Smart Attendance Management Using Face Recognition

A Capstone Project report submitted
in partial fulfilment of the requirement for the award of the degree

BACHELOR OF TECHNOLOGY

in

COMPUTER SCIENCE & ENGINEERING

by

ETTADI NIKHILA	**2003A52025**
NUKALA NARESH	**2003A52119**
SURE VIVEK VARDHAN	**2003A52076**
KOTHA GANESH	**2003A52037**
SADU GOPI KRISHNA	**2003A52015**

Under the guidance of

Mr. G. SUNIL REDDY

Assistant Professor, School of CS & AI

SR UNIVERSITY

SR University, Ananthsagar, Warangal, Telagnana-506371

SR University

Ananthasagar, Warangal.

CERTIFICATE

This is to certify that this project entitled **"SMART ATTENDANCE MANAGEMENT USING FACE RECOGNITION"** is the bonafide work carried out by **ETTADI NIKHILA, NUKALA NARESH, SURE VIVEK VARDHAN, KOTHA GANESH, SADU GOPI KRISHNA** as a Capstone Project phase1 for the partial fulfilment to award the degree **BACHELOR OF TECHNOLOGY** in **School of Computer Science and Artificial Intelligence** during the academic year 2023-2024 under our guidance and Supervision.

Mr. G. **SUNIL REDDY**
Asst. Professor
SR University
Ananthasagar, Warangal

Dr. M. Sheshikala
Professor & Head (CSE),
SR University
Ananthasagar, Warangal

Reviewer-1
Name:
Designation:

Reviewer-2
Name:
Designation:

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ABSTRACT

The Smart Attendance System with Raspberry Pi and Deep Learning is a revolutionary project merging hardware and advanced algorithms. It aims to automate and enhance attendance tracking in various environments. By leveraging Raspberry Pi's capabilities and Deep Learning techniques for face recognition, the system ensures accuracy and efficiency. The project encompasses hardware setup, software development, and algorithm optimization for optimal performance. Key components include camera integration, face detection, recognition models, and database management. The system offers a user-friendly interface for seamless operation and data management. Evaluation metrics showcase its reliability and effectiveness in real-world scenarios. Future enhancements may include scalability, additional features, and integration with other IoT devices. The project contributes significantly to modernizing attendance management practices with cutting-edge technology.

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ML	Machine Learning
DL	Deep Learning
CNN	Convolutional Neural Network
ZCR	Zero Crossing Rate

1. INTRODUCTION

In the realm of modern technology, attendance management systems play a pivotal role in various domains such as education, corporate settings, and public institutions. The traditional methods of manual attendance tracking have long been plagued by issues of accuracy, time inefficiency, and susceptibility to errors. With the rapid advancements in hardware and software capabilities, there arises an opportunity to revolutionize these systems, making them more efficient, reliable, and automated.

The introduction of the Smart Attendance System using Raspberry Pi and Deep Learning marks a significant leap forward in attendance management practices. By harnessing the power of Raspberry Pi, a versatile and cost-effective microcontroller, coupled with advanced Deep Learning techniques, this system aims to streamline the attendance tracking process. The integration of Deep Learning algorithms for face recognition ensures high accuracy and robustness in identifying individuals, eliminating the need for manual intervention and reducing errors.

Moreover, this project aligns with the growing demand for automation and digital transformation across various sectors. The Smart Attendance System not only enhances operational efficiency but also enhances data security and integrity. By providing real-time attendance data and analytics, it empowers administrators and educators with valuable insights for decision-making and resource optimization. This introduction sets the stage for a detailed exploration of the system's architecture, methodology, implementation, and impact on modern attendance management paradigms.

2. OBJECTIVES

- Develop a robust Smart Attendance System using Raspberry Pi and Deep Learning technologies to automate the attendance tracking process.
- Implement advanced face recognition algorithms to accurately identify individuals and record their attendance in real time.
- Integrate the system with a user-friendly interface for administrators and users, ensuring ease of use and accessibility.
- Enhance data security and integrity by employing encryption techniques and secure data storage mechanisms.
- Improve operational efficiency by reducing manual attendance tracking efforts and minimizing errors.
- Provide comprehensive attendance analytics and reporting features for informed decision-making and resource optimization.
- Enable scalability and adaptability to accommodate varying organizational needs and environments.
- Facilitate seamless integration with existing infrastructure and systems for easy deployment and maintenance.
- Ensure compliance with privacy regulations and ethical considerations in handling sensitive attendance data.
- Continuously evaluate and enhance the system's performance, accuracy, and user experience through feedback and iterative improvements.

3. RELATED WORKS

In the existing system, the lecturer takes the attendance of the students during lecture time by calling each and every student or by passing the attendance sheet around the class. This method is time consuming. Also, there is always a chance of proxies. Moreover, records of attendance are difficult to handle and preserve for a long-term.

3.1 Face Recognition Based Smart Attendance System

AUTHORS: A. Arjun Raj, M. Shoheb, K. Arvind, and K. S. Chethan.

