FACIAL RECOGNITION-BASED ATTENDANCE MANAGEMENT USING HAAR CASCADE AND LBPH

Abstract

This chapter explores the ideation, development, implementation and evaluation of a Facial Recognition based Attendance System. In the rapidly evolving technological era, the automation of mundane tasks carried about in traditional ways helps transcend the many inefficiencies of human involvement, including repetitive time-consuming workloads and errors. In this chapter, we delve into the integration of facial recognition technology to revolutionise the way attendance is managed. The findings of this research will provide insights into the potential impact of using face recognition technology for attendance tracking and contribute to the existing body of research on biometric attendance. Overall, this chapter seeks to contribute to the field of attendance management systems and highlight the potential benefits of using face recognition technology, along with providing insights into how this system can be optimised for use in various settings, such as educational institutions, workplaces, and public spaces.

Keywords: Machine learning, Attendance management, Face Recognition, Decision trees, Biometric attendance, Haar Cascades, Face Detection, LBPH, Feature selection.

Authors

Gayathri G L
SSN College of Engineering
Tamil Nadu, India

Vallidevi Krishnamurthy
Vellore Institute of Technology
Chennai, Tamil Nadu, India

Kshitij Srivastava
Vellore Institute of Technology
Chennai, Tamil Nadu, India

I. INTRODUCTION

Maintaining a good level of attendance is a crucial and fundamental aspect of not only within the academic system but also in major corporate institutions. Extensive research has revealed that absenteeism can exert a direct and significant impact on scoring on academic performance, as evidenced by its correlation with achievement test scores [1]. The significance of absenteeism also has far reaching implications in the corporate sector, since it can be indicative of the general job satisfaction levels within the organisation [2]. Furthermore, it is accentuated by its far-reaching ramifications on employee productivity and overall organisational efficiency [3]. Consequently, this field warrants further research in pursuit of innovative methodologies to ensure optimal tracking and management.

This domain of attendance management has witnessed significant advancements in recent years, showcasing the potential of face recognition technology as a promising solution that uses each individual's unique biometric data to identify them. This option has become increasingly attractive due to its non-intrusive nature and inherent accuracy. The chapter at hand embarks on a comprehensive exploration of the Facial Recognition based Attendance System, delving into its multifaceted aspects and profound implications in the realm of educational institutions.

One of the central objectives of this chapter is to rigorously evaluate the accuracy and efficiency of facial recognition technology in comparison to traditional paper-based attendance tracking methods prevalent in today's educational landscape. The intricate interplay between biometric data analysis and attendance management is meticulously examined to uncover the potential advantages and limitations of this modern approach. Through a comparative analysis, the chapter endeavours to shed light on the superior precision and streamlined process offered by facial recognition technology, completely influencing the landscape of attendance management in educational institutions.

In essence, this chapter will explore the benefits of this system, including its ability to accurately and efficiently manage attendance records. The rest of this chapter is organised as follows: Section II presents the problem statement, whereas Section III outlines the motivation. Following that, Section IV presents the Literature Review, Section V talks about the methodology employed and Section VI describes the results achieved. Finally, Section VII holds the conclusion.

II. PROBLEM STATEMENT

In recent years, the use of technology has significantly impacted various aspects of our lives, including attendance management. Moreover, existing traditional attendance management systems incorporate manual entry, such as punchlocks or a book-based system, which have their own share of disadvantages that come along with them. For starters, there is always the possibility for inadvertent human error to occur. Additionally, these methods are often time consuming and resource-intensive, taking away the focus from more critical tasks. Moreover, the lack of any verification mechanism raises concerns regarding the integrity of data and the potential for unauthorised manipulation of records. This is precisely why there is a pressing need for an efficient system that can address all these issues by incorporating advanced technology to automate the process of attendance tracking.

III. MOTIVATION

In response, modern attendance management systems that employ cutting-edge technology, such as face recognition algorithms to improve accuracy and efficiency have been developed. The Attendance Management System using Facial Recognition technology is one such real-world system that can be used. This automated system ensures precision, security and reliability, while revolutionizing the process essential for various educational institutions and organisations.

IV. LITERATURE REVIEW

Attendance management systems using face recognition have gained significant attention in recent years due to their ability to automate the attendance taking process while also improving security measures. Several research papers have been published on this topic, outlining the design, implementation, and performance of such systems.

