Face Recognition Based Attendance System

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***Abstract*— This paper discusses an attendance system machine learning techniques like CNN, LBP and HoG is proposed. The system comprises an equipment package that includes a camera constructed to capture images along with an independent server set up specifically tailored towards data processing activities alongside storage functions respectively. In this way incoming photos taken are then analyzed and thereby matched against pre-existing profiles in order to produce precise identification outputs immediately without manual registration complexities nor dependence on physical ID card usage – subsequently transforming traditional methods into streamlined procedures across multiple levels effectually and efficiently optimizing resources further ensuring proper accountability entirely within organizations currently under test conditions proposed. The system when tested with classifiers attained an accuracy of 98.4% over the existing datasets, thus exceeding prior benchmarks.**

Keywords*—— *Face Recognition, Face Detection, Back Propagation, Convolution, overfitting

I. Introduction

Attendance management plays a vital role in any educational or workplace setting. To ensure accountability and compliance with regulations, keeping track of attendance records is essential. [1] The traditional methods of recording attendance involve manual sign-ins or physical ID cards which are not only time-consuming but also prone to errors. Thanks to advancements in technology, facial recognition has emerged as an efficient and secure alternative for tracking attendance effectively. In this paper, design for smart system that incorporates facial recognition technology to elevate the efficiency and security associated with managing employee or student presence within schools and workplaces is presented. The camera captures images during recordings whilst processing matches against pre-existing databases containing student/employee faces ensuring automatic registration once successfully recognized, furthermore, included within said program resides a completely user-friendly interface designed distinctly intended towards seamless monitoring & record-keeping capabilities relating primarily towards staff/student participants' visits. Discussion surrounding implementation strategy alongside evaluations statistics relevantly exploring further information invested into proposing such heightened formality shall be thoroughly investigated throughout ongoing research on these technological developments and possible future implementations accompanying organization protocols found fitting under numerous supervisory classifications targeting those businesses or educational settings seeking constant work optimization using up-to-date innovation.

The primary objective of the suggested mechanism is to seize and preserve an individual's countenance in a database for attendance verification. The subject matter must be recorded with absolute precision, recognizing each attribute that distinguishes one person from another while also acknowledging their seated position or stance. The smart attendance system proposal aims to achieve high efficiency and ease of use. It operates by utilizing a high-resolution camera that takes photos of students or employees, which are then cross-referenced with an existing pre-enrolled facial database for matches. Advanced algorithms in facial recognition technology minimize the likelihood of false positives, ensuring impeccable identification accuracy during processing. Once positively identified through the software's automatic recording capabilities, there is no need for manual sign-ins nor physical ID cards—attendance management becomes significantly optimized as tracking record-keeping time and effort costs decrease substantially. Apart from its primary operation, the mechanism has a friendly user interface to supervise and control records of attendance. Attendance files are easily accessible for administrators who can create reports and arrange notifications in case of absenteeism. Additionally, integration with other school systems like student information databases is achievable effortlessly resulting in consistent data accuracy.[2]

After conducting an extensive analysis on genuine data, it was found that the proposed system is a valuable tool for optimizing attendance control in academic and professional settings. The precision of its operations stands out as unmatched when compared to alternatives available. This powerful resource not only operates with great speed but also has robust safety measures in place. Thus, utilizing this indispensable apparatus leads to substantial improvement regarding keeping track of student or employee presence at educational institutions and workplaces alike.

II. Literature Survey

The method of recording attendance manually is known to be quite time-consuming; thus, there has been an increasing interest in using automatic systems for this task. Among the various types of automated tools currently available, face-based technology stands out as particularly promising. Despite its heightened popularity, however, one crucial issue concerning facial recognition attendance has yet to be thoroughly addressed within existing research studies.

A new methodology aimed at determining how many cameras with specific resolutions would need installation in order to capture students' faces clearly enough for use in automatic attendance-taking settings that are common throughout typical classroom environments today.

