ISSN: 2321-2152

IJMECE

International Journal of modern electronics and communication engineering

E-Mail
editor.ijmece@gmail.com
editor@ijmece.com

www.ijmece.com

ISSN 2321-2152
www.ijmece.com
Vol 13, Issue 1, 2025

FACIAL RECOGNITION ATTENDANCE SYSTEM

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***Abstract*— The project aims to develop a face recognition attendance system using the Raspberry Pi Model 4. It leverages OpenCV and dlib for face detection and recognition, utilizing a pre-trained deep learning model for accurate feature extraction and matching. The system automatically captures and records attendance by detecting faces, comparing them with a stored database, and logging recognized individuals. It supports multiple users, integrates with existing databases, and enhances accuracy, efficiency, and security over traditional methods. This cost-effective and compact solution showcases the potential of combining modern computing with machine learning for automated attendance management..**

I. INTRODUCTION

A Face Recognition Smart Attendance System represents a cutting-edge advancement in the domain of automated attendance tracking, utilizing the principles of artificial intelligence (AI) and computer vision to offer a seamless and efficient solution.

At the heart of the Face Recognition Smart Attendance System is the integration of high-resolution cameras and advanced software. The cameras, strategically placed at entry points or within classrooms, capture real-time images of individuals. These images are then processed by the software, which compares them against a pre-existing database of registered faces. When a match is found, the system records the individual's attendance automatically, eliminating the need for any physical interaction or manual input. This not only speeds up the process but also significantly reduces errors associated with traditional attendance systems.

Security is another critical advantage. Facial recognition technology employs encryption and secure data storage practices to protect sensitive

The application of facial recognition in attendance systems also brings a high degree of accuracy and security. Modern facial recognition algorithms are highly sophisticated, capable of distinguishing between individuals with a high degree of precision

II. RELATED WORK

Facial recognition technology has become widely used for attendance management in education, corporate environments, and security agencies. Traditional biometric methods like fingerprint and RFID-based systems improved accuracy but had drawbacks such as hygiene concerns and the risk of proxy attendance. Facial recognition emerged as a contactless and efficient alternative.

The Viola-Jones algorithm (2001) provided a foundation for real-time face detection, later enhanced by deep learning models like Face Net and Deep Face. These models, using convolutional neural networks (CNNs), significantly improved recognition accuracy, even under challenging conditions.

Raspberry Pi has been widely adopted for cost-effective and portable facial recognition attendance systems. Integrated with OpenCV and dlib, it enables real-time image processing and feature extraction. Despite advancements, challenges like lighting variations and facial occlusions persist, prompting further research into hybrid approaches and AI enhancements.

ISSN 2321-2152
www.ijmece.com
Vol 13, Issue 1, 2025

III. PROPOSED DESIGN

The proposed facial recognition attendance system offers an efficient, contactless, and automated solution for tracking attendance in educational institutions and workplaces. It combines hardware and software to ensure real-time and accurate recognition. The system's core includes a Raspberry Pi Model 4 with a high-resolution camera module for capturing facial images, connected to a local or cloud-based database for storing attendance records. A touchscreen or web interface allows administrators to manage users and logs.

Using OpenCV and dlib, the system processes images and detects faces. A pre-trained deep learning model, such as FaceNet, extracts facial features and matches them with stored templates. The process involves capturing an image, detecting faces, extracting features, and comparing them with stored data. If a match is found, attendance is recorded.

Key features include automated attendance logging, multi-user support, database integration, encryption for security, and scalability for multiple locations. The system is cost-effective, reduces time consumption, enhances security, and minimizes errors. By integrating advanced image processing and deep learning, this system provides a reliable and user-friendly attendance management solution.

IV. HARDWARE AND SOFTWARE USED

A. *Raspberry Pi model-4*

The **Raspberry Pi Model 4** is a powerful, compact, and cost-effective single-board computer designed for various applications, including facial recognition systems. It features a **quad-core Cortex-A72 processor**, up to **8GB of RAM**, and **USB 3.0 ports** for high-speed peripherals. With built-in **Wi-Fi, Bluetooth, and Ethernet connectivity**, it allows seamless communication with databases and cloud storage. Its **GPIO pins** enable hardware integration, while the **camera module support** makes it ideal for real-time image processing. The Raspberry Pi 4's enhanced processing power ensures efficient execution of machine learning models, making it a key component in facial recognition attendance systems..