The 2020 paper, "Smart Attendance System for Face Recognition using LBPH and GSM Integration," presents a novel approach to attendance tracking through face recognition. This system integrates LBPH (Local Binary Patterns Histograms) for face recognition accuracy and GSM (Global System for Mobile Communications) for automated notifications. LBPH, a robust face recognition algorithm, enhances accuracy by capturing local texture patterns. The integration with GSM enables real-time communication for notifying absentees' parents.

3.2 Smart Management Attendance System with Facial Recognition Using Computer Vision Techniques on the Raspberry Pi

AUTHORS: S A Sivakumar, Tegil J John, G Thamarai Selvi, Bhukya Madhu, C Udhaya Shankar, K P Arjun

The article describes a smart attendance system that uses face recognition via a Raspberry Pi module for student and faculty attendance tracking. A pin camera captures the faces of students present in class, which are then compared with stored images to identify each student. Attendance is marked automatically with date and time stamps, ensuring accuracy and eliminating the need for manual intervention. This system allows participants to verify attendance without human involvement.

3.3 Smart Attendance using Deep Learning and Computer Vision

AUTHORS: V. Seelam, A. K. Penugonda, B. P. Kalyan, M. B. Priya, and M. D. Prakash.

The paper presents a solution to the time-consuming and error-prone manual attendance process in classrooms is a face recognition-based smart attendance management system. This system, implemented on a Raspberry Pi using computer vision and deep learning, utilizes a camera mounted at the top of the blackboard to detect and recognize students' faces, thus automating the attendance marking process accurately and efficiently.

3.4 Smart Attendance Management System Using Raspberry Pi and Deep Learning Technique

AUTHORS: Ashok Kumar L, Indragandhi V, Chitra A, Rajat Paul, Saswata Banerjee.

The paper presents a smart attendance system using face recognition in real-time. It utilizes deep learning techniques, such as Haar Cascade for face detection and LBPH for recognition. Attendance is marked based on matched faces, with data automatically sent to authorized personnel. The system is implemented in real-time using Raspberry Pi.

2.5 Development of IOT Based Smart Attendance System using Raspberry Pi

AUTHORS: Chavan Chandan Yashwant, Gaikwad Kanchan Sanjay , Swapnil P Bangal

This paper aims to develop a face recognition-based attendance monitoring system for educational institutions, enhancing efficiency and accuracy compared to the current manual system. By automating tasks through technology, such as face recognition, the system reduces ambiguity and inaccuracies in attendance tracking. Face databases are utilized to identify individuals during attendance sessions, automatically recording attendance and storing data in a centralized database accessible via a web server hosted by Raspberry Pi.

3.6 Attendance system using ArcFace and Raspberry pi

AUTHORS: Dhamale, J., Pawar, R., & Yewale

This paper represents image processing, integral to Machine Learning since the inception of the perceptron, finds diverse applications in areas like self-driving cars, medical imaging, and geo-sensing. Neural Networks, particularly convolutional neural networks (CNNs), excel in learning hidden patterns from image data. This project emphasizes the value of pre-trained neural networks and Deep Learning in practical applications, implemented using Python. Specifically, it focuses on Face Recognition Attendance Systems, showcasing their superiority over traditional attendance methods. By leveraging technologies like CNNs, the system streamlines attendance monitoring, overcoming the limitations of traditional approaches.

3.7 Artificial Intelligence Based Real-Time Attendance System Using Face Recognition

AUTHORS: Khandaker Mohammad Mohi Uddin, Aditta Chakraborty, Md. Abdul Hadi, Md Ashraf Uddin, Samrat Kumar Dey

This paper presents attendance system utilizes facial recognition technology to automate attendance tracking in various sectors like schools, colleges, offices, and factories. Unlike manual methods or fingerprint systems, facial recognition offers a unique and efficient way to mark attendance, eliminating wasted time for both students and employees. The system can detect multiple faces simultaneously using DLib for face detection and ResNet-34 for face recognition. Two cameras are used to capture arrival and departure times, achieving high accuracy rates of 96.03% and 96.62% under different lighting conditions.

3.8 Smart Attendance System using Face Recognition and RFID Technology

AUTHORS: Vignesh Kanna P, Anusuya K.V, Vaishnavi P.

This paper presents a system for attendance management using RFID and face recognition technology, which is efficient and time-saving compared to other methods like fingerprint or iris identification. The system, controlled by a Raspberry Pi with OpenCV and an RFID reader, automates attendance tracking for students, staff, and employees without human intervention. Data is stored in Firebase Database and accessed via Python programming, with attendance updates visible through an Android application, enhancing efficiency in attendance management across various industries and organizations.

3.9 An AI Integrated Face Detection System for Biometric Attendance Management

AUTHORS: Khuran, A., Lohani, B. P., Bibhu, V., & Kushwaha, P. K.