The need for automatic attendance systems has become crucial in educational institutions. Among them, face-based automatic attendance systems are gaining popularity due to their accuracy and convenience. Nevertheless, there is a lack of research on how to calculate the number of cameras needed to adequately capture every student's face in a normal classroom setting. This paper addresses this problem and provides a mechanism to calculate the amount of cameras utilized for face-based automatic attendance. The suggested methodology was tested in two classrooms of varying sizes and camera resolutions, and the findings demonstrate that the methodology to determine cameras for enough coverage and to identify students' faces when they turn to look at the camera. [3]

The efficiency of educational institutions will be enhanced through the utilisation of technology. Using a variety of biometric methods will be beneficial. Today's most distinctive and well-known technology is face recognition. The planned work keeps track of students' on-the-spot attendance. The proposed work outlines an efficient algorithm for automatically recording attendance without human intervention. The detection and recognition of faces is the system's most crucial stage. The existing approach helps to more effectively monitor student attendance, according to a comparison between the previous attendance system and the one currently under consideration. This technique will actually aid in maintaining attendance and assisting teachers in keeping track of their students.[4]

Among the various techniques available is facial recognition, which offers an unparalleled means of identifying students with precision. Owing to its reliability as compared to traditional attendance sheets or proxies, it has gained widespread acceptance within institutional settings. The suggestion prescribes utilizing real-time strategies that employ highly efficient algorithms so that not only do they eliminate any human intervention but also mark student presence counts accurately while doing so. What sets this model apart lies in detecting holistic expressions among recognized faces without interruptions – all core strengths when comparing manual-entry processes used by teachers previously; these methods represented more workloads coupled with lower accuracy levels. These efforts ultimately lead toward modernization initiatives that push aside small incremental improvements made throughout decades beforehand effortlessly albeit quietly until facing backlash later on about time wasted performing routine tasks repeatedly frequently encountered within classrooms full reign quickly being regained expertise left alone unattended almost lost forevermore.

According to a study, RFID technology should be used to address the issue of regularly monitoring lecture attendance in developing nations. As developed and implemented in this study, the use of RFID for student attendance monitoring can reduce the amount of time needed for manual attendance tracking and give educational administrators the chance to record data from actual classroom interactions for the purpose of allocating accurate attendance scores and making additional managerial decisions.[5]

Several studies have been conducted on the use of facial recognition technology for attendance management in educational institutions. For instance, a study suggested a system to monitor attendance in a school environment using face recognition technology. The system was evaluated using real-world data and was shown to be highly accurate, with a recognition rate of 98.33%. To sum up, extensive research has been conducted on the use of facial recognition technology as an efficient and dependable answer for attendance management. The data indicates that implementing this innovative approach can lead to better control over student presence in educational facilities while significantly reducing administrative burden. Additionally, incorporating facial recognition technology can improve safety measures put in place within institutions by regulating access to secure areas more effectively [6].

III. METHODOLOGY

This paper discusses an approach for monitoring attendance using a visual cam-based module, communication and processing of the data acquired and suggests steps to efficiently collect and process data verifying it across a database of images to implement an attendance system. A solution to this is a system that needs the user to be physically present to mark attendance. A facial recognition-based system also provides a cost-effective solution as it is a standalone system and does not require the users to own and carry peripheral devices. Data analysis is made easier as all the data from the system is logged into an excel sheet which can be used to generate metrics for individual personnel.

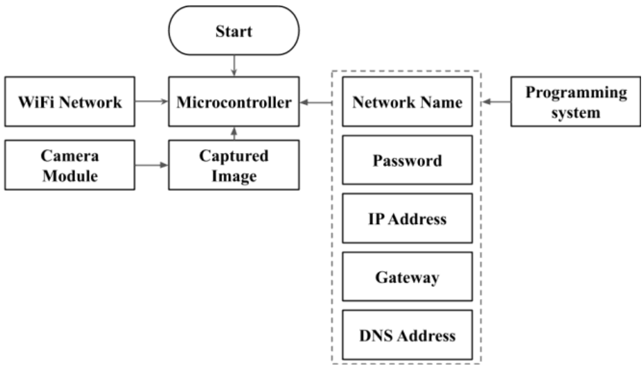

Fig. 1 Hardware Architecture for Attendance System

The hardware for the smart attendance system, the chosen microcontroller needs to be connected to a computer and configured to connect to a WiFi network. This can be done using the microcontroller's built-in WiFi library and specifying the network name, password, IP address, gateway, and DNS addresses in the code which is uploaded to the microcontroller. Once the microcontroller is connected to the network, it can control the camera module to capture images. The microcontroller initializes the camera module, sets the resolution and frame rate for image capture, and triggers image capture as shown in Fig. 1. To ensure that the captured images are clean and noise-free, the microcontroller resizes the image to a smaller size and converts it from RGB to grayscale. This reduces the amount of data that needs to be sent over WiFi to the code and makes it easier to process the image.