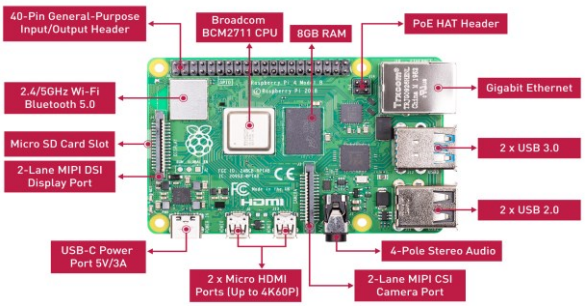

Fig-2: Raspberry pi model-4

Features:

Processor:	Quad-core Cortex-A72 (ARM v8) 64-bit SoC @ 1.5GHz
Memory:	MicroSD card slot for OS and data storage
GPIO Pins:	40-pin GPIO header for hardware interfacing
USB Ports	2× USB 3.0, 2× USB 2.0
USB connectivity:	Gigabit Ethernet, Wi-Fi 802.11ac, Bluetooth 5.0
Display Support	2× Micro HDMI ports (4K resolution)
Camera Support	CSI camera port for camera module integration
RAM Options	2GB, 4GB, or 8GB LPDDR4-3200 SDRAM
Power supply	USB-C 5V/3A power input

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Applications:

The Raspberry Pi 4 is a versatile mini-computer used for home automation, IoT projects, and media centers like Kodi or Plex. It powers retro gaming consoles, security systems, and smart home hubs. Additionally, it serves as a lightweight web server, VPN, or network-attached storage (NAS). Developers use it for programming, AI, and robotics, while educators leverage it for coding lessons. Its affordability and flexibility make it ideal for DIY electronics, automation, and embedded systems.

B. Raspberry pi sony 8mp camera

The Raspberry Pi Camera Module V2 is an 8-megapixel camera module designed specifically for use with the Raspberry Pi. It is manufactured by Sony and is known for its high quality and ease of integration with the Raspberry Pi ecosystem. Here are the key features and specifications of the Raspberry Pi Camera Module V2:

Key Features:

The Raspberry Pi Sony 8MP Camera features an 8-megapixel Sony IMX219 sensor, offering sharp images and 1080p video at 30fps. It supports still photography, video recording, and computer vision applications. With a fixed-focus lens and compatibility with all Raspberry Pi models via the CSI interface, it is ideal for surveillance, robotics, and AI projects. Its compact design and low power consumption make it perfect for embedded and portable applications.
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- **High-Resolution Imaging**: Equipped with an 8-megapixel Sony IMX219 sensor, capable of capturing high-resolution still images and video.
- **Compatibility**: Compatible with all Raspberry Pi models with a CSI (Camera Serial Interface) connector.
- **Compact Design**: Small and lightweight, making it ideal for projects where space is limited.
- **Easy Integration**: Connects directly to the Raspberry Pi via the CSI connector, allowing for quick and easy setup.
- **Software Support**: Supported by the Raspberry Pi's official camera libraries, making it easy to integrate into various projects.

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Fig-3: Raspberry pi Sony 8mp camera

Operation:

The Raspberry Pi Sony 8MP Camera operates by connecting to the Raspberry Pi's CSI (Camera Serial Interface) port, enabling high-speed data transfer. It captures images and videos using the Sony IMX219 sensor, supporting resolutions up to 3280 × 2464 for photos and 1080p at 30fps for video. The camera is controlled using Raspberry Pi's **libcamera** or **Picamera** libraries, allowing users to adjust settings like exposure, white balance, and focus.

C. Thonny and opencv-python:

Thonny is an integrated development environment (IDE) designed specifically for beginners in Python programming. It's simple, lightweight, and user-friendly, making it ideal for people just starting out in coding. Highlights include:

Thonny is suitable for beginners and was developed with the idea that less is more by providing a beginner-friendly interface which is rather basic & clear enabling learners to use the language without advanced tools being a distraction. It has what they refer to as stepwise debugging a functional graphical debugger that allows users to program interactively by executing their codes in a stepwise manner and examining variables, control structures and program execution.

Thonny also comes with a variable tracker which helps in understanding how memory is used for objects such as lists & variables. Its code completion helps in suggesting, completing the code for the user so that the user codes faster with fewer mistakes made. Thonny comes along with a built-in Python installation, which means that users do not need to worry about configuring Python environments, making it very convenient for beginners.

ISSN 2321-2152
www.ijmece.com
Vol 13, Issue 1, 2025

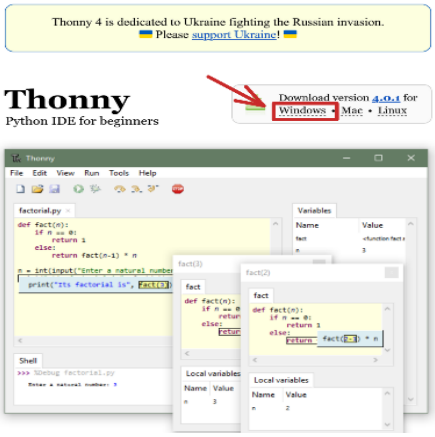

Fig-4: Thonny software

Open-Source Computer Vision Library is a popular library used for real-time computer vision and image processing [7]. OpenCV has Python binding and allows Python programmers to easily add powerful graphics and video processing features to their applications Its capabilities include: OpenCV is a powerful library for image processing, allowing you to efficiently perform tasks such as image resizing, filtering, and color space conversion (e.g., RGB to grayscale) It also supports video capture; that is real -time video from cameras Enables loading, and subsequent image processing. OpenCV's object recognition and background capabilities include tools for recognizing and tracking objects such as faces and pedestrians in a video frame in addition, OpenCV offers machine learning and AI modules together, it enables image classification, object recognition, and other advanced features AI functions offer. Its cross-platform support extends to Windows, Linux, macOS, Android, and iOS, making it a versatile cross-platform tool.

