GUI.
- Able to show an indication to the user whether the face- recognition process is successful or not.

1.3 Project Scope and Direction

The main intention of this project is to solve the issues encountered in the old attendance system while reproducing a brand new innovative smart system that can provide convenience to the institution. In this project, an application will be developed which is capable of recognising the identity of each individuals and eventually record down the data into a database system. Apart from that, an excel sheet is created which shows the students
attendance and is directly mailed to the respected faculty.

The followings are the project scopes:

- The targeted groups of the attendance monitoring system are the students and staff of an educational institution.
- The database of the attendance management system can hold up to 2000 individual‟s information.
- The facial recognition process can only be done for 1 person at a time.
- An excel sheet is created which contains the student attendance and is mailed to the respected faculty.
- The project has to work under a Wi-Fi coverage area or under Ethernet connection, as the system need to update the database of the attendance system constantly.
- The device on which the application is running is powered up by power bank to improve the portability of the
- application.

II. SYSTEM REQUIREMENTS

Creating a face recognition attendance system typically involves a combination of hardware and software components. The specific system requirements can vary based on the complexity of the solution and the number of users. Below are general system requirements for a face recognition attendance system:

1. Hardware Requirements:
- **Camera**:
- High-resolution camera with good low-light performance.
- Ideally, an HD camera or higher for better face recognition accuracy.

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- **Computer/Server:**
- Sufficient processing power to handle real-time face recognition.
- Multi-core processor (quad-core or higher recommended).
- Ample RAM (8 GB or more recommended).

- **Storage:**
- Adequate storage space for storing face templates and attendance records.
- SSDs are preferred for faster data access.

- **Network:**
- Stable internet connection for cloud-based systems.
- For local systems, a stable LAN (Local Area Network) is sufficient.

2. Software Requirements:
- **Operating System:**
- Windows, Linux, or macOS, depending on the chosen development environment.

- **Face Recognition Software:**
- Open-source libraries like OpenCV or commercial face recognition SDKs.
- Deep learning frameworks such as TensorFlow or PyTorch may be used for training custom models.

- **Database Management System:**
- Database to store and manage employee information and attendance records.
- MySQL, PostgreSQL, MongoDB, or other suitable databases.

- **Attendance Management Software:**
- Application to manage and track attendance records.
- Custom-built software or third-party attendance management systems.

- **Integration with Time and Attendance Systems:**
- Integration with existing time and attendance systems if applicable.

3. Additional Considerations:
- **Security:**
- Implementation of encryption for data transmission and storage.
- Access control measures to protect sensitive data.

- **Scalability:**
- If the system is expected to handle a large number of users, ensure scalability in terms of hardware and software.

- **User Interface (UI):**
- Intuitive and user-friendly interface for administrators and end-users.

- **Compliance:**
- Ensure compliance with privacy regulations and data protection laws.

4. Environmental Considerations:
- **Lighting:**
- Ensure proper lighting conditions for accurate face recognition.

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- Consider using infrared cameras for low-light or nighttime scenarios.

- **Placement of Cameras:**
- Position cameras strategically to capture clear facial images.
- Consider the height and angle of the cameras for optimal performance.

III. TECHNOLOGIES

Face recognition attendance systems leverage a combination of hardware and software technologies to accurately and efficiently capture and analyze facial features for attendance tracking. These systems have evolved with advancements in computer vision, artificial intelligence, and biometric authentication. Here's an overview of the key technologies used in facecam attendance systems:

1. Computer Vision:
- Description: Computer vision is a fundamental technology in face recognition attendance systems. It involves the use of algorithms and models to interpret visual information from images or videos. In the context of attendance systems, computer vision enables the detection and analysis of facial features.
- Role: Computer vision algorithms are responsible for identifying faces in images or video streams, extracting facial landmarks, and analyzing unique characteristics that distinguish one individual from another.

2. Face Detection:
-Description: Face detection is a crucial step in the process. It involves locating and isolating faces within an image or video frame. Various algorithms, such as Haar cascades or deep learning-based methods, are used for accurate face detection.
- Role: Face detection ensures that the attendance system focuses on the relevant facial region, making subsequent recognition more accurate and efficient.

3. Facial Recognition:
- Description: Facial recognition technology identifies and verifies individuals based on unique facial features. It involves creating a facial template or signature from the extracted facial landmarks, which is then compared against a database of known individuals.
- Role: Facial recognition is the core technology responsible for determining the identity of a person in the attendance system. It involves pattern matching and similarity analysis between the captured face and stored templates.

