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Enhancement the Attendance System in Educational Institutions Based on Image Processing and Facial Recognition

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ABSTRACT

Currently, accounting for student attendance is one of the key components for raising the calibre of specialized training. It is possible to automate this procedure. The article suggests using facial recognition technology, which enables you to identify multiple people at once without having to make direct contact with them or utilize pricey equipment, to create the attendance system in educational institutions. Based on the article's analysis of contemporary facial recognition techniques, this solution makes use of convolutional neural networks Retina Face and ResNet. Our attendance system's architecture is enhanced by image pre-processing techniques that, when needed, apply algorithms to the image to even out colours, sharpen edge, boost brightness, and reduce noise. These techniques are based on our suggested methodology, which is based on the BREN measure. The computer experiment results are shown, demonstrating the higher efficiency of the suggested approach in comparison to its equivalents.

Key Words: Attendance System, Image Pre-processing, Facial Recognition, Convolutional Neural Network, Retina face.

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1. INTRODUCTION

Enhancing the standard of specialist training is one of the most pressing issues facing contemporary higher education. It has emerged as an alternative to traditional forms of identification, like card IDs. Among all the modalities, face recognition is the most difficult since it is how people naturally identify themselves. Challenges such as position variation, object lighting, facial disguises, and expression variations face the traditional FR approaches based on Visible Spectrum (VS). Regretfully, Face Recognition performance is negatively impacted by these constraints [1]. Improving the educational process alone will not be sufficient to address this issue. Students' participation in training sessions is one of the main factors influencing the quality of specialized training is the participation of students in training sessions [2]. Currently, there are several techniques to automate the process of documenting attendance, including using fingerprint scanners, RFID tags, QR codes, and cell phones. In social interactions, faces are the main object of our attention and play a vital role in expressing identity and emotion. Face recognition (FR) is becoming a very fruitful field of study, mostly because of its many applications in fields including financial security, public security, and human-computer interaction [3]. However, these methods need expensive equipment [4]. An attendance system based on facial recognition technology may identify several people at once without the need for expensive equipment or face-to-face contact [5]. Face recognition is comprised of three steps: face detection (also known as face extraction), face recognition, and extraction feature extraction [6].

The location of human faces on the input image is identified at the face detection stage. A video stream can be entered in addition to photos; these systems are used for real-time person identification. The objectives of this step are to identify any faces in the input image and compute the coordinate rectangles that represent those faces. Finding features on faces found in the earlier stage is the primary responsibility of the feature extraction stage. A series of feature vectors, or face descriptors, that characterize the geometric distribution of the distinguishing characteristics of a facial picture, like the mouth, nose, and eyes, are used to depict a face.

The generated collection of feature vectors for every face is compared with a set of face descriptors kept in the Faces Database during the face identification stage. This stage results in the individual being compared to a database of faces to determine which match is most likely, or in accepting or rejecting an action, like granting access, in this study, we outline the face recognition techniques used in attendance systems, investigate the factors influencing the decline in recognition accuracy, and suggest a way for developing a system for tracking student attendance enabling an increase in recognition precision. The structure of the article is as follows. An overview of facial recognition techniques and facial recognition-based attendance systems is given in Section 1. The architecture of our attendance system is then presented in Section 2, which also examines the issues that lower face recognition accuracy and suggests solutions. The outcomes of computational experiments are shown in Section 3. The research's findings are summed up in the conclusion.

2. An Examination Of Related Works

2.1 Face Recognition Methods

With every new academic year comes an increase in the number of new students, university attendance systems have to deal with a huge number of identifiable pupils. Some previous studies were introduced to investigate and evaluate these images in order to produce an appropriate enhancement, based on the qualities of the optical system and the output images [7]. The optimum solution for such a system is to have a database with personal identification information in it. Simultaneously, it is not advisable to alter or retrain the neural networks or face recognition algorithms in the system itself, since this will demand a significant investment of time and resources. We'll then talk about facial recognition techniques that work well with these kinds of systems.

The first step towards tackling the face recognition challenge is to identify faces in an image or video stream. A whole face that is evenly lit, free of harsh shadows, and unobscured by hair or accessories is ideal for detection.(hat, scarf, and spectacles) in sharp detail.