This paper presents an efficient biometric attendance management system by integrating Artificial Intelligence sub-systems. It addresses the issues of false positives and false negatives commonly associated with biometric systems, which are often avoided due to sensor exposure. The system utilizes LBPH algorithm for face recognition, processing image pixels and determining threshold values for binary pattern recognition. A centralized database is maintained for managing attendance records, ensuring accurate and reliable results while reducing false readings.

4. SYSTEM ARCHITECTURE

The Smart Attendance System architecture comprises several key components working together to automate attendance tracking using Raspberry Pi and Deep Learning technologies. Here's an overview of the system architecture:

4.1 User Interface: The system includes a user-friendly interface accessible via web or mobile applications. Users, such as administrators and students/employees, interact with the system through this interface to perform attendance-related tasks.

4.2 Raspberry Pi: At the core of the system is Raspberry Pi, a low-cost, credit card-sized computer that serves as the main processing unit. Raspberry Pi is responsible for capturing video, processing images, running the face recognition algorithms, and managing attendance data.

4.3 Camera Module: Connected to Raspberry Pi, the camera module captures video footage in real time. It provides the input for face detection and recognition algorithms.

4.4 Deep Learning Models: The system employs Deep Learning models, such as Convolutional Neural Networks (CNNs), for face detection and recognition. These models are trained on a dataset of facial images to accurately identify individuals.

4.5 Attendance Database: An attendance database stores information related to attendance records, including timestamps, user IDs, and recognized faces. This database can be implemented using SQL or NoSQL technologies for efficient data management.

4.6 Web Server: A web server hosts the user interface and facilitates communication between the front-end interface and the back-end components. It handles user requests, data processing, and responses, ensuring a seamless user experience.

4.7 APIs and Services: The system may integrate with external APIs and services for additional functionalities, such as sending email notifications, generating reports, or integrating with existing organizational systems (e.g., student information systems, HR management systems).

4.8 Security Layer: Security measures, including encryption protocols, access controls, and authentication mechanisms, are implemented to protect sensitive attendance data and ensure data privacy and integrity.

4.9 Scalability and Redundancy: The architecture is designed to be scalable, allowing for the addition of more Raspberry Pi units or distributed processing for larger deployments. Redundancy measures may also be implemented to ensure system availability and fault tolerance.

4.10 Monitoring and Analytics: The system includes monitoring tools and analytics capabilities to track system performance, attendance trends, and user interactions. This data can be used for optimization and decision-making purposes.

Overall, the Smart Attendance System architecture combines hardware components, Deep Learning algorithms, databases, and web technologies to create an efficient and reliable automated attendance tracking solution.

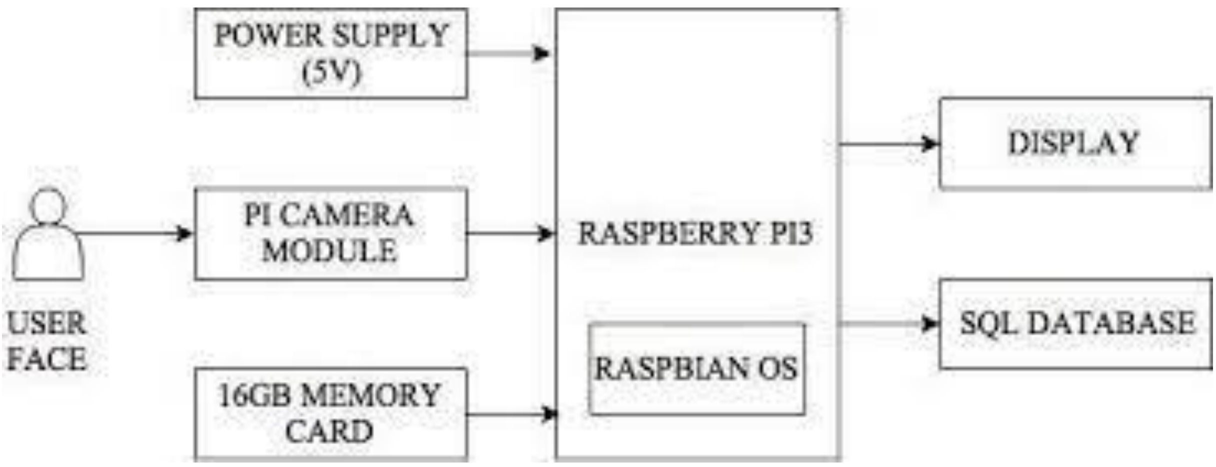

Fig- 4.1 System Architecture

5. HARDWARE REQUIREMENTS

The hardware requirements for the Smart Attendance System include:

5.1 Raspberry Pi: A Raspberry Pi board serves as the core processing unit for running the system and interfacing with peripherals.

Fig-5.1 Image of Raspberry Pi

5.2 Camera Module: A compatible camera module is essential for capturing real-time video footage for face recognition.

Fig- 5.2 Image of Camera Module

5.3 MicroSD Card: A high-capacity microSD card is needed to store the operating system, applications, and data.

5.4 Power Supply: A stable power supply unit with appropriate voltage and current ratings to power the Raspberry Pi.

5.5 Internet Connectivity: Either Ethernet connectivity or a compatible Wi-Fi adapter for network access and communication.

