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# Real-time Facial Recognition for Automated Attendance Tracking A Deep Learning Approach

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**Abstract**

The face serves as a distinctive identifier of an individual's identity. To leverage this, we present an automated system for student attendance using facial recognition technology. This system finds significant applications in various domains, particularly in security control systems. Notably, face recognition is employed in critical areas such as airport security to identify suspects, and the Federal Bureau of Investigation (FBI) utilizes it for criminal investigations.

In our proposed methodology, the process begins with video framing initiated through a user-friendly interface. The Viola-Jones algorithm is then employed to detect and segment the Region of Interest (ROI) containing the face from the video frame. In the pre-processing stage, image size scaling is performed as needed to prevent information loss. Subsequently, median filtering is applied to eliminate noise, and color images are converted to grayscale. The contrast-limited adaptive histogram equalization (CLAHE) is implemented to enhance image contrast.

For face recognition, we apply enhanced Local Binary Pattern (LBP) and Principal Component Analysis (PCA) to extract features from facial images. The enhanced LBP demonstrates superior performance compared to the original LBP, effectively reducing illumination effects and increasing the recognition rate. Following feature extraction, a comparison is made between features extracted from test and training images. Facial images are then classified and recognized based on the best result obtained from the combination of algorithms, specifically enhanced LBP and PCA.

Upon recognition, the attendance of the identified student is marked and saved in an Excel file. Additionally, unregistered students have the opportunity to register on the spot, with notifications issued if students sign in more than once. The average accuracy of recognition is reported as 100% for good-quality images, 94.12% for low-quality images, and 95.76% for the Yale Face Database when two images per person are used for training.

Keywords:CLAHE, FBI ,LBP and PCA

## I. Introduction

The primary goal of this project is to create an automated student attendance system based on face recognition. To enhance performance, this proposed approach restricts test and training images to frontal and upright facial images containing a single face. It is crucial that both test and training images are captured using the same device to maintain consistent image quality. Furthermore, for recognition, students must register in the database, and the enrolment process can conveniently take place on the spot through the user-friendly interface.

## II. Background

Recognition of faces holds significant importance in our daily lives, allowing us to identify family, friends, and familiar individuals. The intricate process of identifying human faces involves various steps, where human intelligence plays a pivotal role in receiving and interpreting information. Information is acquired through images projected into our eyes, specifically the retina, in the form of light, which is an electromagnetic wave. After visual processing by the human visual system, the shape, size, contour, and texture of objects are classified to analyze the information. Robinson-Riegler and Robinson-Riegler (2008) highlight that the analyzed information is then compared to existing representations in our memory for recognition. Building an automated system with the same face recognition capabilities as humans poses a considerable challenge. While humans face limitations in remembering numerous faces accurately, computers with extensive memory, high processing speed, and power are employed to overcome these limitations in face recognition systems.

The human face serves as a unique representation of individual identity, and face recognition is defined as a biometric method wherein an individual is identified by comparing a real-time captured image with stored images in a database (Margaret Rouse, 2012).

In contemporary times, face recognition systems are widely adopted due to their simplicity and remarkable performance. Applications range from airport protection systems and FBI investigations tracking suspects, missing children, and drug activities (Robert Silk, 2017) to social networking platforms like Facebook implementing face recognition for user-friendly photo tagging (Sidney Fussell, 2018). Additionally, companies such as Intel provide users with the ability to use face recognition for accessing online accounts (Reichert, C., 2017), and Apple allows users to unlock their iPhone X using face recognition (deAgonia, M., 2017).

The exploration of face recognition commenced in the 1960s, with Woody Bledsoe, Helen Chan Wolf, and Charles Bisson introducing a system that required administrators to locate eyes, ears, nose, and mouth in images. Further advancements were made by Goldstein, Harmon, and Lesk in 1970, incorporating features like hair color and lip thickness for automated recognition. In 1988, Kirby and Sirovich proposed the use of Principal Component Analysis (PCA) to address face recognition challenges. The journey of face recognition research has continued with numerous studies conducted over the years (Ashley DuVal, 2012).

**Problem Statement**

The conventional technique for marking student attendance often encounters various challenges. The face recognition student attendance system aims to simplify this process by eliminating traditional methods such as calling out student names or checking identification cards. These traditional techniques not only disrupt the teaching process but also pose distractions for students during exams. Attendance sheets are commonly circulated during lecture sessions, especially in classes with a large number of students, leading to logistical difficulties. To address these issues, the face recognition student attendance system is proposed, replacing manual attendance signing, which is cumbersome and distracts students. Additionally, this automated system mitigates fraudulent approaches, sparing lecturers from the need to repeatedly count the number of students to ensure their presence.