Dang, Thai-Viet [4] outlines an approach to building a facial recognition based attendance system using FaceNet model, a deep Convolutional neural network based on the MobileNetV2 architecture having an additional Single-Shot multibox Detection subsection. This system has a two-step process, with the first step involving user login and the second step involving facial detection and recognition, making the process more foolproof, ensuring accuracy of around 91% in practical applications.

In Ismail, Nor Azman, et al. [5], a web-based attendance system using pre-trained deep learning based facial recognition systems is described. SSD Network is employed for facial landmark detection whereas ResNet was used for feature extraction. These models were integrated into a web application and linked to a database for efficient retrieval. This approach, involving the utilisation of a strict matching value, results in a precision of 100% and an accuracy of 92%.

Son, Ngo Tung, et al. [6] is yet another work that elaborates on the pipeline employed for attendance tracking. The findings of this paper determine the feature extraction of FaceArc model to work effectively with similarity based classification algorithms like SVM, but achieving its best score in combination with the KNN classifier. The accuracy yielded by this approach is 92.7%, and in the case where unknown samples are removed, it is approximately 98.5%.

In the work presented by Okokpujie, Kennedy, et al. [7], the Viola-Jones algorithm was used for face detection in the pictures captured through the camera. Facial templates were created using the Fisherfaces algorithm and stored in a database. Attendance tracking was performed by comparing the acquired images with these templates using the Fisher Linear Discrimination algorithm. Results indicated a verification accuracy of 54.17% for varying lighting for the same expression and an accuracy of 70.83% when both facial expressions and lighting conditions were varied. This system also provided real-time attendance reporting due to its integration with cellular networks.

Research performed by Chintalapati, Shireesha, and M. V. Raghunadh [8] also uses Viola-Jones algorithm for face detection owing to its robust real-time capabilities. The captured image is then processed through resizing and histogram normalisation technique. After building the training dataset, the combination of a feature extractor, chosen from PCA, LDA and LBPH, and a classifier, chosen from a distance classifier, Bayes classifier and SVM, is chosen for recognition. It is observed that LBPH performs the best in terms of achieving better recognition accuracy and low false positive rate. In terms of classifiers, SVM and Bayesian obtain the best results in comparison to distance classifiers.

Jha, Abhishek [9] presents a novel approach to face recognition based attendance systems by the generation of a 3D Facial model using MATLAB. Facial detection is performed using the colour based detection technique which makes use of the detection and variation in skin colour, whereas PCA is used for recognition and detection. The results show promise for automating attendance in terms of accuracy and precision.

Elias, Shamsul J., et al.[10] proposes a pipeline that is initiated with the acquisition of student image, which will then be detected by the Viola-Jones algorithm. Following this, the image is compared to various other images of students already stored in the database. Local Binary Pattern (LBP) is used for the recognition of faces. The results indicate acceptable outcomes in a controlled environment, but also acknowledges the reduction of the system's accuracy due to factors such as changes in facial features, varying backgrounds and lighting conditions.

Kulkarni et al. [11] discusses an approach for enhancing ATM security through face and occlusion detection using the Haar Cascade Classifier (HCC) and Local Binary Pattern (LBP) techniques. The proposed system leverages deep learning models like Convolutional Neural Networks to improve feature extraction and classification, aiding in accurate face detection under varying conditions. The HCC proves efficient for face detection, especially in well-lit environments, while the LBP-based model addresses face spoofing detection. The results of the work were promising, with a face detection rate of 93.24% in a highly complex background and an accuracy of 84.8% for the spoof detection module.

Ullah et al. [12] introduces a novel DeepMasknet framework, an architecture comprising 6 convolutional layers, and 4 fully connected layers, capable of both detecting face masks and recognizing masked faces. To evaluate this framework, the authors develop a comprehensive Mask Detection and Masked Facial Recognition (MDMFR) dataset, designed to handle variations in face angles, lighting conditions, gender, age, types of masks, and occlusions like glasses. In the face mask detection performance evaluation, the proposed model achieved optimal accuracy, precision, recall, and F1-score of 100% for face mask detection, demonstrating its reliability in accurately identifying masked and unmasked faces.

Overall, attendance management systems using face recognition have shown great potential in improving efficiency and accuracy in various settings. However, further research is needed to explore their effectiveness in different scenarios and to address privacy concerns associated with facial recognition technology.