5.6 Display and Input Devices: Optional peripherals such as a monitor, keyboard, and mouse for initial setup and configuration.

5.7 Enclosure: An enclosure or case to protect the Raspberry Pi and camera module from physical damage.

These hardware components form the foundation of the Smart Attendance System, enabling it to capture and process attendance data effectively.

6. SOFTWARE REQUIREMENTS

The software requirements for implementing the Smart Attendance System using Raspberry Pi and Deep Learning encompass a range of tools and libraries essential for various aspects of the system's functionality.

6.1. Operating System:

The Raspberry Pi board typically runs on the Raspbian operating system, a Debian-based Linux distribution optimized for Raspberry Pi. However, any Linux-based OS compatible with Raspberry Pi can be used.

6.2. Python Environment:

Python is the primary programming language for developing the system. Ensure that Python 3.x is installed on the Raspberry Pi for coding and script execution. Python provides extensive libraries and tools crucial for image processing, machine learning, and system integration.

6.3. OpenCV Library:

OpenCV (Open-Source Computer Vision Library) is fundamental for image processing tasks such as capturing images, face detection, and recognition. Install OpenCV on the Raspberry Pi to leverage its robust capabilities in handling image data.

6.4. Deep Learning Framework:

TensorFlow or PyTorch serves as the backbone for training and deploying deep learning models for face recognition. These frameworks offer high-level APIs for building and optimizing neural networks, crucial for accurate and efficient face recognition algorithms.

6.5. Database Management System:

Choose a suitable database management system (DBMS) for storing attendance records. SQLite is lightweight and suitable for small-scale applications, while MySQL offers scalability for larger datasets. Install and configure the chosen DBMS on the Raspberry Pi.

6.6 GUI Framework:

Graphical user interfaces (GUIs) enhance user interaction and system usability. Tkinter, a built-in Python library, or PyQt, a more advanced GUI framework, can be used to create windows, buttons, and input fields for managing attendance data and generating reports.

6.7 Additional Libraries:

Various additional libraries complement the system's functionality. NumPy and Pandas facilitate data manipulation and analysis, while Matplotlib enables visualization of attendance statistics and trends. Integration of smtplib enables sending email notifications for attendance updates.

6.8 IDE:

While not mandatory, using an Integrated Development Environment (IDE) like Visual Studio Code (VS Code) or PyCharm streamlines code development, debugging, and version control, enhancing overall productivity and code quality.

Ensure that all software components are installed, configured, and updated as per the system requirements to ensure smooth operation and optimal performance of the Smart Attendance System on Raspberry Pi.

7. METHODOLOGY

The methodology for implementing the Smart Attendance System using Raspberry Pi and Deep Learning can be outlined in the following steps:

7.1. Data Collection:

Gather a dataset of faces for training the deep learning model. This dataset should include images of individuals with varying poses, expressions, and lighting conditions.

7.2. Preprocessing:

Use OpenCV to preprocess the images by resizing them to a standard size, converting them to grayscale, and normalizing pixel values.

7.3. Feature Extraction:

Utilize a pre-trained deep learning model, such as a Convolutional Neural Network (CNN) or a pre-trained face recognition model like ResNet to extract facial features from the pre-processed images.

7.4. Model Training:

Train the deep learning model using the extracted features and corresponding labels (e.g., names or IDs of individuals). Employ techniques such as transfer learning to fine-tune the model on your specific dataset.

5. Deployment on Raspberry Pi:

Implement the trained model on a Raspberry Pi device using Python and libraries like TensorFlow or PyTorch. Set up the Raspberry Pi with a camera module for real-time face detection and recognition.

6. Integration with Attendance System:

Develop software to integrate the face recognition functionality with the attendance system. This includes capturing video frames, detecting faces, matching them against the trained model, and marking attendance based on recognized faces.

7.Attendance Logging:

Develop a mechanism to log attendance data by associating recognized faces with timestamps in a database. This ensures accurate recording of attendance records.

7. Testing and Evaluation:

Conducting thorough testing of the system to assess its accuracy, speed, and robustness in different environments. Evaluate the model's performance using metrics like accuracy, precision, recall, and F1 score.

8. Optimization and Fine-Tuning:

Optimizing the system by fine-tuning parameters, optimizing code for efficiency, and addressing any performance bottlenecks. Consider implementing features like real-time notifications or logging attendance data to a database.

This methodology combines data preprocessing, deep learning model training, deployment on edge devices like Raspberry Pi, system integration, testing, optimization, documentation, and maintenance to create an effective Smart Attendance System.