Zhao et al.'s paper (2003) outlines the challenges of facial identification, particularly the difficulty in distinguishing between known and unknown images. Pooja G.R et al.'s study (2010) highlights the slow and time-consuming training process for the face recognition student attendance system. Furthermore, Priyanka Wagh et al.'s paper (2015) identifies issues such as different lighting conditions and head poses that can degrade the performance of face recognition-based student attendance systems.

Therefore, there is a compelling need to develop a real-time student attendance system where the identification process occurs within defined time constraints to prevent omissions. The extracted features from facial images, representing student identity, must remain consistent despite changes in background, illumination, pose, and expression. The system's evaluation criteria should prioritize high accuracy and fast computation time.

**III. Existing System**

ArunKatara et al. (2017) have highlighted the drawbacks of various identification systems, including the RFID (Radio Frequency Identification) card system, fingerprint system, and iris recognition system. While the RFID card system is chosen for its simplicity, it has the drawback that users may assist their friends by checking in with their friend's ID card. The fingerprint system, although effective, is not efficient as it requires a time-consuming verification process, leading to users having to queue and perform verification individually. On the other hand, iris recognition systems, despite containing more detailed information, may raise privacy concerns due to the invasive nature of capturing intricate details of the user's eyes. Voice recognition, another available method, is found to be less accurate compared to other alternatives.

Given these considerations, the face recognition system is recommended for implementation in the student attendance system. The human face, always exposed, provides sufficient information for accurate identification without the privacy concerns associated with iris recognition. This approach combines effectiveness with user convenience, making it a suitable choice for enhancing the efficiency of the attendance tracking process.

| System type | Advantages | Disadvantages |
| --- | --- | --- |
| RFID card system | Simple | Fraudulent usage |
| Fingerprint system | Accurate | Time-consuming |
| Voice recognitionsystem | - | Less accurate compared to others |
| Iris recognitionsystem | Accurate | Privacy Invasion |

**Table 3.1 - Advantages & Disadvantages of Different Biometric System**

**IV. Proposed System**

There is a common misunderstanding regarding the distinction between face detection and face recognition. Face detection involves determining the face segment or face region within an image, while face recognition goes a step further by identifying the owner of the facial image. S.Aanjanadevi et al. (2017) and Wei-Lun Chao (2007) have outlined several factors that contribute to the challenges faced by both face detection and face recognition. These factors encompass background, illumination, pose, expression, occlusion, rotation, scaling, and translation, with detailed definitions provided in Table 4.1.

| | |
| --- | --- |
| Background | Variation of background and environment around people in the image which affect the efficiency of face recognition. |
| Illumination | Illumination is the variation caused by various lighting |

  

| | |
|---|---|
| | environments which degrade the facial feature detection. |
| Pose | Pose variation means different angle of the acquired the facial image which cause distortion to recognition process, especially for Eigen face and Fisher face recognition method. |
| Expression | Different facial expressions are used to express feelings and emotions. The expression variation causes spatial relation change and the facial-feature shape change. |
| Occlusion | Occlusion means part of the human face is unobserved. This will diminish theperformanceoffacerecognitionalgorithms due to deficiency information. |
| Rotation, scaling and translation | Transformation of images which might cause distortion of the original information about the images. |

**Table 4.1 - Factors Causing Face Detection Difficulties**

Several face detection methods have been explored by previous researchers, with a predominant focus on using frontal upright facial images containing a single face, fully exposed and free from obstructions like spectacles.

Researchers such as AksharaJadhav et al. (2017) and P. ArunMozhi Devan et al. (2017) have recommended the Viola-Jones algorithm for face detection in student attendance systems. They observed that, among various methods like face geometry-based approaches, Feature Invariant methods, and Machine learning-based methods, the Viola-Jones algorithm stands out for its speed, robustness, high detection rate, and superior performance in different lighting conditions. This sentiment is echoed by Rahul V. Patil and S. B. Bangar (2017), who also highlighted the Viola-Jones algorithm's effectiveness in varying lighting conditions. MrunmayeeShirodkar et al. (2015) emphasized the Viola-Jones algorithm's capability to address illumination, scaling, and rotation issues. Moreover, Naveed Khan Balcoh (2012) asserted that the Viola-Jones algorithm is the most efficient among various alternatives, including the AdaBoost algorithm, Float Boost algorithm, Neural Networks, S-AdaBoost algorithm, Support Vector Machines (SVM), and the Bayes classifier.