V. SYSTEM DESIGN

Facial recognition technology has seen significant advancements in terms of increasing security and improving the efficiency of management in various applications. This has consequently warranted its use to tackle the practical challenges of attendance management in contemporary times. The proposed system, "Attendance Management System using Face Recognition" is a sophisticated integration of various cutting-edge tools and technologies. The system is built upon the TKINTER platform to provide it with an exceptionally user-friendly graphical interface. The core functionality utilises Python script and a powerful SQL database for its implementation.

The most important aspect of this project is its image comparison algorithm, which juxtaposes the live video feed acquired by the system with pre-encoded facial images stored in the database. Leveraging facial biometric data, the system accurately identifies individuals, facilitating the creation of precise attendance records. Upon a student's appearance in front of the camera, a face detection algorithm based on a custom-designed Haar Cascade classifier identifies and distinguishes their face from their background. Subsequently, the captured images are employed to train the face recognition algorithm, enabling instantaneous recognition and attendance recording.

The face detection algorithm is a modified version of the traditional Haar Cascade classifier which has been enhanced through adaptive boosting with logistic regression. This classifier has been trained on a diverse dataset of positive images, which contain faces, and negative images, which do not contain any faces, to selectively detect facial features in images and live video feeds. The system captures student photos and records essential details through a form, facilitating comprehensive face recognition training.

For face recognition, the system adopts the highly efficient Local Binary Patterns Histogram (LBPH) algorithm. This method compares the encoded measurements of the detected faces with those stored in the database, accurately recognising known individuals and marking unknown faces. Through the MySQL database, the system also ensures seamless storage, retrieval and management of attendance data. Furthermore, the integration of OpenCV allows for better image and video processing capabilities through essential tools for facial detection and recognition.

Once a match is found, the system generates a timestamped attendance entry, storing the relevant details in a CSV file. The system enables the generation of a comprehensive attendance record for the entire class, which can then be easily exported and accessed through tools such as Microsoft Excel. Placing importance on access management controls, the system requires registration and login credentials to prevent unauthorised access and potential proxy attendances by other students. The user interface has been meticulously designed to offer a holistic and intuitive experience, empowering users to perform data updates, deletions and reviews with ease. Minor modifications to student details can be directly reflected in the interconnected database, negating the need to navigate through complex directory structures or command prompt.

Figure 1 Illustrates the proposed system's architecture, showcasing its capacity to accurately identify and recognize faces, efficiently store attendance information and provide a user-friendly interface for managing attendance records. The system's simplicity ensures minimal training requirements for authorities and an easier process for teachers to record attendance, thereby reducing the laborious efforts associated with conventional methods while curbing the potential for fraudulent or inaccurate attendances. Figure 1 also provides an idea of the intricate design flow of the proposed system, encapsulating all of its comprehensive functionalities.

