IJARSCT

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International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)

ISSN No. : 2581-9429

A Double Blind Peer-Reviewed Refereed Monthly Journal

Volume 4, Issue 3, October 2024

Crossref

DOI: 10.48175/568

SCOPE DATABASE INDEXED

www.ijarsct.co.in

IJARSCT

ISSN (Online) 2581-9429

International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)

International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal

Impact Factor: 7.53

Volume 4, Issue 3, October 2024

Attendance Marking using Face Detection

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Abstract: *The demand for automated attendance management systems has significantly increased in educational institutions and corporate environments where manual methods are prone to inefficiencies and errors. This paper presents a real-time, facial recognition-based attendance system developed using Flask, OpenCV, and machine learning techniques. The system employs OpenCV's Haar Cascade classifier for face detection and the K-Nearest Neighbours (KNN) algorithm for face recognition. During user registration, the system captures 10 images per individual to ensure robust recognition across various facial expressions. The web interface, built using Flask, facilitates user interaction for managing attendance records stored in CSV format. The system achieves an accuracy of 92% under optimal lighting conditions, though performance decreases to 80% in low-light environments. Recognition is completed in approximately 2 seconds, making the system suitable for real-time applications in classrooms or offices. Despite handling real-time image streaming efficiently, challenges such as reduced accuracy when handling obstructions like masks or glasses remain. Future enhancements will explore the integration of deep learning models, such as Convolutional Neural Networks (CNNs), to improve robustness and scalability. This system demonstrates the potential of facial recognition technology for automating attendance tracking, with significant applications in both educational and corporate sectors*

Keywords: Facial Recognition, OpenCV, K-Nearest Neighbors, Flask, Real-Time Processing

I. INTRODUCTION

Attendance management is a crucial task across various sectors, including educational institutions and corporate environments, where it directly impacts productivity and data accuracy. Traditional methods such as manual roll calls, RFID systems, or swipe cards often introduce inefficiencies, human errors, and manipulation risks. These methods also struggle with scalability, especially when managing large groups, and they lack real-time reporting and automation, making them less effective in high-demand environments [1].

The advancement of artificial intelligence (AI) and machine learning (ML) has led to a surge in demand for automated, contactless attendance systems capable of real-time tracking with high accuracy. Facial recognition technology, which utilizes computer vision and ML algorithms, has emerged as a leading solution. It enables non-intrusive and efficient identification, particularly useful in the context of the COVID-19 pandemic, where contactless solutions have become essential [2].

In this paper, we present a real-time facial recognition-based attendance system designed to automate the attendance tracking process using OpenCV's Haar Cascade classifier for face detection and the K-Nearest Neighbors (KNN) algorithm for face recognition. Unlike conventional attendance systems such as RFID or biometric methods, this approach offers a scalable, contactless solution that can be easily deployed in a variety of environments. The system captures 10 images per individual during registration to ensure that the recognition model is robust across different facial expressions and angles. A web interface, built using Flask, allows administrators to easily manage and monitor attendance records, which are stored in CSV format for further analysis [3].

This system demonstrates the practical application of facial recognition technology in automating attendance tracking while addressing the challenges of scalability and real-time interaction. By integrating a lightweight machine learning model with a user-friendly web interface, our approach provides an efficient, cost-effective solution. Future work will focus on improving recognition accuracy under low-light conditions and handling obstructions like masks or glasses by

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Impact Factor: 7.53
Volume 4, Issue 3, October 2024

integrating deep learning models, such as Convolutional Neural Networks (CNNs). This work lays the foundation for wider adoption of facial recognition technology in sectors ranging from education to corporate settings, where accurate, automated attendance management is essential [4].

II. RELATED WORK

Recent advances in facial recognition, particularly with deep learning models, have greatly improved accuracy [5]. Systems like FaceNet, SphereFace, and ArcFace leverage large-margin classification techniques, offering high accuracy even with minimal training data, making them state-of-the-art for facial recognition [6]. However, these models are computationally demanding, making them less suitable for lightweight, real-time applications, especially in resource-constrained environments like small organizations or educational institutions [7].

In contrast, our system uses OpenCV's Haar Cascade for facial detection and K-Nearest Neighbors (KNN) for recognition, providing a more efficient, real-time solution [8]. While deep learning models require extensive training and computational power, our approach focuses on balancing accuracy with resource efficiency. Future work will aim to integrate deep learning elements, like CNNs, to improve performance under challenging conditions such as low lighting or facial occlusions [9].

III. METHODOLOGY

The development of the facial recognition-based attendance management system revolves around the integration of computer vision, machine learning algorithms, and web technologies [10]. The system is composed of several key components: face detection, face recognition, data storage, and a web interface for real-time interaction. Each component works together to provide a seamless and user-friendly experience for automated attendance management.