4. Deep Learning:
- Description: Deep learning, a subset of machine learning, has revolutionized facial recognition by enabling the training of sophisticated neural networks. Convolutional Neural Networks (CNNs) are commonly used to automatically learn hierarchical features from facial images.
- Role: Deep learning enhances the accuracy and robustness of facial recognition models by allowing them to learn and adapt to a wide range of facial variations and conditions.

5. Biometric Authentication:
- Description: Facial recognition serves as a biometric authentication method, relying on the uniqueness of facial features for identification. Biometric authentication enhances security and accuracy compared to traditional methods like passwords or keycards.
- Role: The biometric authentication process ensures that the attendance system accurately associates the detected face with the correct individual, reducing the possibility of false positives or negatives.

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6. Database Management:

- Description: A well-organized database is crucial for storing and managing facial templates, employee information, and attendance records. Database management systems facilitate efficient retrieval and storage of data.
- Role: The attendance system relies on databases to store and retrieve facial templates, enabling quick and accurate comparisons during the recognition process.

7. Cloud Computing:

- Description: Cloud computing technologies offer scalable and accessible solutions for face recognition attendance systems. Cloud-based systems provide the flexibility to store, process, and manage data remotely.
- Role: Cloud computing allows for centralized management, real-time updates, and accessibility from various locations, making it suitable for organizations with distributed or remote workforces.

8. Security Measures:

- Description: Security technologies, including encryption and access control mechanisms, are implemented to protect sensitive facial data and ensure the integrity of the attendance system.
- Role: Security measures safeguard against unauthorized access, data breaches, and other potential risks associated with the use of biometric information.

In summary, face recognition attendance systems integrate a variety of cutting-edge technologies, including computer vision, facial detection, deep learning, biometric authentication, database management, and cloud computing. These technologies collectively contribute to the accuracy, efficiency, and security of attendance tracking in diverse environments. As advancements in these fields continue, facecam attendance systems are likely to benefit from increased performance, robustness, and user-friendliness.

IV. ARCHITECTURE

The architecture of a face cam attendance management system involves the integration of various components to ensure accurate face recognition, efficient data processing, and secure attendance tracking. Below is a high-level overview of the architecture for a face cam attendance management system:

1. Data Acquisition Layer:

- Camera Module:
- Responsible for capturing high-resolution images or video frames of individuals' faces.
- May include multiple cameras strategically placed for optimal face detection.

2. Preprocessing Layer:

- Face Detection Module:
- Uses algorithms (e.g., Haar cascades or deep learning models) to identify and locate faces in the captured images or video frames.
- Ensures accurate isolation of facial regions for subsequent processing.
- Image Preprocessing:
- Enhances the quality of captured images, adjusting for lighting conditions, resolution, and noise.
- Improves the overall performance of facial recognition algorithms.

3. Feature Extraction Layer:

- Facial Recognition Module:
- Utilizes deep learning models, such as Convolutional Neural Networks (CNNs), to extract unique features from the detected faces.
- Creates facial templates or embeddings for each individual for subsequent matching.

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4. Database Management Layer:
- Face Database:
- Stores facial templates, employee information, and historical attendance records.
- Utilizes a database management system (e.g., MySQL, PostgreSQL) for efficient storage and retrieval of data.

5. Recognition and Authentication Layer:
- Matching Algorithm:
- Compares the extracted facial features (templates) with the stored templates in the database.
- Determines the identity of the individual based on similarity scores.
- Biometric Authentication:
- Validates the identity of the individual using the facial recognition results.
- May include additional security measures such as liveness detection to prevent spoofing.

6. Attendance Management Layer:
- Attendance Tracking Module:
- Records attendance data for identified individuals.
- Manages real-time attendance tracking and updates the attendance database.
- Integration with Time and Attendance Systems:
- Interfaces with existing time and attendance systems if applicable.
- Ensures seamless integration with broader workforce management processes.

7. User Interface Layer:
- Admin Panel:
- Provides a user-friendly interface for system administrators.
- Enables system configuration, monitoring, and reporting.
- End-User Interface:
- Allows employees to interact with the system for tasks like enrollment, checking attendance records, and resolving discrepancies.

8. Security Layer:
- Encryption and Security Measures:
- Implements encryption for data transmission and storage to ensure the security of facial templates and sensitive information.
- Enforces access control mechanisms to restrict unauthorized access.