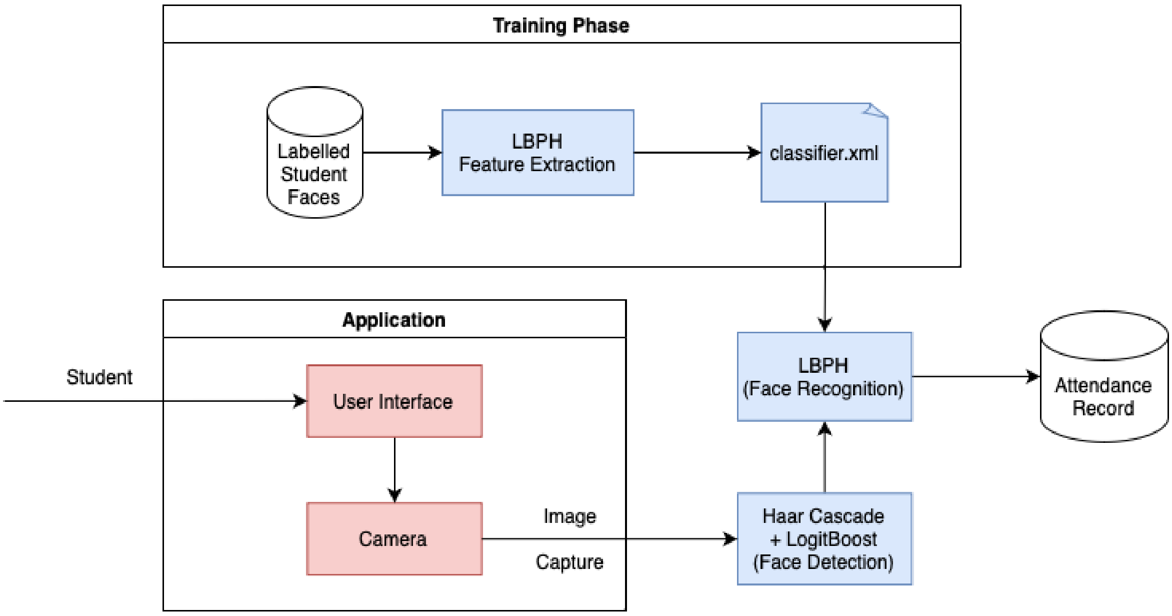

Figure 1: System Architecture

Overview of the Machine Learning Systems Employed: Haar cascade classifier has emerged as an effective face detection algorithm used in biometric systems, since it is robust, fast and computationally inexpensive. It is a feature-based object detection algorithm that utilises haar-like features, which leverage edge and line detection characteristics to locate and identify faces in images or real-time video streams [13]. Initially introduced by Viola and Jones, this groundbreaking technique has revolutionised face detection applications, especially in attendance management systems.

The training process of the Haar cascade classifier involves feeding a vast dataset containing both positive images (images with faces) and negative images (images containing various elements except for faces). The algorithm meticulously learns from these labelled images to effectively discern and differentiate facial attributes. In practice, the Haar cascade uses the cascade function and cascading window. It traverses the image region by region, employing a fixed 24x24 box to compute distinctive features within each region. Each pixel in the image is subjected to a unique Haar feature evaluation, enabling the algorithm to detect critical facial characteristics, such as contours and regions exhibiting significant pixel intensity variations [16]. These features are sensitive to specific patterns in an image, such as edges, corners, and gradients. The basic functioning of this algorithm is depicted in Figure 3.

To expedite computation, the algorithm constructs an integral image, derived from the original image, that allows for rapid feature calculation. The integral image is responsible for reducing the computational complexity by enabling fast and efficient feature evaluation through integral summation operations within fixed-sized blocks. Consequently, the Haar cascade classifier performs optimally, irrespective of image size.

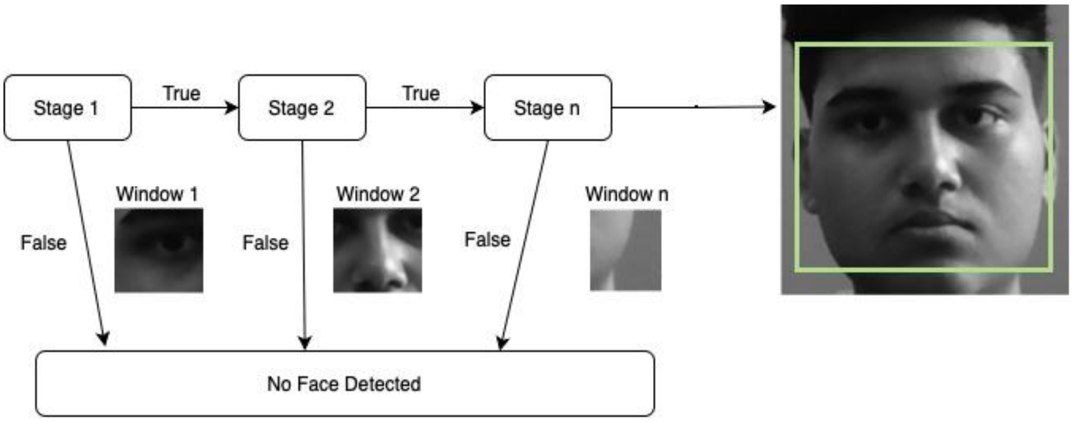

Figure 3: Haar Cascades Algorithm

To further enhance the classifier's accuracy and robustness, the LogitBoost adaptive boosting technique is also applied. This powerful machine learning algorithm makes use of an ensemble of weak classifiers to form a strong classifier capable of precise face detection. The LogitBoost algorithm operates through multiple stages, each containing a collection of weak classifiers and attempts to minimise the overall logistic loss [14]. During each stage, the algorithm strategically selects weak classifiers that exhibit the highest differentiation between positive and negative training samples. The amalgamation of these selected weak classifiers results in a highly effective and powerful classifier, significantly boosting the overall accuracy of the face detection algorithm. Furthermore, the LogitBoost algorithm's incorporation greatly enhances the classifier's ability to capture complex relationships between facial features and target variables. This proves particularly advantageous in addressing non-linear relationships, allowing the system to achieve exceptional accuracy and adaptability in real-world attendance management scenarios.