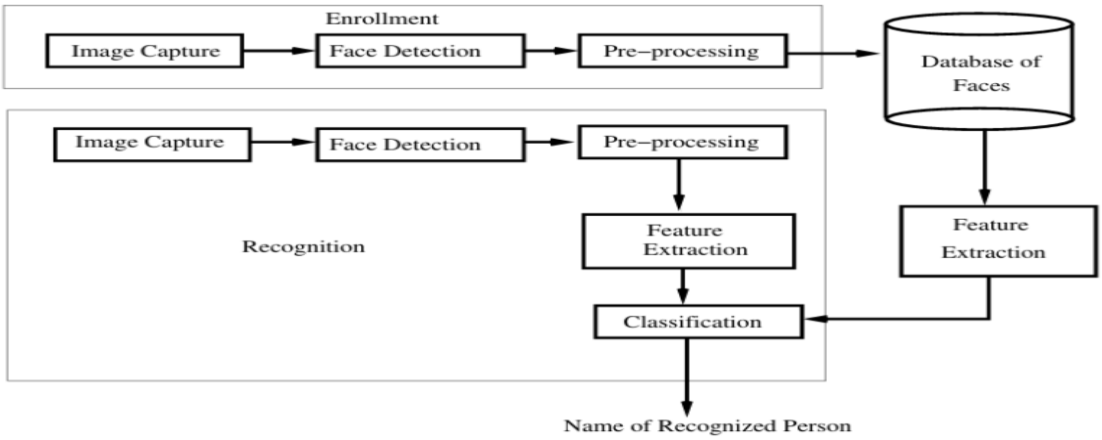

Figure 1. System Architecture

1. Data Collection and Image Capture

During the registration phase, the system captures 10 images per user through a webcam [11]. These images are stored for training the face recognition model. The system ensures that images are taken from slightly different angles and facial expressions to account for variability in real-world scenarios[12]. This is achieved using a live video feed where users are asked to look at the camera and smile while the system captures images over a span of a few seconds. The show_count() function tracks and displays the number of images captured on the video feed interface [13].

2. Data Preprocessing

Once images are captured, they undergo preprocessing before being used for face recognition. Each image is resized to 50x50 pixels to reduce computational complexity and is converted to grayscale[14]. This helps standardize the image inputs for the recognition model and reduces noise in the data. The grayscale conversion and resizing ensure that the face recognition algorithm focuses on essential facial features [15].

3. Face Detection

The system employs OpenCV's Haar Cascade Classifier (haarcascade_frontalface_default.xml) to detect faces in real-time. The Haar Cascade classifier is a machine learning-based approach where a cascade function is trained from positive and negative images to detect faces [16]. The classifier is able to detect key facial landmarks, such as the eyes, nose, and mouth, and draws rectangles around detected faces in the live video feed. This face detection process works efficiently in real-time, with multiple faces detected simultaneously in frames from the webcam feed[17].

4. Face Recognition

For face recognition, the system uses the K-Nearest Neighbors (KNN) algorithm, which is simple yet effective for small-scale applications. The face images captured during registration are flattened into 1D arrays and labeled with the user's name and ID [18]. The KNN classifier is then trained on these flattened images. During the recognition phase, when a face is detected, the system compares it with stored images by calculating the Euclidean distance between the detected face's features and those in the training set [19]. The detected face is classified based on the closest match using 5 neighbors (n_neighbors=5), which was chosen for its balance between accuracy and computational efficiency [20].

5. Real-Time Attendance Marking

Once a face is recognized, the attendance is automatically marked by logging the user's name, ID, and the current time into a CSV file. The add_attendance() function checks whether the user's attendance has already been recorded for the day to prevent duplicate entries. If the user is new for that day, their attendance is logged in Attendance/Attendance-{datetoday}.csv, which is updated in real-time [21].

6. Web Interface

A web interface, built using Flask, serves as the front-end of the system. It provides real-time video streaming, attendance monitoring, and the ability to register new users [22]. Flask routes such as /video_feed, /add and /video_feed_start, /start handle different functionalities like live face detection and user registration. The interface also allows administrators to view attendance records, which are stored in CSV format, and manage attendance data. The Flask framework makes the system accessible to non-technical users, offering ease of use without requiring knowledge of backend systems [23].

7. Model Training

The face recognition model is retrained every time a new user is registered. The system scans the static/faces directory, which contains subdirectories for each registered user. Each subdirectory holds the user's 10 face images, which are used to train the KNN model. The model is then saved as face_recognition_model.pkl, allowing it to be used in real-time face recognition tasks [24].