The concepts put forth by P. Viola and M. Jones in the early 2000s serve as the foundation for several contemporary object detection algorithms [8, 9]. The Viola-Jones approach is based on utilizing a cascade of weak classifiers to quickly detect a face in a window moving across the image after extracting facial features from the image using Haar functions. When it comes to recognition efficiency compared to working speed, the Viola-Jones approach is among the best; nonetheless, recognition accuracy declines with head turning and dim lighting.

Comparing each image area with a predetermined template is the basis of another class of approaches [10,11]. Although these algorithms have a very low running speed, they are not appropriate for real-time problems despite being highly accurate. Contemporary systems are often constructed using convolutional neural networks (CNNs, or convolutional neural networks).

Though they demand a lot of processing power, the network can detect faces with a significant head tilt and dim lighting. Researchers can achieve excellent performance accuracy in object detection with a wide range of modification options offered by convolutional neural networks [12].

Face detection is the first step in face recognition, followed by feature extraction. It receives an image of the chosen face as input data. A facial descriptor that characterizes a person's distinctive facial traits is the output. Three categories of feature extraction techniques holistic, local, and hybrid are distinguished in [6].

The entire face is input by holistic methods, which pro-project it onto a correlation plane or a little subspace. The primary concept behind holistic approaches is to process the full face and encode its picture into a pixel matrix. Holistic approaches are comparatively easy and fast. However, because there are numerous calculations involved in recognition, accuracy issues could surface when dealing with extremely big databases. The Principal Component Method (PCA) is among the most intelligent of these techniques [13].

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Local methods do not consider the face as a whole; instead, they rely on the recognition of specific facial features. Finding distinguishing facial traits is the primary objective of local approaches [6]. These techniques are intended to describe particular facial characteristics (such the inner and outer corners of the eyes) or specific portions of the face (like the nose, lips, forehead, eyes, and lower portion of the chin), the combination of which is a descriptor.

Building histograms of directed gradients (also known as Histogram of Oriented Gradients (HOG)) is the most widely used local technique [14]. The method's core notion is that the distribution of edge directions or intensity gradients can be used to characterize an image. These histograms are often created by partitioning the image into cells and allocating a histogram of gradient directions for the pixels contained in each cell; the sum of these histograms is known as the description torus.

A hybrid strategy can improve the performance and usability of face recognition systems by combining the advantages of local and holistic approaches. In the identification step, the generated vector is compared to previously identified faces in the database. There are several approaches to compare; the most common and straightforward is the Euclidean metric comparison of descriptors [15]. The degree to which the faces resemble each other in terms of relevant descriptors increases with decreasing distance between them.

2.2. Attendance systems

There are several methods out there now for resolving the face recognition issue. These systems share a similar architecture, but various algorithms and techniques are chosen to solve each of the three face recognition stages.

The YOLOv3 neural network [16] and the Microsoft Azure face recognition service [17] are used in [18] for face detection and feature extraction, respectively, enabling the authors to achieve nearly 100% recognition accuracy. Neural networks were trained on 20 photos of each identified student because the system in issue was designed for a small group of students. This method does not make systems flexible. Every student's data must be gathered, and the neural network must then be trained.

In [18], faces in a photo are identified using a histogram of directed gradients (HOG, Histogram of Oriented Gradients) [14], from which a retrained convolutional neural network extracts a face descriptor. The support vector machine, often known as the SVM or support vector machine, is employed for the final identification step [22].This system's recognition accuracy was 81%.

Face detection and feature extraction are handled in [20] using the MTCNN model [21] and the Arc Face neural network, respectively. For identification, the support vector machine, or SVM [22], was selected. The accuracy attained is 89%. The head's direction was identified and aligned using picture pre-processing in this system. Support vector machines, a less complex method of comparing descriptors than a neural network, are employed for identification in systems [4] and [20], although they also necessitate prior training. It is challenging to apply such algorithms to massive, regularly updated databases of recognized faces.

