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PROTOTYPING OF CLASS-ATTENDANCE SYSTEM USING SMART CARD AND RASPBERRY

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ABSTRACT

This study presents a novel automatic class attendance system utilizing biometric facial recognition based on a Raspberry Pi and a camera module. The detection algorithm operates by analyzing several facial features, including the distance between the eyes, forehead to chin distance, nose to mouth distance, eye socket depth, cheekbone shape, and lip, ear, and chin contours. The system follows a four-step process: capturing and scanning, extracting features, comparing, and matching the captured images. Designed for real-time recognition, this system automates the attendance tracking process, replacing traditional manual methods. Leveraging the Raspberry Pi 3 Model B+ microprocessor and open-source Python libraries, particularly OpenCV, the facial recognition algorithm efficiently records attendance. The system demonstrates exceptional performance, achieving a 100% accuracy rate with a detection time of just 1 second. It is capable of capturing a student's face from a distance of 1.25 cm and can recognize faces at orientations of 0° and 45°. With its rapid and reliable performance, this facial recognition system is highly suitable for integration into various applications.

Keywords:Face Recognition, Raspberry Pi, Authentication, Automatic, Database, OpenCV.

I.INTRODUCTION

Verification has become a critical task in the information technology era, with face recognition technology emerging as a popular method for authentication. Biometric recognition systems have gained significant traction, leading to substantial advancements in technology [1, 2]. Four decades ago, face recognition was regarded as one of the most challenging domains in artificial intelligence [3, 4]. Traditional attendance verification methods are time-consuming and can be easily manipulated, as paper attendance sheets are prone to misuse [5, 6]. In contrast, smart attendance systems utilizing real-time face recognition provide an effective solution for tracking students' attendance. Conventional sign-up methods are often slow and inconsistent, as they rely on students signing in for absent classmates. A person's face serves as their true identity [7, 8], making facial recognition one of the most accurate identification systems available. This technology has potential applications across educational institutions, hospitals, and corporate environments, representing a significant breakthrough in image processing [9, 10]. Authentication remains a key challenge in computer-based communication, with face recognition widely employed in applications such as system security and access control [11, 12]. G. Krishnan et al. [13] proposed an

attendance system that leverages face recognition using the principal component analysis (PCA) algorithm, allowing for automatic face recognition and database logging of attendance. Similarly, A. Jha [14] designed a student identification system that utilized face recognition during lectures, with a teaching assistant managing attendance through an automated MATLAB implementation.

M. Muqeet [15] contributed to this field by proposing a Raspberry Pi-based attendance management system that used a webcam to capture students' faces. The system recorded images and employed various face extraction stages via OpenCV, achieving a 92% accuracy rate.

Recent advancements include M. Arsenovic et al. [16], who developed a deep learning-based attendance system using convolutional neural networks (CNNs) for face detection and embedding generation. Their system demonstrated a 95.02% accuracy rate in real-time settings with original face image datasets.

Recording attendance manually poses a significant burden on educators [17, 18]. Thus, implementing a smart attendance management system in classrooms is imperative. The primary contribution of this study is the design and development of an automatic class attendance system utilizing biometric facial recognition, powered by the Raspberry Pi 3 Model B+ and Python. This system integrates the OpenCV library and a camera module for effective facial detection and recognition. It is designed to operate effectively regardless of external conditions such as lighting, facial expressions, or background noise.

The proposed system focuses on distinct facial features—such as the eyes, ears, nose, and overall facial contours—enhancing accuracy. The facial landmark detection algorithm calculates various measurements, including the distance between the eyes, forehead to chin distance, nose to mouth distance, eye socket depth, and cheekbone shape. Ultimately, this study presents a novel approach to attendance management, aimed at reducing issues related to plagiarism and proxy attendance in educational settings.

