WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Face Recognition Based Smart Attendance Management System For Smes Using Haar Cascade Algorithm

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A B S T R A C T :

This paper is about to streamline and modernize the traditional manual attendance tracking method, which is both time-consuming and challenging to maintain. The proposed system leverages advanced biometric technology, particularly Face Recognition algorithms. Human faces serve as the primary dataset for training using OpenCV, employing the LBPH Face Recognizer. It uses machine learning techniques to detect and recognize faces in real-time. Haar Cascade, a pre-trained classifier, is used for efficient face detection, while LBPH, a texture-based algorithm, is employed for robust face recognition. It captures facial images, trains the LBPH model on a dataset of known individuals, and matches detected faces with the trained model to identify users. The user interface is developed through the Flask framework, providing a user-friendly web page.

Keywords: Biometric Technology, Face Recognition, OpenCV, Haar Cascade Classifier, LBPH model and Flask framework,

Introduction

In educational institutions or Small and Medium Enterprises(SME's), managing attendance is a crucial but often cumbersome task. Traditional manual methods of attendance tracking are not only time-consuming but also prone to errors and inaccuracies. This inefficiency not only affects administrative tasks but also hampers the ability to monitor student punctuality and performance. The Face Recognition based smart attendance management system for SME's Using Haar Cascade Algorithm aims to address these challenges by introducing a cutting-edge solution based on Machine Learning-based Face Recognition technology[1]. The system replaces manual attendance recording with a more efficient, automated process where students mark their attendance using facial recognition. The face recognition algorithm ensures accuracy and prevents proxy attendance, a common issue with traditional methods.

By integrating LBPH (Local Binary Pattern Histogram) Face Recognizer[2] the system learns and identifies student faces, offering seamless and error-free attendance tracking. This is divided into two main modules, the Admin Module and the Student Module. The Admin Module enables administrators to upload and manage student data, track attendance patterns, generate reports, and send automated notifications to parents regarding their child's attendance status and academic performance[3]. The Student Module allows students to mark attendance via facial recognition, view their profile, and download their marks[4]. In addition to enhancing attendance management, the system features real-time notifications to parents through Mail using SMTP library, ensuring improved communication between educational institutions and parents. This fosters greater parental involvement in a child's education, creating a more engaged and supportive learning environment.

The Haar Cascade is an object detection algorithm of high strength mostly employed in detecting faces within images and video streams[5]. The technique is built around the employment of Haar-like features, or rectangular features used to describe intensity differences among neighborhoods in an image. An integral image is utilized by the algorithm to support quick calculation of features to perform quickly calculable summation operations on rectangular windows. A collection of poor classifiers, each relying on one Haar-like feature, are combined to create a strong classifier via weighted voting. The resulting strong classifier is in a cascade structure, where various stages progressively eliminate non-object areas, allowing for efficient detection. As an object goes through each stage of the cascade, it is either classified as possible or rejected, which drastically minimizes the workload. The LBPH is a face recognition model used for processing facial images consistently under all lighting conditions, it first converts them to grayscale[6]. The Local Binary Pattern (LBP) operator, which generates a binary representation of the pixel values in each region, is applied after the image has been divided into small regions. This is the fundamental step in the LBPH method. After that, these binary patterns are transformed into histograms, which show how local features are distributed throughout the picture. The LBPH model can successfully identify faces under a variety of circumstances by comparing these histograms using distance metrics.

Methodology

To overcome the manual attendance tracking and reducing the errors, proxy in the attendance we use Face Recognition Based Smart Attendance Management System for SMEs i.e for schools, classrooms etc., that utilizes the Haar Cascade algorithm for face detection and the Local Binary Pattern Histogram (LBPH) for face recognition to automate attendance tracking. The system begins with data collection, capturing multiple face images of employees under different conditions, which are then pre-processed by converting them to grayscale, resizing, and applying histogram equalization (Fig 1). Using Haar Cascade, the system detects faces in real time from a live video stream, extracts the Region of Interest (ROI)[7], and passes it to the LBPH model for recognition. The LBPH algorithm encodes facial features, computes histograms, and matches them with stored employee images in the database. If a match is found with a confidence score above the threshold, the system automatically marks attendance, storing the employee's ID, name, date, and time in an MySQL database.