In a study conducted by Varsha Gupta and Dipesh Sharma (2014), Local Binary Pattern (LBP), Adaboost algorithm, local successive mean quantization transform (SMQT) Features, sparse network of winnows (SNOW) Classifier Method, and Neural Network-based face detection methods were compared alongside the Viola-Jones algorithm. Their conclusion highlighted that the Viola-Jones algorithm exhibits the highest speed and accuracy among all methods. While methods like Local Binary Pattern and SMQT Features offer simplicity and the ability to handle illumination issues, their overall performance falls short of the Viola-Jones algorithm for face detection. A comprehensive evaluation of the advantages and disadvantages of these methods is presented in Table 4.2.

  

| Face detection method | Advantages | Disadvantages |
|---|---|---|
| Viola jones algorithm | 1. High detection speed<br>2. High accuracy. | 1. Long training time.<br>2. Limited head pose.<br>3. Not able to detect dark faces. |
| Local Binary pattern | 1. Simple computation.<br>2. Hightolerance against the monotonic illumination changes. | 1. Only used for binary and grey images.<br>2. Overall performance is inaccurate compared to Viola-Jones algorithm. |
| AdaBoost algorithm (part ofViola jones algorithm) | 1. Need not to have any prior knowledge about face structure. | 1.The result highly depends on the training data and affected by weak classifiers. |
| SMQT Features and SNOW Classifier Method | 1. Capable to deal with lighting problem in object detection.<br>2. Efficientin computation. | 1.The region contain very similar to grey value regions will be misidentified as face. |
| Neural-Network | 1. High accuracy only if large size of image were trained. | 1.Detection process is slow and computation is complex.<br>2.Overall performance is Weaker than Viola-Jones algorithm. |

**Table 4.2 - Advantages & Disadvantages of Face Detection Methods**

**Viola-Jones Algorithm**
The Viola-Jones algorithm, pioneered by P. Viola and M. J. Jones (2001), stands out as the most widely used algorithm for localizing facial segments in static images or video frames. The fundamental concept of the Viola-Jones algorithm comprises four key components. The initial part involves Haar features, followed by the creation of an integral image in the second step. The third part entails the implementation of Adaboost, and finally, the process is completed with cascading.

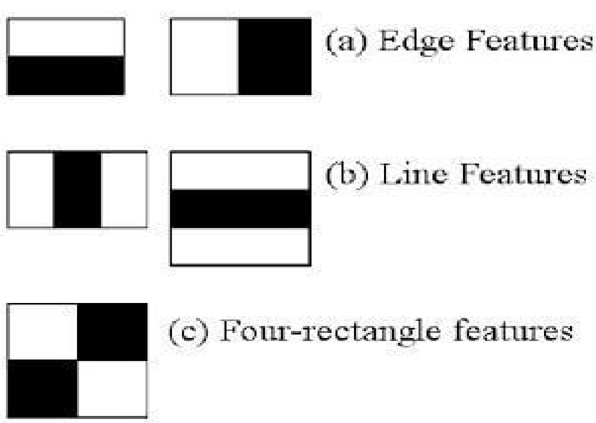


**Figure 4.2.1 - Haar Feature (Docs.opencv.org, 2018)**

  

Viola-Jones algorithm analyses a given image using Haar features consisting of multiple rectangles (Mekha Joseph et al., 2016). Figure 2.1 shows several types of Haar features. The features perform as window function mapping onto the image. A single value result, which representing each feature can be computed by subtracting the sum of the white rectangle(s) from the sum of the black rectangle(s) (Mekha Joseph et al., 2016). The illustration is shown in Figure 4.2.2.

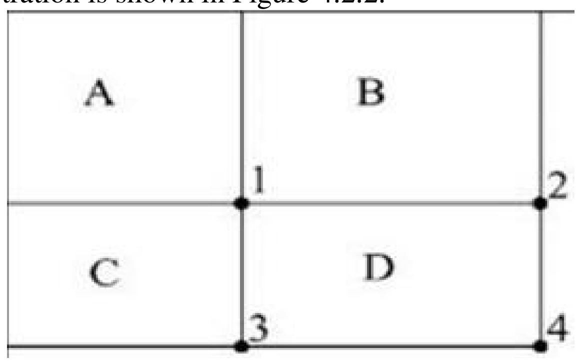


**Figure 4.2.2 - Haar Feature (Docs.opencv.org, 2018)**

The integration of an image in a specific location is determined by the sum of pixels on the left and top of the respective location. To provide a clear illustration, the value of the integral image at location 1 is the sum of pixels in rectangle A. The cumulative nature of integral image values is evident, where the value at location 2 is the summation of A and B (A + B), at location 3 is the summation of A and C (A + C), and at location 4 is the summation of all regions (A + B + C + D) (SrushtiGirhe et al., 2015). Consequently, the sum within the D region can be computed with simple addition and subtraction by considering the diagonal at location 4 + 1 − (2 + 3) to eliminate rectangles A, B, and C.