III.METHODOLOGY AND ALGORITHM

The proposed system employs facial detection and recognition technology to automate the process of recording students' attendance in classrooms or meeting halls, eliminating the need for human intervention. This approach is grounded in the analysis of facial features, particularly focusing on geometric relationships, such as the positioning of the eyes, nostrils, and other facial landmarks, to accurately locate and identify faces.

The operational flow of the attendance system consists of several key steps. Initially, the Python script is activated, prompting a message on an LCD screen to indicate that attendance data will be saved. The Raspberry Pi serves as the microprocessor for the system, utilizing open-source libraries, including OpenCV, in conjunction with a camera module. Attendance data is stored on a 32 GB memory card attached to the Raspberry Pi.

The facial recognition process begins with the camera capturing images of all

registered students, which are then stored in a database. When a student enters the classroom, the system recognizes the individual and records their attendance, simultaneously displaying their information on the LCD screen. The facial recognition system first detects the eyes, followed by the eyebrows, nose, mouth, and ears. It maps and analyzes the facial geometry and expressions, identifying key landmarks crucial for distinguishing one face from another. The recognition algorithm calculates various distances, such as between the eyes, from the forehead to the chin, and other facial features. This data is then converted into a unique identifier, often referred to as a "faceprint," which functions similarly to a fingerprint. Lighting conditions significantly affect facial recognition accuracy. The system is designed to perform well in various environments, as it does not rely on a static background. However, optimal lighting conditions enhance performance.

In summary, the facial recognition process consists of four main steps:
1. Capturing and Scanning: The camera captures the image of the student.
2. Extracting: Unique biometric data is extracted from the image.
3. Comparing: The extracted data is compared with the database entries.
4. Matching: The system determines whether there is a match between the captured image and stored images.

IV.HARDWARE COMPONENTS

The core objective of this project is to develop an automatic class attendance system utilizing biometric facial recognition based on the Raspberry Pi platform. The primary hardware components include the Raspberry Pi 3 Model B+ and a camera module.

Raspberry Pi 3 Model B+: This low-cost, credit card-sized computer is equipped with a 1.4 GHz microprocessor and supports dual-band Wi-Fi and gigabit Ethernet. It is ideal for various applications, including IoT projects.

Camera Module: The Raspberry Pi Camera Module v1.3 is specifically designed for the Raspberry Pi. It features a 5 MP sensor capable of capturing high-resolution images. The compact size makes it suitable for applications where space is a constraint.

V.SOFTWARE COMPONENTS

Raspbian Operating System: This open-source operating system, optimized for Raspberry Pi hardware, provides a wide range of pre-compiled software packages for easy setup and use.

OpenCV: The Open Source Computer Vision Library is crucial for image processing tasks. It contains numerous algorithms suitable for face detection and recognition, and supports multiple programming languages, including Python.

Python: This versatile programming language is employed for developing the system's code. Its simplicity and efficiency make it suitable for rapid application development and scripting.

VI. EXPERIMENTAL PERFORMANCE AND RESULTS

The developed system was tested with a local database to capture and recognize students' faces using the Raspberry Pi camera module. The system effectively identifies students, displaying relevant information on the LCD screen. The facial recognition technology proved capable of handling variations in size, expression, lighting, and orientation, making it adaptable to different backgrounds without significant loss of performance.

The system operates seamlessly, with attendance being recorded in real time. The recognition process is highly efficient, taking approximately one second to complete. Extensive testing at various distances and angles confirmed that the system maintains accuracy, although recognition diminishes when faces are at extreme angles.

VII.CONCLUSION

This research successfully demonstrates a novel automatic class attendance system utilizing biometric facial recognition technology based on the Raspberry Pi 3 Model B+. The system operates effectively under varying conditions and provides a high level of accuracy, making it suitable for implementation in educational institutions and other settings requiring reliable attendance tracking. By automating the attendance process, the system not only saves time but also enhances the security and organization of attendance data. The findings suggest that this technology could be beneficial across various sectors, including universities, schools, and businesses.

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