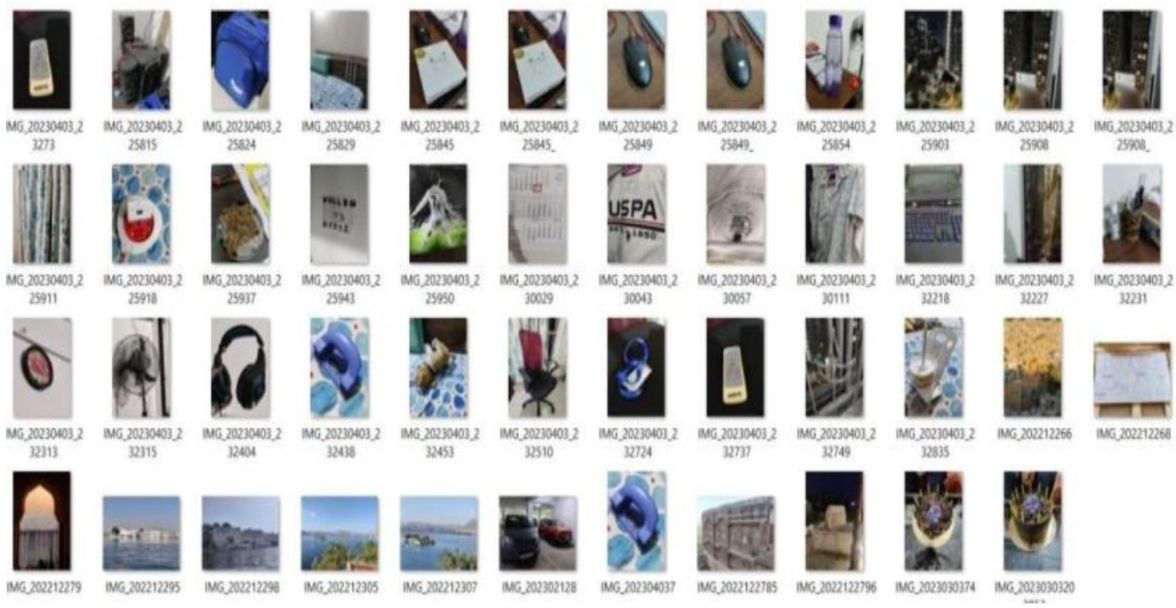

Figure 4: Negative Sample Image Dataset

In addition to face detection, the system also employs the Local Binary Patterns Histogram (LBPH) algorithm for face recognition. LBPH effectively partitions the face region into smaller grids and computes binary patterns for each pixel, based on local brightness compared to surrounding pixels [15]. These binary patterns are subsequently aggregated into a histogram, effectively capturing the unique texture and facial features of each individual, like illustrated in Figure 6.

Figure 5: Positive Sample Image Dataset

Within the context of the specific Attendance Management System using Face Recognition, the dataset of approximately 62 positive images is carefully curated. These images capture plain faces in well-lit environments while diligently minimising background noise and irrelevant features. This deliberate selection reduces the ratio of target pixels to non-target pixels, thereby optimising the classifier's efficiency and overall accuracy. For successful face recognition, the system undergoes supervised learning, where the classifier is trained on a dataset of labelled face images. During training, the LBPH algorithm extracts and generates histograms of local binary patterns for each face image, subsequently utilising these histograms as features to train the classifier.