In work [23], the face detection stage is carried out using cascade classifiers based on Haar features; the descriptor is extracted using the dlib library's face encoding function [8], and the resulting descriptors are compared using the Euclidean metric. The image was changed to shades of gray in order to enhance the photograph's quality. With good quality and 83% recognition accuracy for frontal face photos taken in daylight, this system boasts a fast processing speed. In [24], a different strategy is employed, which enables 90% recognition accuracy. Convolutional neural networks are employed for face detection, while Principal Component Analysis (PCA) is used for descriptor extraction [13]. To compare descriptors, one computes the Mahalonobis cosine distance. The use of a neural network for face detection and picture pre-processing techniques, which allow to normalize contrast and minimize noise, give the system a greater recognition accuracy than [23]. Similar to each other, systems [23, 24] do not require further training. In these methods, identification is accomplished by extracting the feature vector and comparing it to those that are already stored in the database.

Two categories of facial recognition systems can be identified by examining their analogy. First, there are systems that use linear classifiers or neural networks that have been pre-trained on a set of faces and can then identify faces in

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additional images or a video stream [4, 18, 20]. The second type of systems uses information from databases to identify individuals, with neural networks trained on standard data sets [23, 24]. The first class of systems has more accurate recognition. Although second-type systems are less accurate, they enable the rapid insertion of new recognitions to the database without the need for further neural network training.

3. System Implementation for Attendance Records

3.1. General System Architecture

Figure 1 displays the architecture of the system. The three primary elements of the system are the web interface, facial recognition, and image capturing. Three parts make up our attendance system: a web interface, a facial recognition module, and an image capture module.

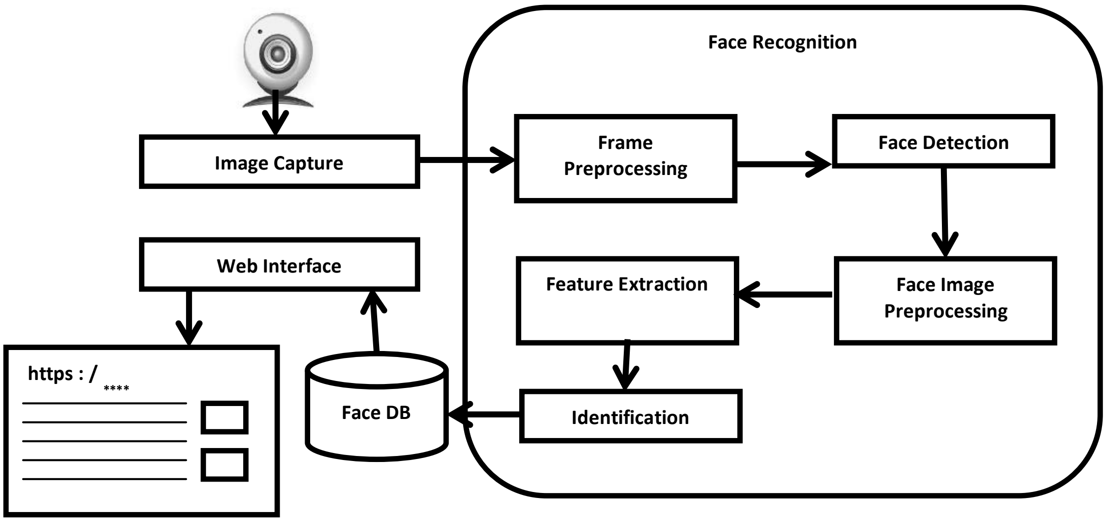

Figure1. General attendance system architecture

The image capture module gets a video stream from the classroom webcam by connecting to it. The camera's recorded video stream is split up into frames. All phases of recognition facial detection, feature extraction, and identification are carried out by the face recognition module. Our method is enhanced with the phases of frame pre-processing and face picture pre-processing, which can increase the recognition accuracy, in comparison to the usually accepted structure of face recognition. With the help of the web interface module, you can view the facial recognition outcome on the captured image as a webpage.