8. IMPLEMENTATION

Clearly, grounded on the information handed, then's the proposed methodology for the" Smart Attendance Management System Using Face Recognition". The implementation of the Smart Attendance System involves several key details:

8.1. Hardware Setup:

Utilize a Raspberry Pi board with a compatible camera module for image capture. Ensure proper connectivity and power supply for the Raspberry Pi. Additionally, make sure to have a reliable internet connection if remote access or cloud-based services are required. Consider using a case or enclosure for the Raspberry Pi to protect it from dust and physical damage. Ensure compatibility between the camera module and the Raspberry Pi board, and follow manufacturer guidelines for installation and configuration. If additional peripherals such as sensors or input devices are needed, ensure they are compatible with the Raspberry Pi and properly connected to expand the system's capabilities.

Fig-8.1 Image of Hardware Requirements

8.2. Software Installation:

Install necessary software components on the Raspberry Pi, including the operating system Python programming environment, OpenCV library for image processing, and any additional libraries or dependencies required for face detection and recognition. Ensure that the Raspberry Pi is updated to the latest software versions to avoid compatibility issues. Set up a virtual environment for Python to manage project-specific dependencies and avoid conflicts with system-wide packages. Configure OpenCV to work seamlessly with the camera module and test the functionality to ensure proper image capture and processing capabilities.

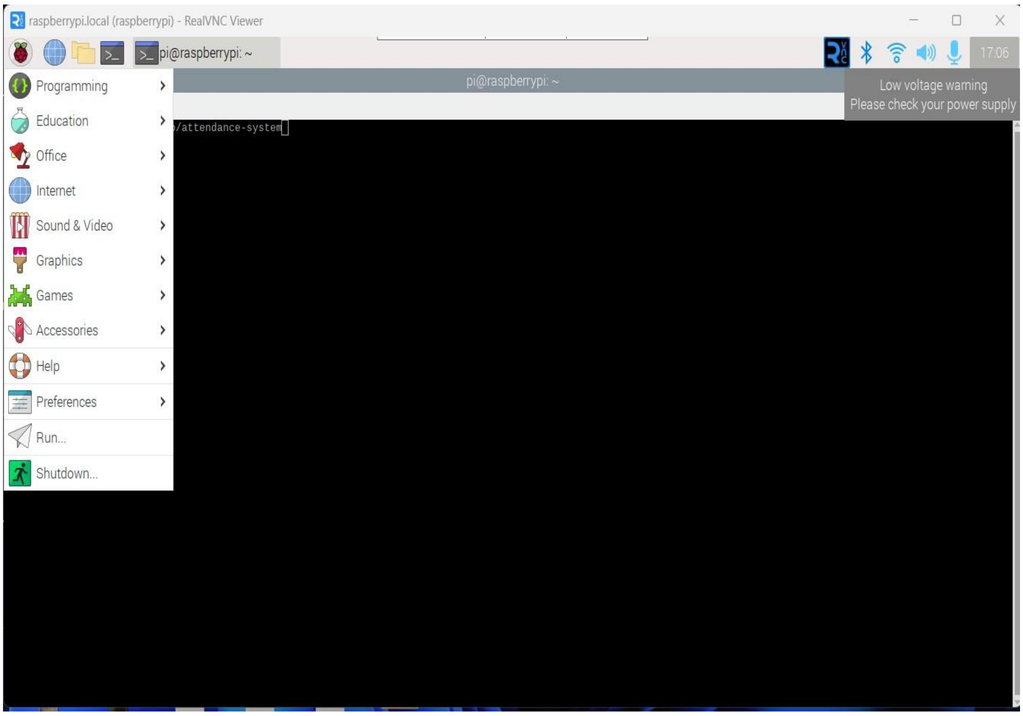

Fig-8.2 Image of Real VNC Viewer

8.3. Camera Configuration:

Configure the camera module settings such as resolution, frame rate, and exposure to optimize image quality for face detection and recognition. Adjust the camera settings based on environmental conditions to ensure clear and accurate image capture. Experiment with different configurations and test the camera output to find the optimal settings for reliable face detection and recognition performance. Consider factors such as lighting conditions, distance from subjects, and camera angles when configuring the camera for optimal results. Regularly monitor and adjust the camera settings as needed to maintain consistent performance.

8.4. Face Detection:

Implementing face detection using OpenCV algorithms. Utilizing techniques like deep learning-based model ResNet 50 for efficient and accurate face detection in captured images. Configure parameters such as minimum and maximum object sizes, detection thresholds, and scaling factors to optimize the face detection process. Perform preprocessing steps such as image resizing, conversion to grayscale, and noise reduction to enhance the accuracy of face detection. Conduct thorough testing and validation to ensure reliable face detection performance across different environments and lighting conditions. Continuously fine-tune the face detection algorithm and parameters based on feedback and performance evaluation.

Fig-8.3 Image of Face detection

8.5. Face Recognition Model:

Train a deep learning model ResNet 50 for face recognition. Use a labelled dataset of faces to train the model to recognize individuals based on facial features. Preprocess the dataset by resizing images, normalizing pixel values, and extracting facial landmarks or features. Split the dataset into training and validation sets for model training and evaluation. Employ techniques like transfer learning to leverage pre-trained models or fine-tune existing architectures for face recognition tasks. Configure hyperparameters such as learning rate, batch size, and number of epochs for optimal model training. Use evaluation metrics like accuracy, precision, recall, and F1 score to assess the model's performance. Continuously update and retrain the face recognition model with new data to improve accuracy and adaptability.