As noted by BurakOzen (2017) and Chris McCormick (2013), Adaboost, also known as 'Adaptive Boosting,' is a widely recognized boosting technique that combines multiple "weak classifiers" into a single "strong classifier." The training set for each new classifier is selected based on the results of the previous classifier, determining the weight given to each classifier to make it significant.

However, the application of Adaboost may lead to false detections, requiring manual removal based on human vision. Figure 4.2.3 provides an example of false face detection, indicated by a blue circle.

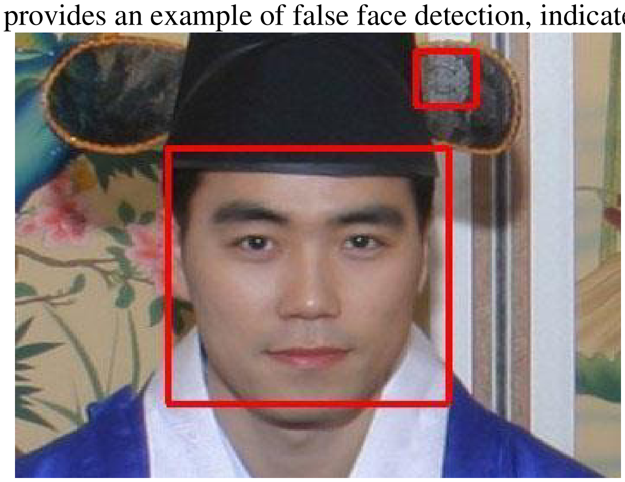

**Figure 4.2.3 - False Face Detection (Kihwan Kim, 2011)**

**Pre-Processing**

In the study conducted by Subhi Singh et al. (2015), it was recommended to perform pre-processing by cropping the detected face and converting the color image to grayscale. Additionally, they proposed applying an affine transform to align the facial image based on coordinates in the middle of the eyes and performing scaling of the image.

Similarly, ArunKatara et al. (2017), AksharaJadhav et al. (2017), and ShireeshaChintalapati, and M.V. Raghunadh (2013), in their respective papers, suggested the application of histogram equalization to facial images and scaling of images during pre-processing.

The significance of pre-processing in enhancing system performance cannot be understated, as it plays a crucial role in improving the accuracy of face recognition. Among the essential pre-processing steps, scaling stands out as a key technique to manipulate image size. Scaling down an image contributes to increased processing speed by reducing computational demands, given the reduction in the number of pixels. Image size and pixels convey spatial information, which, according to Gonzalez, R. C., and Woods (2008), is a measure of the smallest discernible detail in an image. It is imperative to manipulate spatial information with care to avoid image distortion and prevent the checkerboard effect. Maintaining uniform image size across all images is crucial for normalization and standardization purposes.

In line with these considerations, Subhi Singh et al. (2015) advocated the use of Principal Component Analysis (PCA) for feature extraction from facial images, emphasizing the preference for images with the same length and width, scaled to 120 × 120 pixels. This approach aligns with the broader objective of standardizing image dimensions to enhance the effectiveness of subsequent image processing steps.

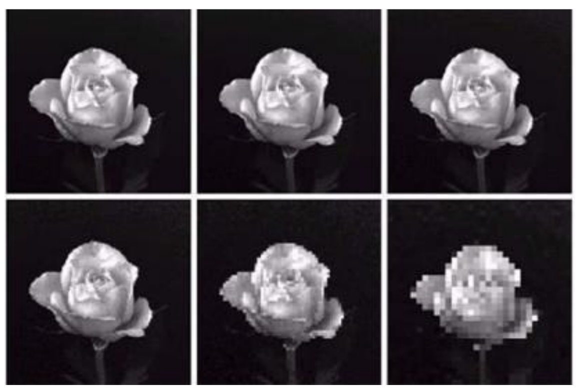

**Figure 4.2.4- Images Show Checkerboard Effect Significantly Increasing from Left to Right (Gonzalez, R. C., & Woods, 2008)**

In addition to image scaling, the common practice in pre-processing involves converting a color image to a grayscale image. Grayscale images are deemed less sensitive to illumination conditions and demand less computational time. A grayscale image is an 8-bit image where the pixel values range from 0 to 255, while a color image is a 24-bit image with pixel values spanning 16,777,216. Consequently, color images necessitate more storage space and computational power compared to grayscale images, as noted by Kanan and Cottrell (2012). When color information is unnecessary for computation, it is regarded as noise. Moreover, pre-processing plays a crucial role in enhancing image contrast.

In the work of Pratiksha M. Patel (2016), it is highlighted that histogram equalization is a pre-processing method employed to enhance image contrast. This technique ensures a uniform distribution of intensities across the intensity level axis, effectively reducing uneven illumination effects.