The system's functioning can be succinctly explained as follows. Every frame that is received is sent to the facial recognition module by the image capture module. The primary processes in the face recognition module include feature extraction, identification, frame pre-processing, face detection, and face image pre-processing. Initially, pre-processing the frame enables you to remove images that are not appropriate for identification and, if feasible, enhance the overall quality of the picture (by decreasing noise, enhancing sharpness, etc.). Next, the picture is subjected to a face detection algorithm. Facial traits are taken from each image of the chosen face after it has undergone additional pre-processing. This two-phase quality enhancement and verification process image quality is important because, even with excellent video stream frame quality, the face image on it might not be clear enough to be recognized. For instance, a high resolution frame might have small faces in the background; as a result, the extracted snapshot of that face would be low quality and unusable for identification. To identify the face, the generated descriptor is compared with those in the facial database once the facial features have been extracted. The user receives the comparison result via the web interface when it has been entered into the database.

In order to create the attendance system in educational institutions, we used the Python programming language in conjunction with interoperability libraries. Interface with libraries that enable image pre-processing, such as dlib [25], OpenCV [26], and artificial neural networks, such as Keras [27], Tensor flow [28]. Retina Face network, a pre-trained convolutional neural network, was employed for the face detection step [19]. The open-source WIDER Face (hard)

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dataset is used to train the Retina Face network [29]. This collection includes images of faces that are small in size, have varying head turns, and have poor illumination. These are all common issues with the attendance system. The convolutional neural network ResNet [30] was employed, one of the pioneers in the field of descriptor creation, at the feature extraction stage. The descriptor that we are given describes several facial features, including the nose, eyes, lips, and corners. The descriptor may have up to fifty of these important points. An individual's identification will be more accurate the more points they have. When comparing descriptors, the Euclidean metric is employed.

3.2. Increasing The Precision Of Face Recognition

Accurate recognition is influenced by a number of things. The following elements are found in studies [4,18, 20, 23, 24] to diminish the accuracy of recognition:

- Insufficient resolution, noise, and inadequate illumination of the face shot (Fig. 2d–f).

- Occlusion, or hiding the face with objects such as light (Fig. 2e), accessories (headdresses, ties, glasses, scarves, bright makeup, etc., Fig. 2h), and head turns (self-occlusion, Fig. 2b).

- Facial expressions conveying emotion (Fig. 2c).

- Variations in people's physical characteristics (gender, body type, ethnicity, etc. Without these troublesome elements, face recognition accuracy can be as high as possible. Such a face (Fig. 2a) shall hereafter be referred to as reference one. The challenge of moving a face shot closer to the stage womb view is the key to improving recognition accuracy.

Many techniques for enhancing image quality have been developed recently in the field of image processing [31]. This work employed the following techniques:

- Using the OpenCV library's Medianblue function to blur the image to decrease noise.

- Using the equalizeHist function from the OpenCV library, one may apply unsharp masking to sharpen images. Additionally, histogram manipulations can be used to balance out colors and boost brightness.

Moreover, each face image is normalized and reduced to a single size, which is required for an accurate comparison of face descriptors. The process of normalizing input data involves shifting its characteristics inside the range of 0 to 1.

It is not necessary to apply pre-treatment everywhere in order to enhance quality. There are three possible states for a photograph: inappropriate for recognition, pre-processing needed, and suitable for recognition. As a result, it is essential to perform a preliminary examination of the final photograph's quality. The evaluation of image quality establishes threshold values between poor and excellent photography and is a quantitative analysis of how people perceive quality in images. An investigation of quality comparison metrics and their efficacy was conducted in work [32].

a-Reference person	b-Self-occlusion	c-Emotional expression	d-Low resolution

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e-Noise	**f-Poor Lighting**	**g-Light occlusion**	**h- Occlusions with an accessory**

Figure 2.Factors affecting the accuracy of face recognition

The BREN measure [33], which offers a quality assessment in values ranging from 0 to 255, was employed in our experiment. We suggested breaking the range of BREN measure values into five intervals (Fig. 3), each of which represents a different level of picture quality: the image is not suitable for recognition, it is suitable for recognition with preprocessing, or it is acceptable for recognition without preprocessing. These intervals' numerical values were ascertained by experimentation. This was accomplished by gathering twenty photographs of various quality, calculating the quality evaluation using the BREN measure, and comparing the image quality numerically and visually to identify the limits of the intervals.