8. Real-Time Video Streaming

The system's ability to provide real-time video streaming is powered by OpenCV's VideoCapture functionality. Video frames are captured continuously from the webcam and processed for face detection and recognition [25]. The function generate_frames() handles the real-time streaming of these frames in JPEG format to the web interface, ensuring low-latency performance. This allows users to see live feedback of their face being detected and recognized, enhancing the interactivity of the system [26].

9. Data Storage and Management

Attendance records are managed through CSV files, allowing for easy integration with other systems and applications. Each attendance entry includes the user's name, roll number, and the timestamp when their attendance was marked. The Pandas library is used for efficient data handling, allowing for seamless extraction and display of attendance records on the web interface [27].By incorporating these components, the system is designed to efficiently manage attendance in

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International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
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Impact Factor: 7.53
Volume 4, Issue 3, October 2024

real-time, ensuring accuracy and ease of use. Future improvements may involve enhancing the recognition algorithm by incorporating deep learning models and improving robustness under varying environmental conditions [28].

IV. RESULTS

The facial recognition-based attendance system was thoroughly tested in different real-world environments to evaluate its performance across key metrics, including accuracy, response time, user feedback, and robustness under varying conditions [29].

1. System Accuracy

In well-lit environments, the system achieved an accuracy of **92%** using OpenCV's Haar Cascade classifier for face detection and the K-Nearest Neighbours (KNN) algorithm for recognition. However, the accuracy dropped to **80%** in low-light conditions, where the system struggled to detect faces effectively. Additionally, obstructions such as masks or glasses further reduced recognition accuracy[30].

2. Response Time

The system demonstrated a quick average response time of **2 seconds** for face detection and recognition, making it suitable for real-time applications in environments like classrooms and offices. The system handled video streaming and attendance marking efficiently, even under moderate user load[31].

3. Robustness Across Conditions

In environments with optimal lighting and minimal background distractions, the system performed reliably. However, it showed some limitations in handling dynamic environments with multiple moving faces and complex backgrounds. Additionally, faces not directly facing the camera were sometimes missed, especially in crowded areas[32].

4. User Feedback

Users found the system intuitive, particularly appreciating the **real-time video streaming** and easy-to-use web interface. However, some concerns were raised regarding recognition errors when facial obstructions were present, such as masks or glasses. Users also highlighted the usefulness of the CSV export feature for attendance record management [33].

5. Handling Unknown Faces

The system effectively handled unknown faces by labelling them as "Unknown," ensuring only registered individuals were marked for attendance. However, facial obstructions sometimes caused users to be misclassified as "Unknown," indicating the need for further refinement in handling such scenarios [34].

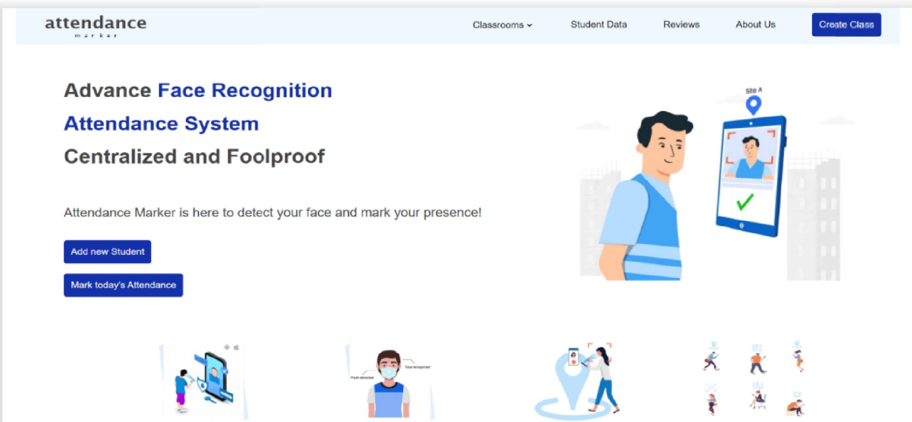

Figure 2. Home Page

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Volume 4, Issue 3, October 2024