  

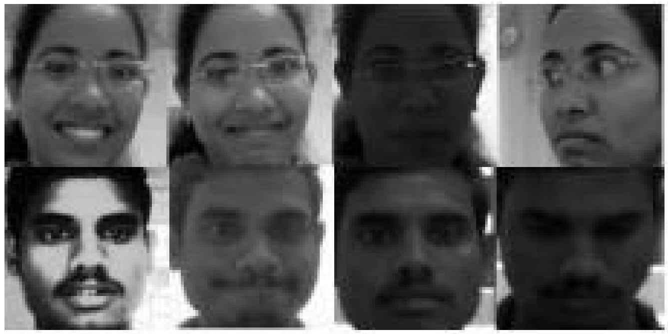

**Figure 4.2.5 - Facial Images Were Converted To Grayscale, Histogram Equalization Was Applied and Images Were Resized to 100x100 (ShireeshaChintalapati and M.V. Raghunadh, 2013)**

Several techniques exist to enhance image contrast beyond Histogram Equalization. Neethu M. Sasi and V. K. Jayasree (2013) conducted a study on both Histogram Equalization and Contrast Limited Adaptive Histogram Equalization (CLAHE) to improve myocardial perfusion images. In a study by Aliaa A. A. Youssif (2006), contrast enhancement and illumination equalization methods were explored for the segmentation of retinal vasculature. Additionally, a paper by A., I., and E.Z., F. (2016) delved into Image Contrast Enhancement Techniques and their performance. Unlike Histogram Equalization, which operates on the entire image data, CLAHE works on small regions throughout the image. Consequently, Contrast Limited Adaptive Histogram Equalization is considered to surpass conventional Histogram Equalization.

**Feature Extraction**

A feature is a dataset that encapsulates the information within an image, and its extraction is crucial for effective face recognition. However, the process of selecting features can be challenging, necessitating a feature extraction algorithm that is consistent and stable across various changes to ensure high accuracy results.

Several methods for feature extraction in face recognition exist. In the works of Bhuvaneshwari et al. (2017), Abhishek Singh and Saurabh Kumar (2012), as well as Liton Chandra Paul and Abdulla Al Sumam (2012), PCA (Principal Component Analysis) is proposed for face recognition. D. Nithya (2015) also utilized PCA in a face recognition-based student attendance system. PCA is renowned for its robustness and high-speed computation. Essentially, PCA preserves data variation while eliminating unnecessary correlations among original features. It serves as a dimension reduction algorithm, compressing each facial image represented by a matrix into a single column vector. Additionally, PCA centralizes image data by removing the average value from each image. The distribution of facial images' principal components is known as Eigenfaces, where each facial image from the training set contributes to these Eigenfaces. Consequently, Eigenfaces encode the best variations among known facial images. Training and test images are then projected onto Eigenface space to obtain projected training images and projected test images, respectively. Recognition is performed by computing the Euclidean distance between the projected training images and the projected test image. The PCA feature extraction process encompasses all trained facial images, leading to the extracted feature containing correlations between facial images in the training set. Therefore, the recognition results of PCA heavily depend on the composition of the training set.

  

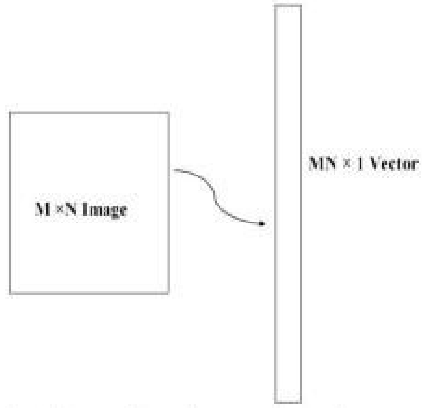


**Figure 4.2.6 - PCA Dimension Reduction (Liton Chandra Paul and Abdulla Al Sumam, 2012)**

Linear Discriminant Analysis (LDA), also known as Fisher face, stands as a widely recognized algorithm for face recognition. In a paper authored by Suman Kumar Bhattacharyya and Kumar Rahul (2013), LDA was introduced as a solution for face recognition. LDA operates by extracting features through the grouping of images belonging to the same class while effectively separating images from different classes. Its capacity to perform well under various conditions, such as different facial expressions, illumination, and poses, is attributed to its characteristic of class separation.