9. Scalability and Performance Optimization:
- Load Balancing:
- Distributes processing load across multiple servers to ensure scalability and handle a larger number of concurrent users.
- Optimizes system performance for real-time face recognition
- Caching Mechanisms:
- Utilizes caching to store frequently accessed data, reducing response times and enhancing system efficiency.

10. Cloud Integration (Optional):
- Cloud Services:
- Leverages cloud computing resources for storage, processing, and scalability.
- Allows for remote access and management of the attendance system.

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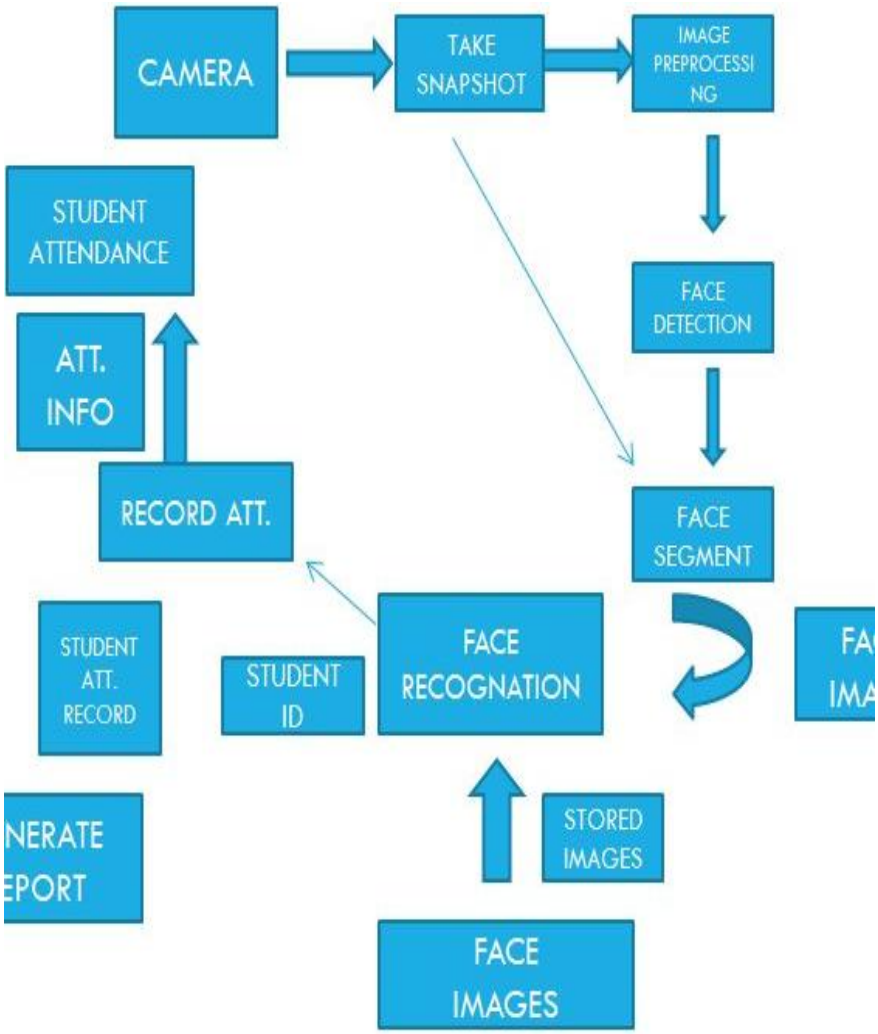
11. Logging and Monitoring:

- Logging System:
- Generates logs for system events, errors, and user activities.
- Facilitates system monitoring, troubleshooting, and auditing.

This architecture provides a comprehensive framework for the development and deployment of a facecam attendance management system. The modular design allows for flexibility, scalability, and customization based on specific organizational needs and technological advancements.



V. MODULES DEVELOPMENTS

Developing modules for a face cam attendance management system involves breaking down the system into smaller, manageable components, each responsible for specific functionalities. Here are key modules that you might consider developing:

1. User Registration and Enrolment Module:

- Functionality:
- Allows administrators to enroll new users into the system.
- Captures facial images for user templates.
- Components:
- User registration form.
- Face image capture functionality.

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2. Face Detection and Preprocessing Module:
- Functionality:
- Identifies and isolates faces in captured images or video frames.
- Applies preprocessing techniques to enhance image quality.
- Components:
- Face detection algorithm (e.g., Haar cascades or deep learning-based models).
- Image preprocessing methods.