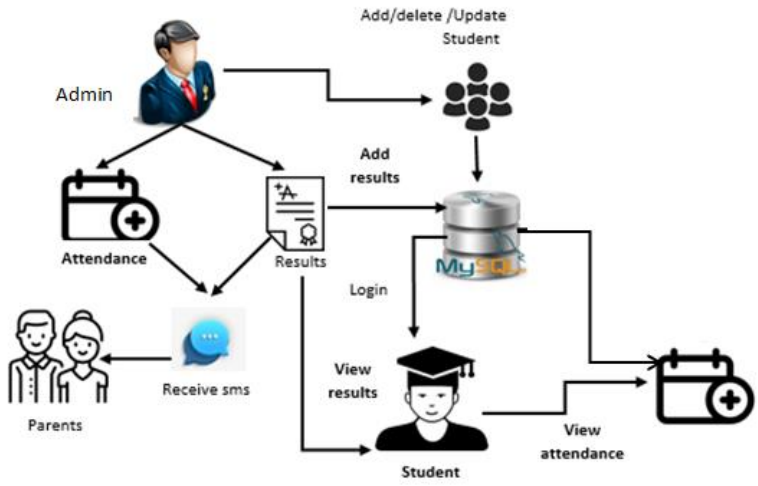

Fig. 1- Architecture of system

The Feature Extraction & Face Recognition process consists of two stages: Training and Recognition. During training, the LBPH (Local Binary Patterns Histogram) model trains on detected face images, mapping their patterns into histograms and storing facial features into a trained model file[8]. When recognizing, the system matches new face data with stored features, calculates similarity scores, and detects individuals. When a face is identified, the system proceeds to Attendance Logging, wherein it cross-matches the identified face with staff records, logs the Name, Date, and Time, and updates the status of attendance in the database (Fig 2).

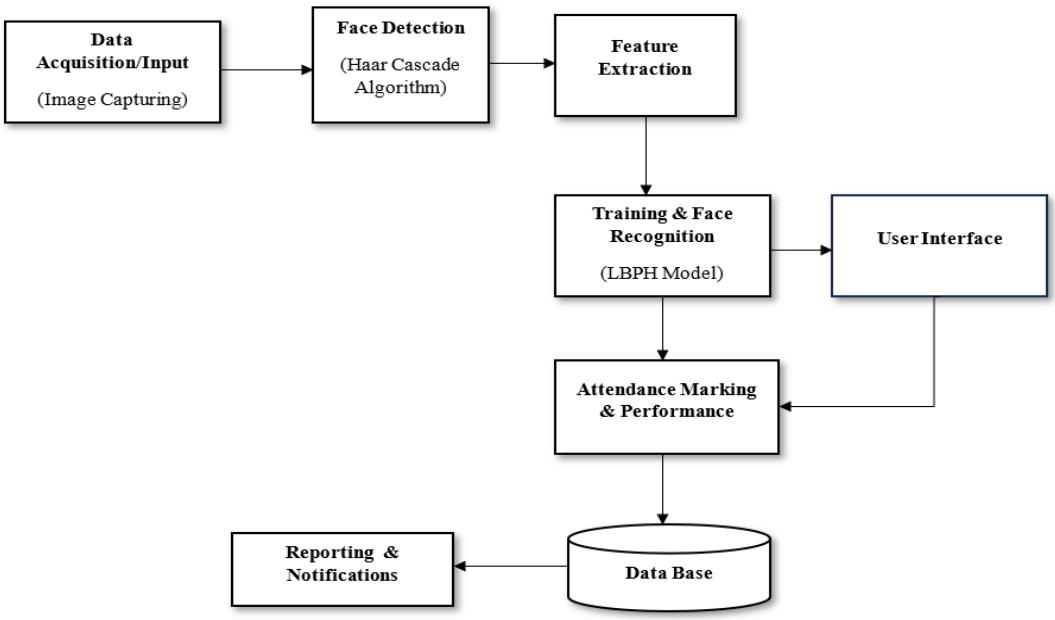

Fig. 2- Architecture of Methodology

Evaluation Metrics

3.1 Haar Cascade Algorithm:

For evaluating the performance of Haar Cascade Algorithm used in face detection, several key metrics are commonly employed. These metrics help determine how effectively the model/Algorithm can detect the faces from an image.

$$Accuracy = \frac{TP+TN}{TP+TN+EF+FN} \quad (1)$$

$$Precision(P) = \frac{TP}{TP+EP} \quad (2)$$

$$Recall\ (R) = \frac{TP}{TP+FN} \quad (3)$$

$$Intersection\ over\ Union(IoU) = \frac{Area\ of\ Overlap}{Area\ of\ Union} \quad (4)$$

3.2 LBPH Model:

Since LBPH is a Face Recognition model used to recognize faces, its performance is measured based on how well it correctly classifies faces.

$$Accuracy = \frac{Total\ Predictions}{Correct\ Predictions} \quad (5)$$

$$Euclidean\ Distance = \sqrt{\sum(Xi - Yi)2} \quad (6)$$

Results & Analysis

The input is given by the admin through camera i.e OpenCV, after entering the details of one person the capturing gets started. It detect the faces using bounding box for the face inside the image (Fig. 3).