In the context of LDA, the term "same class" refers to facial images of the same individual, even with differences in facial expressions, lighting conditions, or poses. On the other hand, facial images belonging to individuals with distinct identities are categorized into different classes. The within-class scatter matrix is computed based on images within the same class, while the between-class scatter matrix is derived from images of different classes. LDA aims to maximize the ratio of the determinant of the between-class scatter matrix to the determinant of the within-class scatter matrix. It is generally acknowledged that LDA tends to yield lower error rates compared to PCA, especially when a larger number of samples per class are used for training, coupled with a small size of different classes.

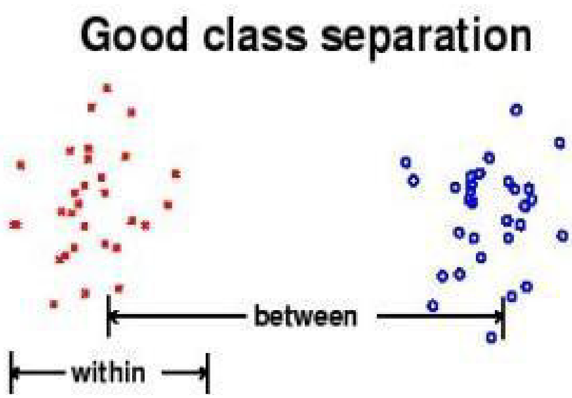


**Figure 4.2.7 - Class Separation in LDA (Suman Kumar Bhattacharyya and Kumar Rahul, 2013)**

The original Local Binary Patterns (LBP) operator was first introduced in a paper by TimoOjala et al. (2002). In the work of Md. Abdur Rahim et al. (2013), they suggested using LBP to capture both texture details and contours for representing facial images. The process involves dividing each facial image into smaller regions, and a histogram is extracted for each region. These histograms are then concatenated into a single feature vector, serving as the representation of the facial image. To measure similarities between facial images, the Chi-square statistic is employed.

  

In this approach, the smallest window size for each region is set at 3 by 3. The computation involves thresholding each pixel in a window, where the middle pixel serves as the threshold value. Pixels in the neighborhood greater than the threshold value are assigned the value 1, while those lower than the threshold value are assigned 0. Consequently, the resulting binary pixels form a byte value that represents the center pixel.

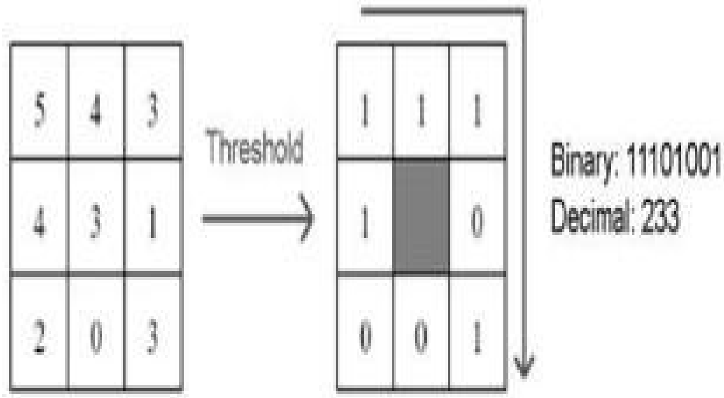


**Figure 4.2.8 - LBP Operator (Md. Abdur Rahim et.al, 2013)**

LBP enjoys several advantages that contribute to its widespread implementation. It exhibits a high tolerance for monotonic illumination changes and can effectively handle various facial expressions, image rotations, and the aging of individuals. These robust characteristics have led to the widespread use of LBP in real-time applications.

Initially utilized solely for face detection, neural networks have undergone further exploration for implementation in face recognition. In the study conducted by Manisha M. Kasar et al. (2016), Artificial Neural Network (ANN) was investigated for its efficacy in face recognition. The ANN comprises a network of artificial neurons referred to as "nodes," functioning similarly to the human brain in terms of recognition and classification. These nodes are interconnected, and values are assigned to determine the strength of their connections, where a high value indicates a strong connection. Neurons are categorized into three types of nodes or layers: input nodes, hidden nodes, and output nodes. Input nodes are assigned weights based on their impact, while hidden nodes incorporate mathematical and thresholding functions to predict probabilities and filter unnecessary inputs. The resulting output is produced at the output nodes, and multiple hidden layers can be employed for enhanced processing.