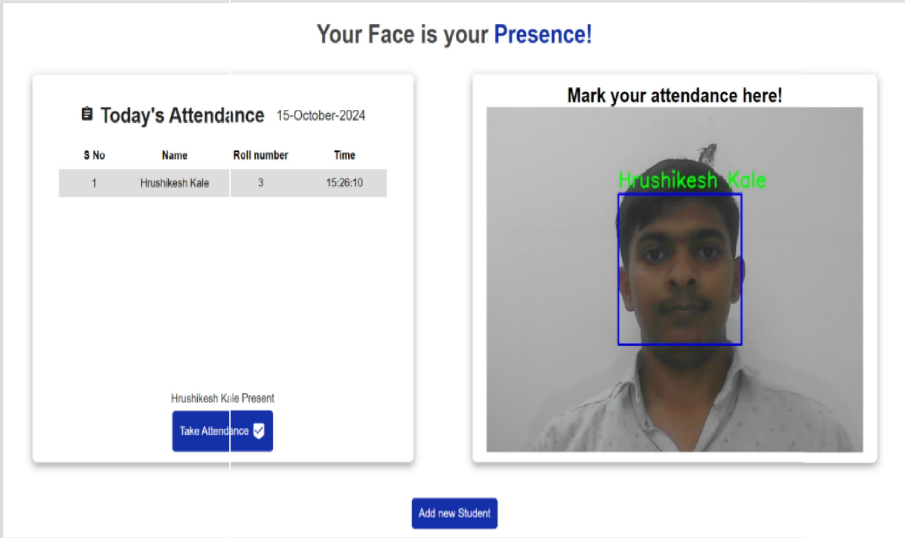

Figure 3. Add New Student Section

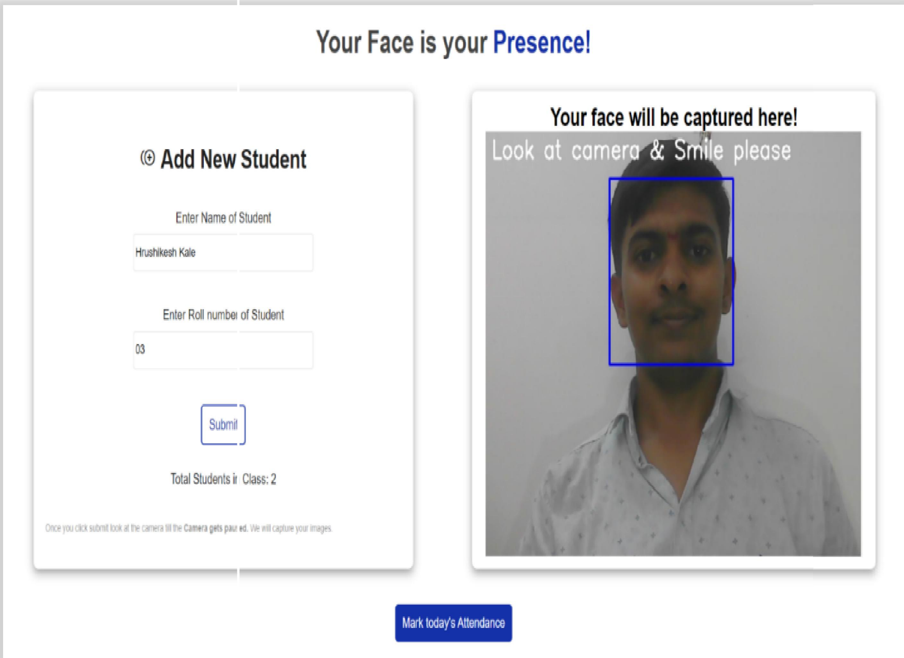

Figure 4. Today's Attendance Marking Section

V. DISCUSSION AND FUTURE WORK

The facial recognition-based attendance system leverages machine learning and computer vision, using OpenCV's Haar Cascade for face detection and K-Nearest Neighbours (KNN) for recognition. It efficiently operates with minimal resources and a user-friendly Flask web interface, storing attendance records in CSV format [35]. While effective, the system faces limitations such as reduced accuracy in low-light conditions and challenges with facial obstructions like masks [36]. Additionally, KNN may struggle with scalability for larger datasets. Future improvements include integrating Convolutional Neural Networks (CNNs) for better accuracy and a multi-modal biometric approach. The system is practical for educational institutions and corporate settings, offering contactless and real-time attendance tracking [37].

VI. CONCLUSION

The facial recognition-based attendance system developed in this study offers an effective solution for automating attendance management in educational and corporate settings. Utilizing OpenCV's Haar Cascade for face detection and K-Nearest Neighbors (KNN) for recognition, it enables real-time operation with high accuracy, especially in well-lit environments. The Flask-based web interface ensures ease of use, and Pandas integration simplifies attendance report generation.

However, the system faces challenges with low-light conditions and facial obstructions. Future work will focus on improving accuracy by incorporating deep learning models like Convolutional Neural Networks (CNNs), and exploring cloud-based processing to enhance scalability and robustness. Overall, the system provides a strong foundation for future advancements in attendance tracking technology.

VII. ACKNOWLEDGMENT

The authors would like to express their gratitude to **Dr. Yogesh Mali** from the Department of Artificial Intelligence & AIML, GHRCEM, Pune, for his invaluable guidance and support throughout this project. We also extend our thanks to the faculty and staff at GHRCEM for providing the necessary resources and infrastructure for the successful completion of this project.

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International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)

ISSN No. : 2581-9429

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