A. Image Preprocessing

Image pre-processing is performed on the dataset present as training dataset. The images are initially resized followed by normalizing the image. Image smoothing, cropping and augmentation is performed as final preprocessing steps. When employing a camera module to detect faces, normalisation, smoothing, cropping, and augmentation are essential preprocessing methods. To enhance the face detection algorithm, normalisation helps by correcting the image's brightness, contrast, and colour balance. A crucial strategy for improving the quality of the face detection algorithm is smoothing, which removes noise from the image. A filter that removes the high-frequency components of the image while keeping the key facial features can be applied to the image data to achieve smoothing. The accuracy and effectiveness of the face detection algorithm can also be increased by cropping the image to concentrate on the area of interest where faces are anticipated to be present. By cropping the image, we can focus on the regions where faces are most likely to appear, reducing the quantity of data that needs to be processed, and enhancing the algorithm's speed and accuracy. Augmentation methods like rotation, scaling, and flipping can generate more robust training data that is more diversified, which can enhance the performance of the face detection system. By overcoming problems like overfitting, augmentation can enhance the face detection algorithm's capacity for generalisation.

B. Face Detection Algorithms

There are numerous object detection techniques, including the Convolutional Neural Networks (CNNs), Local Binary Patterns, HCC and HoG. In this system, an algorithm suitable for accurate face detection and hardware compatibility is required

a)Convolutional Neural Networks(CNNs):

Although CNN has greater complexity than any of the available algorithms, are currently the most accurate and recent technique for face detection. This algorithm has achieved exceptional performance on multiple face detection benchmarks, including the WIDER FACE dataset. CNNs can learn complex representations of faces by processing large amounts of training data, making them highly effective for tasks such as face detection. Moreover, CNNs have the capability to be adjusted for particular assignments, leading to additional enhancements in precision.

In CNN, images go through multiple steps such as convolution, activation function application, down sampling and backpropagation.

b)Convolutional Operation

This operator is used for extracting feature maps. To define the output shape of the 2D convolution layer following equation can be used:

$$y = (x - k+2p)/s+1 \quad (1)$$

y = output shape
x = input shape
k = kernel size
p = padding of 2D layer
s = stride of 2D layer

For calculating the number of parameters in a convolution layer the refer given formula:

$$n= (a*k2*b)+b \quad (2)$$

n = number of parameters
a = input channels
k = kernel size
b = output channels

c)Pooling Operator:

This operator is used for down sampling the feature maps to reduce their size and computational complexity. To calculate the output shape of the pooling layer equation (3) is used.