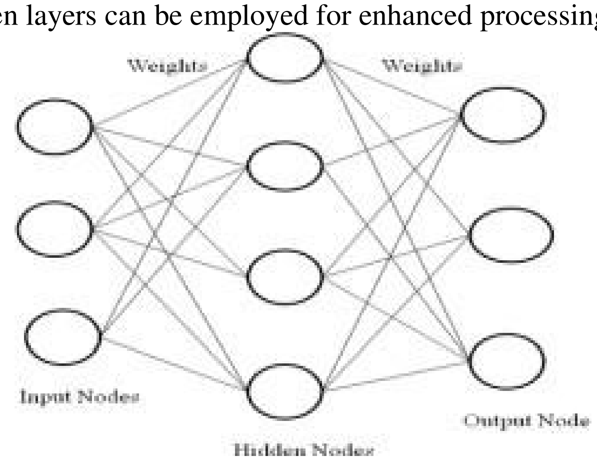


**Figure 4.2.9 - Artificial Neural Network (ANN) (Manisha M. Kasar et al., 2016)**

  

The Convolutional Neural Network (CNN) stands out as another neural network algorithm designed for face recognition. Much like the Artificial Neural Network (ANN), CNN comprises the input layer, hidden layer, and output layer. The hidden layers of a CNN are composed of various layers, including convolutional layers, pooling layers, fully connected layers, and normalization layers. However, achieving accurate performance with CNN requires training on a substantial dataset, often involving thousands or millions of facial images. The training process is time-consuming, exemplified by applications like Deep face introduced by Facebook.

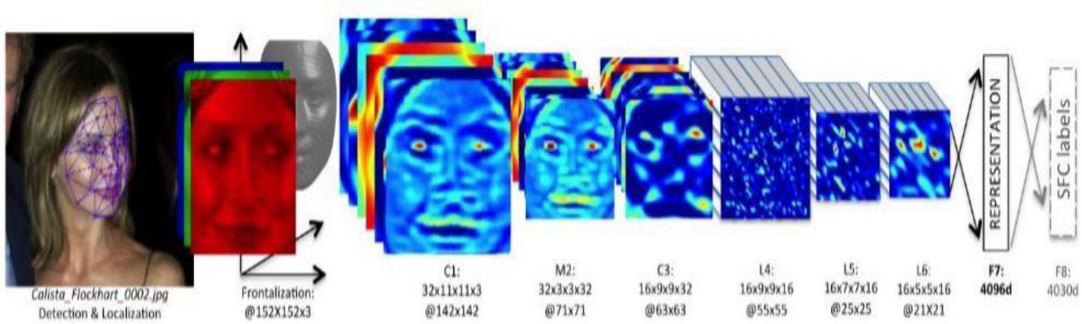


**Figure 4.2.9 - Deepface Architecture by Facebook (YanivTaigman et al, 2014)**

**V. System Methodology**

While our primary focus is on utilizing our own database for designing a real-time face recognition student attendance system, we also leverage databases provided by previous researchers to enhance system efficiency, effectiveness, and for evaluation purposes.

The Yale face database serves a dual role as both a training set and a testing set to assess system performance. Comprising one hundred and sixty-five grayscale images of fifteen individuals, the Yale face database includes eleven images per individual, each captured under different conditions. These conditions encompass variations such as centre-light, with glasses, happy, left-light, without glasses, normal, right-light, sad, sleepy, surprised, and wink. The diverse scenarios provided by this database ensure that the system operates consistently across a range of situations and conditions.

For our proprietary database, student images are captured using both a laptop's built-in camera and a mobile phone camera. Each student contributes four images, with two allocated to the training set and two to the testing set. Images captured with the laptop's built-in camera are categorized as low-quality, while those captured with the mobile phone camera are considered high-quality. The high-quality image set comprises images of seventeen students, while the low-quality image set includes images of twenty-six students.

**Figure 5.1 - Sample Images in Yale Face Database (Cvc.cs.yale.edu, 1997)**

  

**Figure 5.2 - Sample of High Quality Images**

**Figure 5.3 - Sample of Low Quality Images**

**Limitations of the Images**

The proposed approach requires the input image to be frontal, upright, and feature only a single face. While the system is capable of recognizing students with or without glasses, it is essential for students to provide both facial images, one with glasses and one without, for training purposes. This helps enhance accuracy in recognizing students without glasses. To maintain consistency, both the training and testing images must be captured using the same device, preventing any variations in image quality.

Students are required to register to facilitate recognition, and the enrollment process is conveniently conducted on the spot through a user-friendly interface. Adhering to these conditions is crucial to ensure optimal performance of the proposed approach.

**Face Detection**

The Viola-Jones object detection framework will be employed for face detection in the video camera recording frame, as explained in before. However, it's important to note that the Viola-Jones framework has a limitation— it requires facial images to be frontal and upright, with the individual facing the camera within a video frame.

**Pre-Processing**

Images from the testing set and training set are captured using a camera, introducing unwanted noise and uneven lighting. To address these issues, several pre-processing steps are deemed necessary before proceeding to feature extraction.

Among the pre-processing steps undertaken are image scaling, median filtering, conversion of color images to grayscale images, and adaptive histogram equalization. Subsequent sections will delve into the specifics of these steps.