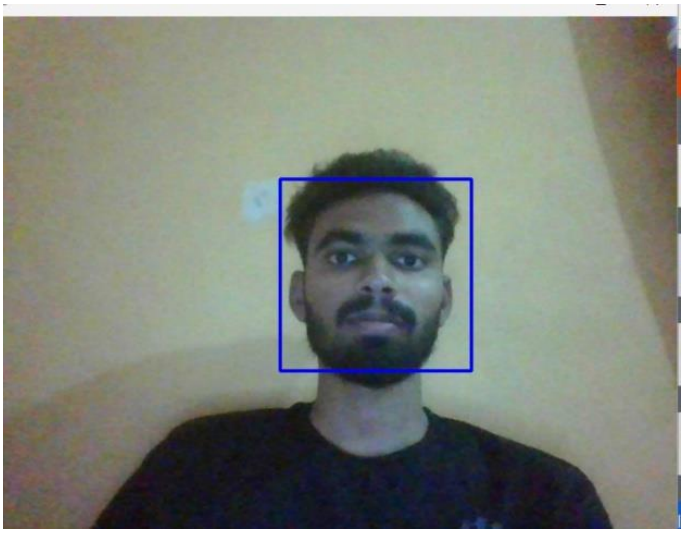

Fig. 3- Face Detection Using Bounding Box After User Detail Entry via OpenCV Camera Input

The images are captured in multiple frames with average rate i.e,(~50ms per frames), this detects the face form the images and detect the faces with multiple expressions using multiple frames. These frames follows a sequence numbers and it gives identical value for each frame. It captures multipule frames until the admin click the capture button. After completion the data is stored into a database (Fig. 4).

Fig. 4- Multi-Frame Face Detection with Sequential Numbering and Expression Capture Using OpenCV

The data is trained by using the collected dataset as input and LBPH model extract the features and these extracted features are compered by analyzing the histogram patterns for face recognition (Fig. 5).

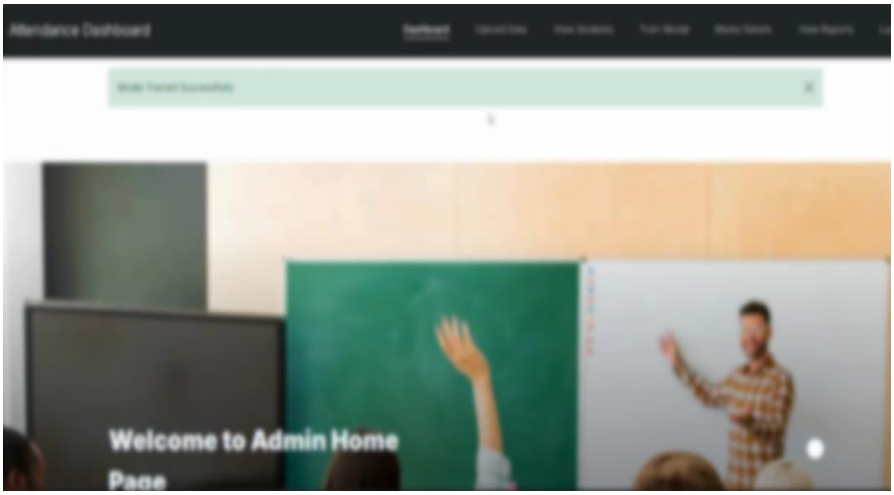

Fig. 5- Feature Extraction and Face Recognition Using LBPH Model Based on Histogram Pattern Analysis

Conclusion & Future Work

The Haar Cascade and LBPH-based Face Recognition-Based Smart Attendance Management System is a convenient and effective solution for automated tracking of attendance for SMEs i.e marking Student's attendance. Through the synthesis of Haar Cascade's real-time detection capacity and LBPH's accurate recognition potential, the system offers effective results while being computationally efficient. The method removes the flaws of manual attendance marking for students, limiting errors and suppressing fraudulent activities. The contactless functionality provides convenience and encourages hygiene in the workplace.

We developed a model that which is able to accept the attendance of student in the given times by the face recognition if student is not recognized I the given attendance taken time they will be allotted attendance as late coming. We have implemented Flask Framework, where student details are stored and a model is trained and then the student picture is taken which is tested and attendance is marked to the student by the captured face image. The admin can be able to manage and maintain the database, as we also added some special features like adding marks of a student, notifications through mails.

In the future, we can also implement this idea and can apply in different fields, like corporate offices, and in many work places. We can also integrate AI into the system and can be developed as an mobile application which can be easy to consider the attendance of a person with a lesser time.

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