3. Facial Recognition and Authentication Module:
- Functionality:
- Matches extracted facial features with stored templates.
- Implements biometric authentication to verify user identity.
- Components:
- Facial recognition algorithm (e.g., deep learning-based models).
- Biometric authentication methods.

4. Attendance Tracking Module:
- Functionality:
- Records attendance data for identified individuals.
- Manages real-time attendance tracking and updates the attendance database.
- Components:
- Attendance recording algorithm.
- Database integration for attendance data storage.

Database Management Module:
- Functionality:
- Stores and retrieves facial templates, employee information, and attendance records.
- Components:
- Database management system (e.g., MySQL, PostgreSQL).
- Data models for user profiles, attendance records, and templates.

6. Admin Panel Module:
- Functionality:
- Provides a user-friendly interface for system administrators.
- Allows configuration, monitoring, and reporting.
- Components:
- Admin dashboard.
- Configuration settings.
- Reporting tools.

7. End-User Interface Module:
- Functionality:
- Allows employees to interact with the system for tasks like checking attendance records.
- Components:
- User dashboard.
- Attendance history display.

8. Security Module:
-Functionality:

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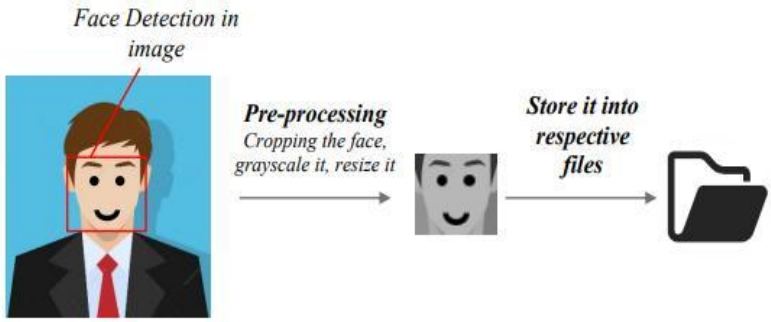
- Implements encryption for data transmission and storage.
- Enforces access control mechanisms.
- Components:
- Encryption methods.
- Access control policies.

9. Integration with me and Attendance Systems Module:
- Functionality:
- Interfaces with existing time and attendance systems if applicable.
- Components:
- Integration protocols (e.g., APIs).
- Compatibility modules.

10. Scalability and Performance Optimization Module:
- Functionality:
- Ensures the system can handle a larger number of users and transactions.
- Implements load balancing and caching mechanisms.
- Components:
- Load balancing algorithms.
- Caching strategies.

11. Cloud Integration Module (Optional):
- Functionality:
- Leverages cloud computing resources for storage, processing, and scalability.
- Components:
- Cloud service integration.
- Remote access and management tools.

Logging and Monitoring Module:
- Functionality:
- Generates logs for system events, errors, and user activities.
- Facilitates system monitoring, troubleshooting, and auditing.
- Components:
- Logging system.
- Monitoring tools.



VI. ADVANTAGES AND DISADVANTAGES

A facecam attendance management system offers several advantages, but it also comes with certain disadvantages. Here's a breakdown of the pros and cons:

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Advantages:

1. **Accuracy:**

- Pro: Facecam attendance systems provide high accuracy in identifying individuals, reducing the likelihood of errors associated with manual methods.

2. Non-Intrusive Biometric:

- Pro: Facial recognition is non-intrusive, requiring minimal physical contact compared to fingerprint or retinal scans, making it more user-friendly.

3. Efficiency and Speed

- Pro: Automated face recognition is quick and efficient, allowing for real-time attendance tracking without causing delays.

4. Reduced Fraud and Buddy Punching:

- Pro: Facecam systems help reduce instances of fraud and buddy punching, as the system relies on unique facial features for identification.

5. User-Friendly:

- Pro: Employees find face recognition systems easy to use, as they simply need to look at the camera for attendance recording.

6. Contactless:

- Pro: In the context of the COVID-19 pandemic, facecam systems provide a contactless solution, minimizing the risk of virus transmission.

7. Scalability:

- Pro:Facecam attendance systems can be easily scaled to accommodate a growing number of users without significant infrastructure changes.

8. Integration with Other Systems:

- Pro: Integration with time and attendance systems, HR software, and other platforms is generally feasible, streamlining overall workforce management.

Disadvantages:

1. Privacy Concerns:

- Con: Facial recognition systems raise privacy concerns as they involve the collection and storage of biometric data, which may be sensitive.