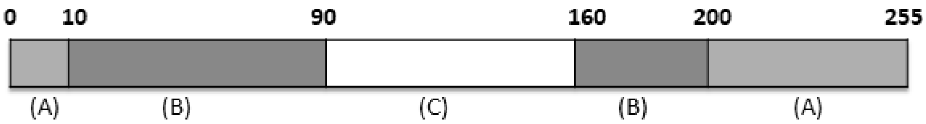

Figure 3.Breaking down the BREN scale to check image quality ((A) not suitable for recognition (B) suitable after pre-processing (C) suitable for recognition).

Additional issues include occlusion, emotive face expressions, and diverse appearances in photos. The overall recognition accuracy is greatly decreased by these issues [13]. Certain ways are needed to solve each sort of problem that has been outlined. For example, face alignment techniques can be used to handle the challenge of face recognition from various perspectives. An algorithm for identifying the type of emotion and producing a "neutral" facial expression can be used to tackle the difficulty of recognizing a person with various facial expressions. The majority of feature extraction techniques exclusively target certain issues, including head tilt or occlusion. Convolutional neural networks, for example, are deep learning techniques that have multiple layers. While each layer can address a single challenge, the combination of these layers can address a number of issues that lower recognition accuracy [34]. This work does not take these algorithms into consideration.

4. COMPUTING EXPERIMENTS

To test the effectiveness of the developed attendance system [35], we conducted computational experiments. Efficiency is defined as face recognition accuracy in the presence of unfavourable variables (see section 2.2). A database of faces was created, comprising the full names and photos of 25 students from one cohort, in order to perform computer experiments. Eighty group photos were shot in a variety of problematic situations. Three to twenty students from the face database are represented by each picture. Eight groups of photos were created based on the existence of problematic aspects in each image. The number of faces (Nfaces) in each of the 80 photos was manually tallied, and the number of faces that were correctly recognized (Ntruefaces) was used to calculate the attendance based on the accounting system’s output. The following formula was used to determine the facial recognition accuracy in a single photo:

$$accuracy = \frac{N_{truefaces}}{N_{faces}} \times 100\% \quad (1)$$

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Table1. Computational experiments

No.	Low resolution, noises	Poor lighting ness	Occlusions	Emotional expression life	Self-occlusion	Accuracy (%)
1	×	×	×	×	×	**100**
2	×	×	√	√	×	**85**
3	√	×	×	×	×	**82**
4	√	√	√	√	×	**77**
5	√	√	×	×	×	**71**
6	√	×	√	√	√	**65**
7	√	√	×	×	√	**62**
8	×	×	×	×	√	**60**
9	√	√	√	√	√	**57**

Table 1 presents the experiment findings. The "Accuracy" column displays the arithmetic average of accuracy for each photo in the group that has the designated issues or factors.

The accuracy of the system is 100% for reference faces. Accuracy drops by 15–25% when facial expressions are slanted and the head is turned. It is important to note that the system performs poorly in low light and with low resolution facial images. In these circumstances, accuracy drops by an additional 10%. Our reference face accuracy is, on average, more than 10% greater than that of comparable systems [24, 23].

5. CONCLUSION

At the moment, keeping track of student attendance plays a big role in raising the standard of specialized instruction. This procedure can be automated with the use of facial recognition technologies. We went on the most recent techniques for each step of face recognition, including identification, feature extraction, and face detection in photos. We looked at the current attendance records. There are two sorts of systems that have been identified: those that need extra training when the database of recognized faces is changed, and those that are pre-trained on common face databases and don't need extra training. Our research suggests architecture for a system that records attendance and doesn't require further training when the person database is updated. The three primary parts of the system are the web interface, face recognition, and picture capturing. Using our method based on the BREN measure, we have added image pre-processing methods to our system, which enable us to categorize image quality into three classes: not suitable for recognition, suitable for recognition after pre-processing, and suitable for recognition. Following quality classification, the image may be pre-processed (noise reduction, sharpening, brightness and color alignment increases), discarded if it is not acceptable for recognition, or left unaltered if it is determined to be suitable for recognition. The system was put into place. Computational tests were conducted to verify the efficacy of our recognition technique personnel in contrast to analogy in order to assess the accuracy of recognition.

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