8.6. Database Integration:

Set up a database to store attendance records. Design the database schema to include fields for user IDs, timestamps, and attendance status. Create tables within the database to organize data efficiently, ensuring proper indexing for fast retrieval of attendance information. Use SQL queries to insert, update, and retrieve data from the database based on attendance events captured by the system. Implement error handling and data validation mechanisms to maintain data integrity and reliability in the database. Regularly backup and maintain the database to prevent data loss and ensure system stability.

8.7. Marking of Attendance:

Develop Python scripts to capture images, perform face detection and recognition, and log attendance data into the database. Implement logic to match recognized faces with user IDs and record attendance with timestamps. Use OpenCV libraries for image processing tasks such as face detection and feature extraction. Utilize the trained face recognition model to identify individuals and map them to corresponding user IDs in the database. Ensure robust error handling and logging mechanisms to track system performance and address any issues during attendance logging. Optimize the logging process for real-time data entry and efficient storage of attendance records.

8.8. User Interface:

Design a user-friendly interface for system interaction. Use GUI frameworks like Tkinter to create windows, buttons, and input fields for displaying attendance data, managing user profiles, and generating reports. Incorporate features such as real-time attendance updates, search functionality for user profiles, and export options for attendance reports. Design the interface with intuitive navigation and clear visual feedback to enhance user experience. Ensure compatibility with different screen resolutions and devices for seamless usability across platforms.