2. Liveness Detection Challenges:

- Con: Some facecam systems may face challenges in detecting liveness, making them susceptible to spoofing with photographs or videos.

3. Environmental Factors:

- Con: Performance may be affected by environmental factors such as lighting conditions, shadows, or camera angles, leading to reduced accuracy.

4. Initial Cost:

- Con: The initial implementation cost of a facecam system, including cameras and software, can be relatively high compared to traditional methods.

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5. Technical Complexity:
- Con: Implementing and maintaining facecam systems require technical expertise, and organizations may face challenges if they lack the necessary skills.

6. Dependence on Infrastructure:
- Con: Facecam attendance systems depend on a reliable infrastructure, including stable internet connectivity and power supply. Any disruptions may affect system performance.

7. Cultural and Legal Considerations:
- Con:Cultural norms regarding biometric data collection may vary, and legal frameworks may impose restrictions on the use of facial recognition technology.

8. Data Security Risks:
- Con:The storage and transmission of biometric data pose security risks, and organizations must implement robust security measures to safeguard this sensitive information.

9. System Reliability:
- Con: In some cases, facecam systems may experience reliability issues, especially if not properly maintained or if there are software bugs.

10. User Acceptance:
- Con: Some individuals may feel uncomfortable or resistant to the idea of facial recognition, impacting user acceptance within an organization.

When considering the adoption of a facecam attendance management system, organizations should carefully weigh these advantages and disadvantages, taking into account their specific needs, the regulatory environment, and the level of acceptance among employees and stakeholders. Additionally, staying informed about evolving technologies and best practices in the field is crucial for successful implementation and ongoing management.

VII. FUTURE SCOPE

The future scope for facecam attendance management systems is promising, driven by ongoing advancements in technology and an increasing demand for efficient, secure, and contactless workforce management solutions. Here are some potential future scopes and developments for facecam attendance systems:

1. Improved Accuracy and Performance:
- Future facecam systems are likely to see improvements in accuracy and performance through advancements in computer vision algorithms, deep learning models, and increased processing power. This can lead to more reliable and faster recognition.

2. Enhanced Liveness Detection:
- Addressing challenges related to liveness detection will be a focus area. Future systems may incorporate advanced techniques such as 3D facial recognition, eye movement tracking, and other biometric indicators to ensure that the system is interacting with a live person and not a static image.

3. AI-Based Dynamic Adaptation:
- Artificial intelligence (AI) will play a crucial role in future facecam systems, allowing them to dynamically adapt to changes in facial appearance, expressions, and environmental conditions. AI algorithms could continuously learn and optimize performance over time.

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4. Multimodal Biometrics Integration:

- Future systems may integrate multiple biometric modalities, combining facial recognition with other biometric methods such as fingerprint scanning or voice recognition. This multimodal approach can enhance overall security and accuracy.

5. Edge Computing for Real-Time Processing:

- The adoption of edge computing in facecam systems could enable real-time processing of facial recognition on local devices, reducing latency and dependency on centralized servers. This would be particularly beneficial for applications requiring quick response times.

6. Privacy-Preserving Technologies:

- Addressing privacy concerns will be a priority. Future systems may incorporate privacy-preserving technologies such as federated learning, where models are trained across decentralized devices without exchanging raw data, enhancing data security and privacy.

7. Blockchain Integration for Data Security:

- Blockchain technology could be integrated into facecam attendance systems to enhance data security, transparency, and tamper-proof record-keeping. This could help build trust in the integrity of attendance records.

8. Emotion and Health Monitoring:

- Future facecam systems might include capabilities for emotion detection and health monitoring through facial analysis. This could provide additional insights into the well-being and emotional state of individuals in the workplace.

VIII. CONCLUSION

Before the development of this project. There are many loopholes in the process of taking attendance using the old method which caused many troubles to most of the institutions. Therefore, the facial recognition feature embedded in the attendance monitoring system can not only ensure attendance to be taken accurately and also eliminated the flaws in the previous system. By using technology to conquer the defects cannot merely save resources but also reduces human intervention in the whole process by handling all the complicated task to the machine. The only cost to this solution is to have sufficient space in to store all the faces into the database storage. Fortunately, there is such existence of micro SD that can compensate with the volume of the data. In this project, the face database is successfully built. Apart from that, the face recognizing system is also working well. At the end, the system not only resolve troubles that exist in the old model but also provide convenience to the user to access the information collected by mailing the attendance sheet to the respected faculty.

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