$$y = (x - i)/s +1 \quad (3)$$

y = output shape
x = input shape
i = pool size
s = stride

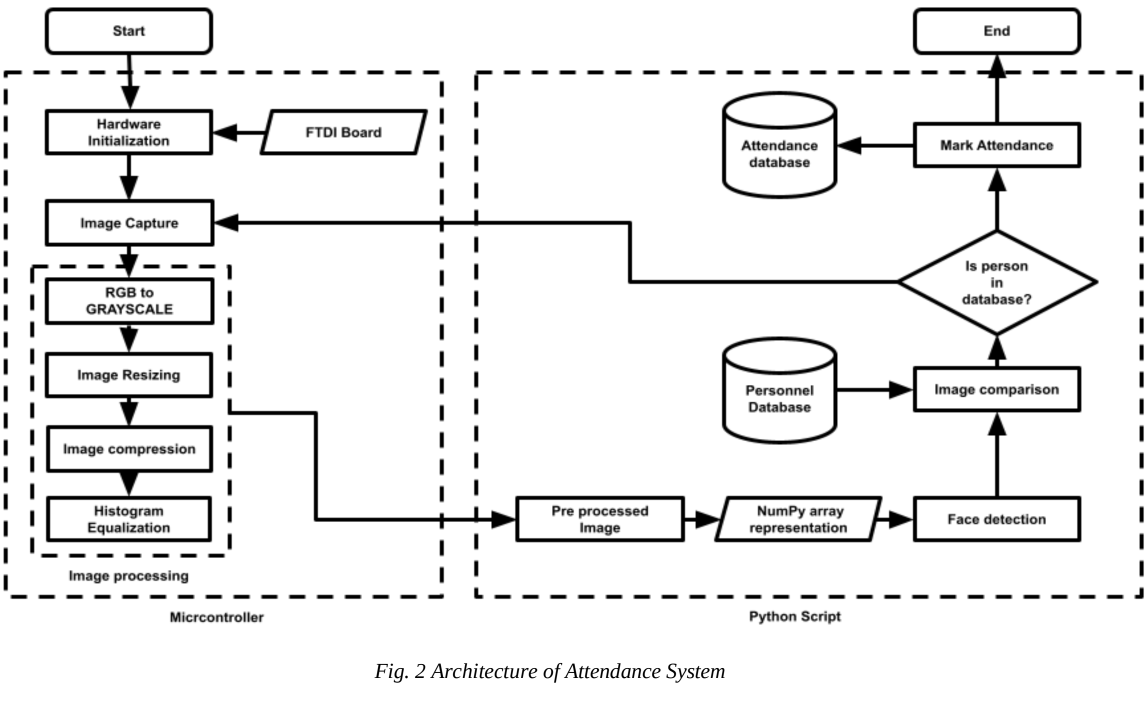

Fig. 2 Architecture of Attendance System

d)Backpropagation and weight update:

The computational method known as backward propagation is utilized in neural networks, specifically Convolutional Neural Networks (CNNs), to adjust the network's weights within each layer for fine-tuning. Throughout training procedures, information inputs are presented to an artificial neuron and produce output feedback that parallels data from human flesh-and-blood counterparts' neurological responses. Contrasting this synthesized reply with intended results yields discrepancies between expected and actual outcomes classified efficiency as erroneousness or waste found under such monikers: 'loss.' Backpropagation's objective seeks optimal changes to weight allocations so as not to exceed maximal loss margins for optimized machine learning operation configurations. The error in the output layer is found by equation (4).

$$e = outp - outr \quad (4)$$

e = error
outp = predicted output
outr = true output

If an error is to be found from some hidden layer use the equation stated in (5) can be done.

$$e = w^* eout \quad (5)$$

e = hidden layer error
w = weighted output
eout = output error

There might be a case of weight update in the convolution layer. To calculate the same equation (6) can be used.

$$w = r.(x^*e) \quad (6)$$

w = weight update
r = learning rate
x = input
e = error

C. Model Implementation

After hardware initialization, image preprocessing and face detection, the model was tested on two classifiers namely SVM and RF as suggested in Fig.2.

a) Support Vector Machine

SVM is a supervised classification technique often implemented for regression and outliers detection. The data that is fed to the algorithm is converted into a higher-dimensional feature space by SVM's kernel trick.

When taking data as input, SVM uses kernel functions to transform it into the format needed for data processing. SVM generated decision boundary is established by equation (7). Defining function of the linear kernel is displayed as follows in (7):

$$y(A) = Vw^T * A + l \quad (7)$$

Vw - weight vector
A - data to be classified
l - linear coefficient

b) Random Forest:

Random forests (RF) create a variety of different decision trees while training. Combining predictions from child trees results in the final prediction, which is either the mean prediction for regression or the mode of the classes for classification. Since they combine results to make decisions, they are known as ensemble approaches.

Equation (8) can then be used to determine the significance of every feature on a decision tree:

$$fi = nij/nik \quad (8)$$

fi sub(i)= significance of i
nij = division of i based on significance of j
nik = importance of node for all nodes

IV. RESULTS AND DISCUSSION

Facial recognition technology has become increasingly important in security systems, marketing, attendance tracking to name a few. The ability to identify individuals using facial recognition technology accurately and efficiently has led to its widespread adoption in many different industries. Facial recognition technology has become more accurate and efficient than ever before. This paper aims to evaluate the performance of three different facial recognition methods - LBP, HOG, and CNN - combined with two popular classifiers, SVM and RF, to identify the most accurate and efficient approach for a smart attendance system which is summarized in Fig.3. LBP is a texture-based method, HOG is a gradient-based method, and CNN is a supervised distance metric method.