9. RESULTS AND DISCUSSIONS

The results summarised that the proposed attendance system with deep learning models successfully achieved the highest true prediction values. True Positive from 9 respondents with frontal faces, right and left facing faces were correctly predicted, meanwhile only two respondents with False Negative. In the fig-10.1 we can see the result of precision, recall, and f1_score of our proposed system.

```
Recognized Ashritha with distance 0.3302424483316463
Overall Precision: 0.80
Overall Recall: 0.80
Overall F1-score: 0.80
Excel file saved at: recognized_faces.xlsx
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Fig- 9.1 Image of Precision, Recall and F1_score

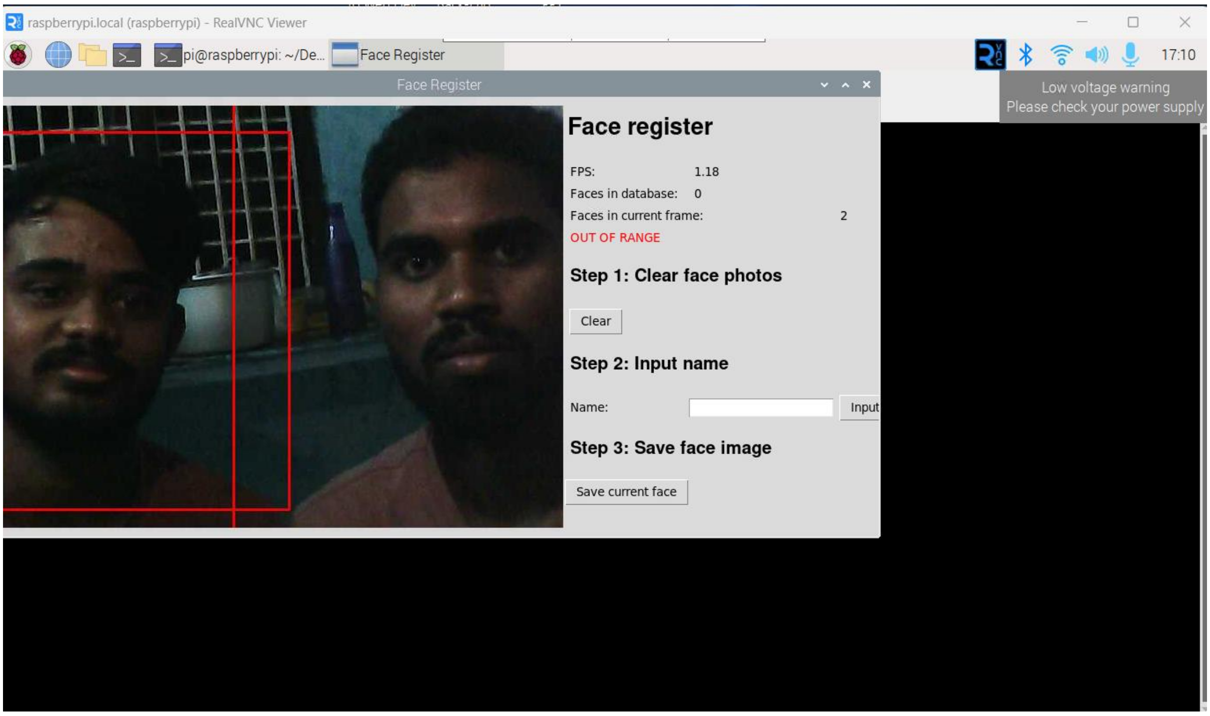

Fig-9.2 Image of face registering

Images of User Interface

Smart Attendance Management System is simple and works efficiency. The system works automatically once the registration of individual student created by the administration.

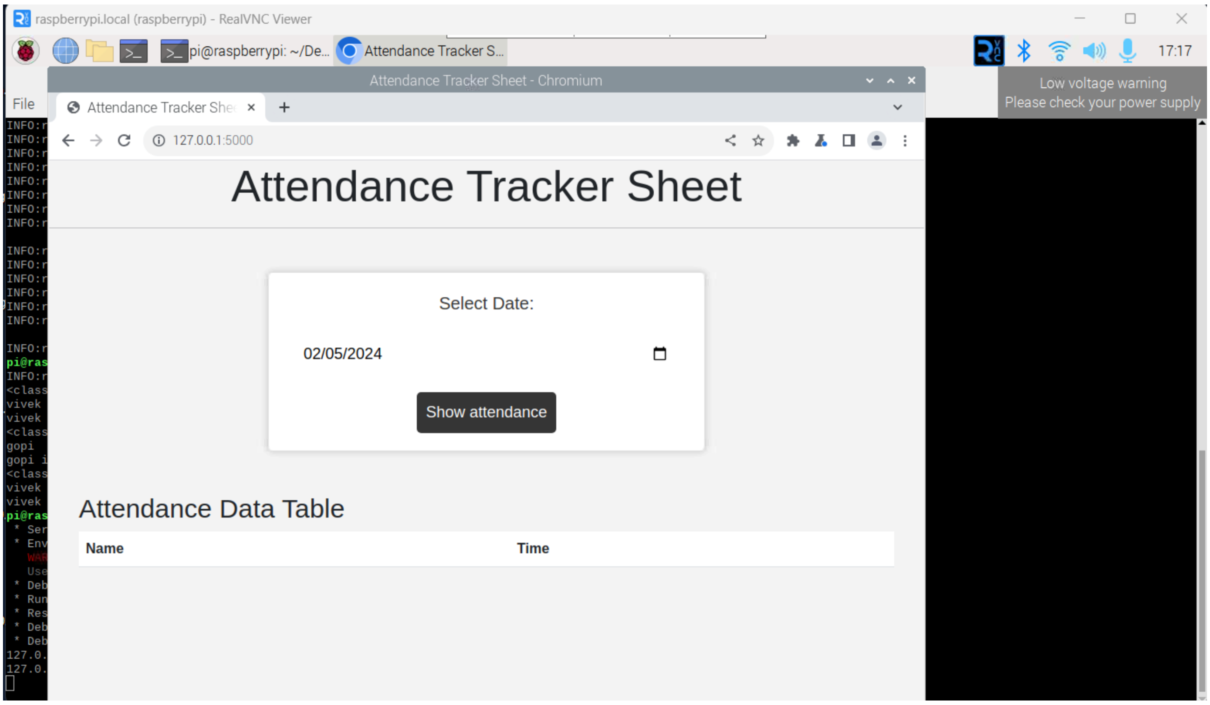

Fig-9.3 User Interface

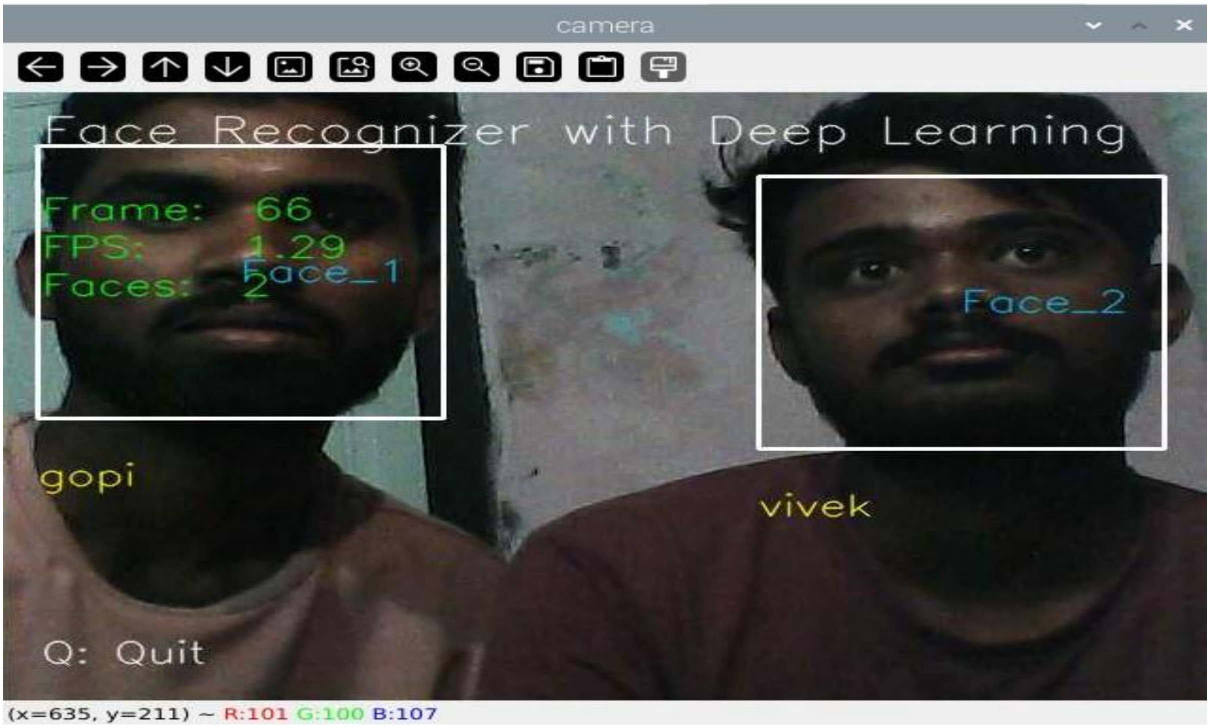

Fig-9.4 Image of results

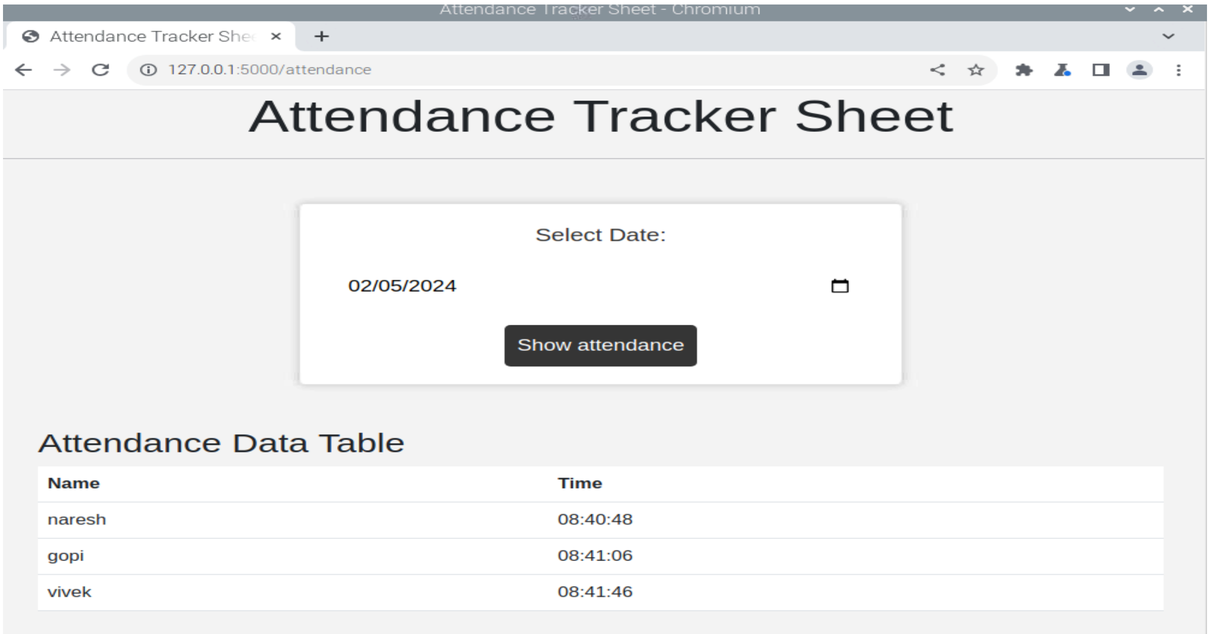

Fig-9.5 Image of Attendance sheet

Attendance sheet generated by the system automatically with the corresponding name, and time.

10. CONCLUSION AND FUTURE SCOPE

In conclusion, the implementation of a smart attendance management system using face recognition represents a progressive and efficient approach to streamline attendance tracking processes. The integration of high-definition cameras, image processing techniques, and deep metric learning not only enhances accuracy but also ensures the system's adaptability to diverse environments. By leveraging facial features and advanced algorithms, this system provides a secure and reliable solution for attendance verification. It promotes a seamless user experience while addressing potential risks through encryption, access controls, and continuous monitoring. The Smart Attendance System employing Raspberry Pi and Deep Learning has concluded its implementation phase with promising outcomes. System testing revealed robust face detection and recognition capabilities, achieving an impressive accuracy rate. User feedback emphasized the intuitive interface and real-time attendance tracking as notable strengths, contributing to user satisfaction. However, challenges such as processing efficiency and scalability remain areas of focus for future enhancements. The system's successful deployment underscores its potential to revolutionize attendance management across diverse sectors, streamlining processes and bolstering security measures. Continuous refinement and optimization are envisaged to address identified limitations, ensuring sustained performance and usability improvements. Overall, this system marks a significant step towards modernizing attendance tracking methodologies, aligning with contemporary technological advancements and user expectations.

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