  

**Scaling of Image**

Image scaling is a routine task in image processing, crucial to prevent the loss of spatial information. (Gonzalez, R. C., & Woods, 2008) To ensure precise outcomes, especially in the feature extraction process, it is essential for test images and training images to be standardized to the same size and dimension. In this proposed approach, both test and training images are set to a standardized size of 250 × 250 pixels.

**Median Filtering**

Median filtering, known for its robust noise reduction capabilities, is widely applied in various applications. This method effectively removes unwanted noise while retaining useful details in images. As the color images captured by the camera are in RGB format, median filtering is executed on three distinct channels of the image. Figure 3.3 illustrates the image before and after noise removal through median filtering across the three channels. If the input image is grayscale, median filtering can be directly performed without channel separation.

**Figure 5.4 - Median Filtering Done on Three Channels**

**Figure 5.5 - Median Filtering Done on a Single Channel**

**Conversion to Grayscale Image**

The camera captures color images; however, the proposed method for contrast improvement, CLAHE, can only be applied to grayscale images. The application of CLAHE enhances the contrast, effectively reducing the illumination effect in the images. To facilitate subsequent steps, color images need to be converted into grayscale images. This conversion is necessary for the Local Binary Pattern (LBP) to extract grayscale features from the contrast-improved images, represented as 8-bit texture descriptors (Ojala, T. et al., 2002). Converting color images to grayscale not only enables effective contrast enhancement but also reduces the computational complexity, leading to a higher speed of computation (Kanan and Cottrell, 2012). Figure 5.2 illustrates the process of converting images to grayscale.

  

**Figure 5.6- Conversion of Image to Grayscale Image**

**Contrast Limited Adaptive Histogram Equalization**

Histogram equalization or histogram stretching is a technique of image contrast enhancement. (Pratiksha M. Patel, 2016). The contrast improvement is usually performed on the grayscale images. Image contrast is improved by stretching the range of its pixel intensity values to span over the desired range of values, between 0 and 255 in grayscale. The reason that Contrast Limited Adaptive Histogram Equalization (CLAHE) is used instead of histogram equalization is because histogram equalization depends on the global statistics. Hence, it causes over enhancement of some parts of image while other parts are not enhanced properly. This distorts the features of the image. It is a serious issue because the features of the image have to be extracted for the face recognition. Thus, CLAHE which is depend on local statistic is used.

**Figure 5.7- Contrast Improvement**

**Feature Extraction**

Variations in facial images imply alterations in textural or geometric information. To enable face recognition, it becomes necessary to extract and classify these features from the facial images accurately. In this project, the approach involves utilizing enhanced Local Binary Pattern (LBP) and Principal Component Analysis (PCA) for face recognition. The inspiration for this methodology is drawn from the nature of human visual perception, which relies on both local and global statistical features for effective face recognition. Enhanced LBP focuses on extracting local grayscale features by performing feature extraction on small regions across the entire image. Conversely, PCA emphasizes the extraction of global grayscale features, entailing feature extraction conducted on the entirety of the image.

## VI. Conclusion and Research Scope

**Conclusion:**

In this study, we have successfully developed a face recognition student attendance system featuring a user-friendly interface, implemented through MATLAB's Graphic User Interface (GUI). The interface incorporates various functionalities, with designated buttons serving specific purposes. The 'Start' button initializes the camera and automatically performs face recognition based on the detected face. The 'Register' button facilitates the enrolment or registration of students, while the 'Update' button trains the system with the latest images added to the database. Additionally, the 'Browse' button enables the selection of facial images from a specified database, and the 'Recognize' button tests the system's functionality by recognizing the chosen image.

  

Furthermore, we have adopted an enhanced Local Binary Pattern (LBP) with a radius of two as the proposed algorithm in this approach. The rationale behind choosing this specific radius size will be elaborated upon in the discussion section.

**Research Scope:**

While this study has successfully introduced a face recognition student attendance system with a MATLAB GUI, there are several avenues for future research and improvement. Firstly, the system's performance can be enhanced by exploring and incorporating advanced facial recognition algorithms or techniques. Additionally, the scope can be extended to investigate the system's robustness in various environmental conditions, such as different lighting and poses.

Furthermore, the user interface can be refined for better usability and accessibility. Integration with cloud-based solutions and real-time data processing can also be explored to enhance the system's scalability and efficiency. Moreover, investigating the security aspects of the system, particularly in preventing unauthorized access or manipulation, would be a valuable area for future research.

In conclusion, the proposed face recognition student attendance system lays the foundation for further research and development, offering possibilities for refinement, enhancement, and expansion to address evolving challenges and requirements in attendance tracking systems.

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