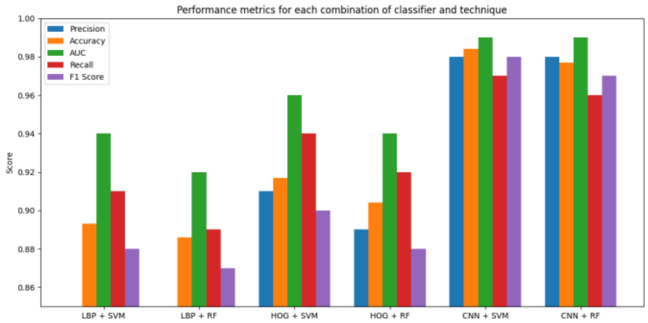

Fig. 3 Comparative Analysis for Techniques

Results of the study showed that the CNN method outperformed all other methods, achieving a maximum accuracy of 98.4% with SVM and 97.7% with RF. The LBP method achieved an accuracy of 89.3% with SVM and 88.6% with RF, while the HOG approach improved the accuracy to 91.7% with SVM and 90.4% with RF. Interestingly, the SVM classifier was found to be the most efficient classifier, with an average accuracy of 93.1% when combined with LBP, HOG, and CNN approaches. The RF classifier also achieved a high average accuracy of 91.8% when combined with these methods. Although the CNN with SVM outperformed all other combinations, the LBP and HOG methods still achieved decent accuracy when combined with SVM or RF. Therefore, the choice of the facial recognition method and classifier should depend on the specific application's accuracy and efficiency requirements. This study highlights the importance of choosing the right combination of facial recognition method and classifier for a particular application. The accuracy and efficiency of the facial recognition system can significantly impact the performance of the entire system. Therefore, developers and researchers should carefully evaluate the performance of different methods and classifiers before implementing them in a real-world scenario. The findings of this study also highlight the potential of deep learning approaches, such as CNN, for achieving high accuracy in facial recognition tasks. However, deep learning algorithms are computationally expensive and require a significant amount of training data. The study sheds important light on the effectiveness of various classifiers and algorithms for facial identification, and it emphasises the promise of deep learning techniques for reaching high accuracy in facial recognition tasks.

Technique	Classifier	Precision	Recall	F1 Score	AUC	Accuracy
LBP	SVM	.895	.894	.894	.938	89.3%
LBP	RF	.887	.886	.886	.930	88.6%
HOG	SVM	.919	.917	.918	.969	91.7%
HOG	RF	.906	.904	.905	.957	90.4%
CNN	SVM	.985	.984	.984	.998	98.4%
CNN	RF	.977	.977	.977	.997	97.7%
Average	SVM	.933	.931	.932	.968	93.1%
Average	RF	.923	.922	.922	.961	91.8%

TABLE I. CLASSIFIER AND ACCURACY COMPARATIVE ANALYSIS.

V. CONCLUSION

In the smart attendance system, the CNN approach combined with the SVM classifier produced the best accuracy of 98.4% based on comparative analysis, making it the most efficient set-up for face recognition. The SVM classifier maximises the distance between classes, improving classification accuracy. It creates a hyperplane to partition data into various classes. The CNN technique, a deep learning technique, enables the system to learn and extract features from images with high accuracy.

This combination can be especially helpful in areas of business and education where effective attendance control is essential. By automating attendance management, smart attendance system can do away with human sign-ins and paper ID cards. The technology can help administrators save time and resources so they can concentrate on more crucial responsibilities.

Additionally, a safe and precise solution for attendance management is offered by the CNN approach combined with the SVM classifier. Face recognition technology also reduces the likelihood of errors or the loss of actual identity cards, which can be a security issue in traditional attendance management systems.

Additionally, the interface of the smart attendance system makes it easier to administer and keep track of attendance records. The system may produce statistics and analytics to track attendance trends and patterns, enabling targeted interventions and assistance for students or workers who might need extra help.

In smart attendance system, the CNN approach combined with the SVM classifier is the most successful pairing for facial recognition. This combination can enhance attendance management in companies and educational institutions, resulting in more effectiveness, accuracy, and security. Administrators may focus interventions and assistance for students or staff members thanks to the system's user-friendly interface and ability to provide reports and statistics. The proposed system can save time and resources, eliminate errors, and increase accountability, making it a valuable addition to any attendance system.

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