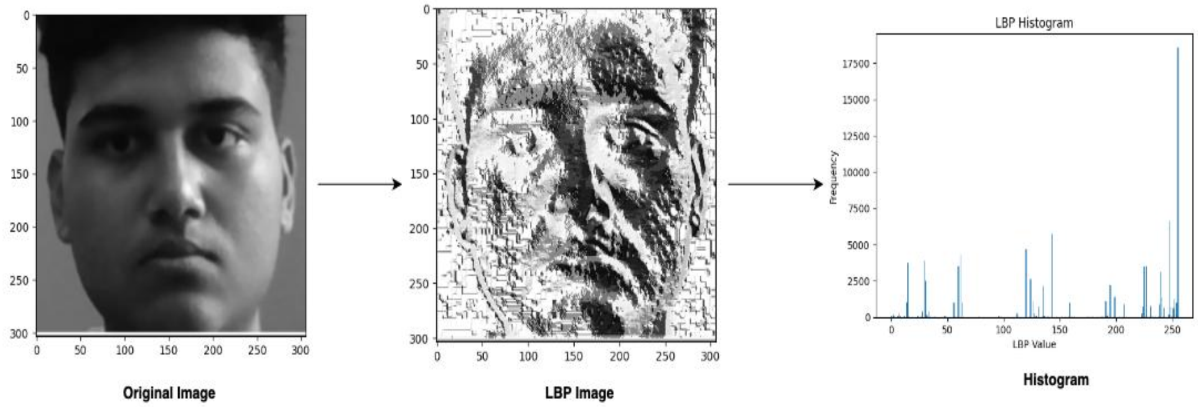

Figure 6: Positive Sample Image Dataset

The resulting trained model, stored in the classifier.xml file, holds vital information for recognizing faces in new images. During face recognition, the LBPH algorithm extracts local binary patterns from the face region of the new image and compares the resulting histogram with the histograms in the classifier.xml file to accurately identify the individual in the image.

Through the amalgamation of Haar cascade and Logit Boost algorithms for face detection, along with the powerful LBPH algorithm for face recognition, the Attendance Management System is equipped with advanced capabilities, ensuring unrivalled accuracy and efficiency in the face recognition process. The integration of these cutting-edge techniques enables the system to excel in real-world classroom scenarios, optimising attendance management with superior precision and adaptability

VI. RESULTS AND DISCUSSION

In Figure 6, we observe the subsequent step of the attendance system after processing the input details in student form, the initiation of the face capturing procedure. In this process, the system captures a substantial number of images, precisely 50 images for each registered student. Each individual's images are uniquely identified and labelled by student ids.

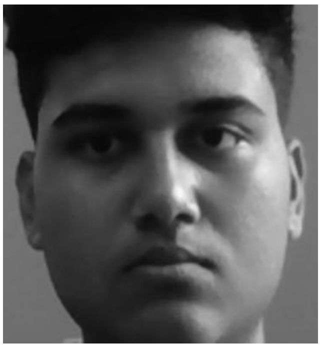

Figure 7: Face Recognition

In Figure 7, we witness the results of the system's training phase. The database of facial images, along with their unique student identification are used to train the model. The system, consequently, is able to simultaneously detect multiple faces within a single frame, accurately recognising and discriminating the features of distinct individuals. Even in dynamic real-time video feeds with moving subjects, the system adeptly recognises individuals, demonstrating its robustness and efficiency in practical applications.

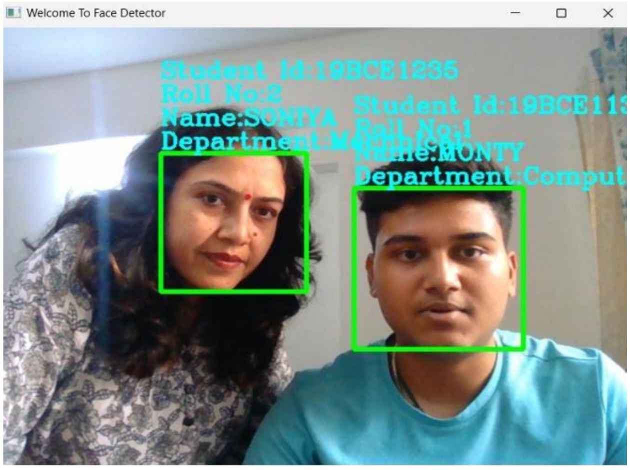

Figure 8: Face Detection and Capturing

VII. CONCLUSION

Using Haar cascades and local binary patterns in CPU-based systems emerges as a highly effective and … approach for face detection and attendance marking in modern-day institutions. CPU-based systems offer super single-threaded performance in comparison to GPUs, rendering them the most pragmatic choice. Moreover, their power efficiency and ease of programmability are also advantageous. The intrinsic speed and computational efficiency of Haar cascades, outperforming Convolutional Neural Networks (CNNs), position them as an ideal choice for real-time face detection tasks. This seamless integration of CPU-based systems also results in a sophisticated and agile solution, precisely capturing and marking the attendance, making sure there is no room for error. Furthermore, the automation of such essential administrative tasks using advanced technologies drives productivity and efficiency in diverse organisational settings.

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