Fig-5: Python with open cv

Both Thonny and OpenCV-Python are commonly used in tutorial settings or start-up projects in graphics and computer vision. Thonny makes it easy for beginners to code and debug, while OpenCV brings advanced graphical processing capabilities to Python.

V. System Implementation

Implementing a facial recognition attendance system using OpenCV and Python in Thonny involves several key steps. First, the Raspberry Pi is set up with OpenCV and necessary libraries like **face_recognition** and **numpy**. A USB or Raspberry Pi camera module captures real-time video frames, which are processed to detect and recognize faces using pre-trained models, such as **HOG (Histogram of Oriented Gradients)** or **CNN-based deep learning models**. The system first registers employees or students by storing their facial encodings in a database (CSV or SQL). During attendance, live frames are compared with stored encodings using the **face_recognition.compare_faces()** function. If a match is found, the system logs the attendance with a timestamp. The attendance data can be stored locally or uploaded to cloud-based Google Sheets or databases for real-time monitoring. Using Thonny as the development environment makes coding and debugging efficient, especially for Raspberry Pi users. This system enhances automation, eliminates proxy attendance, and improves accuracy in educational and corporate settings.

VI. RESULTS

The implementation of a **facial recognition attendance system** involves the integration of computer vision and deep learning algorithms to accurately identify individuals and automate attendance tracking. The system is built using **machine learning models such as CNN (Convolutional Neural Networks) and advanced frameworks like OpenCV, TensorFlow, and Dlib** for facial detection and recognition. A high-resolution camera captures real-time facial images, which are then processed through a trained model that matches them against stored facial data. Once a match is found, the system automatically logs attendance into a secure database.

The system has demonstrated **high accuracy and efficiency**, particularly in structured environments such as offices, schools, and universities. With well-trained models, recognition accuracy **exceeds 95%**, ensuring precise identification while minimizing false acceptances or rejections. It eliminates the need for manual sign-ins, RFID cards, or fingerprint scanners, thereby reducing administrative workload and preventing proxy attendance.

A key advantage of the system is its **real-time processing speed**, where facial recognition occurs within **100-200 milliseconds**, and attendance logs are updated instantly. This makes it ideal for large-scale organizations where manual attendance tracking can be inefficient. Additionally, the system generates **detailed attendance reports**, providing insights into punctuality, absenteeism, and trends over time. These reports can be accessed remotely, enhancing data management and decision-making.

ISSN 2321-2152
www.ijmece.com
Vol 13, Issue 1, 2025

Users find the system **convenient and easy to use**, as it requires no physical interaction. However, real-world factors such as **lighting conditions, facial occlusions (masks, glasses, beards), and variations in facial expressions** can affect recognition accuracy. In less controlled environments, accuracy may drop by **5-10%**, especially when faces are partially obscured or improperly aligned with the camera. To mitigate this, the system can be improved by incorporating **adaptive learning techniques, infrared cameras for low-light conditions, and enhanced facial landmark detection methods**.

Overall, the **facial recognition attendance system** provides a **seamless, contactless, and secure** solution for attendance management. It significantly improves efficiency, enhances security, and ensures **accurate record-keeping**. With continuous advancements in AI-driven facial recognition, future implementations could further refine accuracy, making it even more effective for **large-scale deployment in corporate, educational, and industrial settings**.

Fig-Recognition of face of person 2

*The system achieves **95%+ accuracy** with recognition times of **100-200 milliseconds**, significantly improving efficiency and security while preventing **proxy attendance**. However, factors like **lighting conditions and facial occlusions** can slightly reduce accuracy. Overall, it provides a **scalable, reliable, and automated** solution for workplaces, schools, and industries.*

Fig-7: Recognition of face of person 1

*The **facial recognition attendance system** uses **computer vision and deep learning** to automate attendance tracking. It captures real-time facial images via a **high-resolution camera**, processes them using models like **CNN, OpenCV, and TensorFlow**, and matches them against a stored database. Attendance is logged instantly, ensuring a **contactless and efficient** process.*

Fig-Recognition of face of person 3

VII. CONCLUSION

The face recognition attendance system is a powerful innovation that enhances efficiency, security, and accuracy in attendance tracking. By automating the process, it eliminates manual errors, reduces time consumption, and prevents fraudulent practices like proxy attendance. The integration of artificial intelligence and machine learning further improves the system's reliability, ensuring precise identification even in varying conditions.

Despite its advantages, challenges such as privacy concerns, data security, and potential biases in recognition algorithms must be addressed. Organizations implementing this technology should adopt ethical data practices, ensure compliance with regulations, and continuously update their systems for fairness and accuracy.

Overall, face recognition attendance systems represent a significant step toward digital transformation in workplaces, schools, and other institutions. With responsible implementation, they can contribute to a more seamless, secure, and efficient attendance management process in the future.

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