COMPARATIVE ANALYSIS OF APPEARANCE-BASED FEATURE EXTRACTION TECHNIQUES IN FACE RECOGNITION: PROPOSED STUDY

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Abstract: *The necessary step that must be considered in developing efficient face recognition is feature extraction. The recognition accuracy of a face is determined by the amount of measurable and relevant features extracted from the face image. A number of feature extraction methods in appearance-based technique such as commonly used linear subspace techniques: Linear Discriminant Analysis (LDA), Locality Preserving Projections (LPP) Independent Component Analysis (ICA) and Principal Component Analysis (PCA) have been used in face recognition. The focus of this paper is to conduct comparative analysis on three appearance-based feature extraction algorithms: Linear Discriminant Analysis, Locality Preserving Projections and Principal Component Analysis by applying Contrast Limited Adaptive Histogram Equalization (CLAHE) approach to further know the influence on the performance of face recognition system.*

1. INTRODUCTION

Face recognition is a physiological approach of biometric system that identifies or verifies individual based on feature vectors derived from face image [1]. The extraction of features can be referred to as representation of original image in a measurable form in order to simplify decision making such classification and pattern detection [2]. The process of finding reliable and discriminative features is seen to be an essential phase in image processing and computer vision task [3]. Feature extraction remains one of the most significant steps in pattern recognition, which major purpose is to obtain reduced features accurately for classification [4].

The extraction of facial feature is one of the principal components and attempted problems in computer vision, it performs two vital functions: converts input vector into a feature vector and also reduces its dimensionality [5] [6]. In complex data analysis or pattern recognition such as face image data, part of the key problems encounter is amount of features involved. It is very important to extract a well-defined feature just to make the process of recognition more effective and accurate. The face representation is a predominant phase that should be correctly observed before classification [7].

Faces not properly represented can affect the performance of classifier. Analyzing huge volume of features normally involve a large memory usage and computation power. The feature extraction major task is to obtain only the important information from the input features to accomplish the desired function based on the representation of reduced form of the complete features input [8]. The techniques developed for feature extraction can be divided into two main categories: geometrical (feature-based) and appearance-based approaches [9].

The techniques of geometric normally involve distinct features which include nose, eyes, mouth and a head structure to be employed in designing a face recognition model using the dimension and point of these characteristics. Appearance-based approach applies statistical values for extraction, in which large set of images of face are to be detected using statistical or machine learning techniques [10].

This technique considers a face image as patterns of two dimensions; theory of feature in this method is unlike the simple facial features such as eyes and mouth. Appearance method is identified to be an efficient facial feature extraction approach due to its ability to reject the redundant information and also retain significant information of image [11] .

Feature extraction using appearance-based techniques have been considered for its efficiency in dimensionality reduction ability in computer vision applications like face recognition system [4]. Several feature extraction techniques under appearance-based approach have been applied such as Fisher Linear Discriminant Analysis (LDA), Principal Component Analysis (PCA), Locality Preserving Projections (LPP), Discrete Cosine Transform (DCT), Discrete Wavelet Transform (DWT) and Independent Component Analysis (ICA) [12].

The proposed study will conduct a comparative analysis on three appearance-based feature extraction methods; PCA, LDA and LPP in facial recognition system in order to reveal which one performs better in face recognition system with respect to application illumination control technique on three techniques.

2. FEATURE EXTRACTION

Feature extraction is a method of defining a set of features which shows representation of information that is essential for analysis and classifying images into different classes in pattern recognition [13]. The principal problem in facial recognition is how to extract information from face images or photographs. Extraction of features can be seen as the procedure of obtaining important information from a face image. This information must be valuable to the next stage of identifying the subject with a standard error rate. The feature extraction process must be efficient in terms of computing time and memory usage, output should also be optimized for the classification step.

Different feature extraction techniques can be grouped into two main categories: appearance-based (holistic) approach, and feature-based (geometric) approach [14].

2.1 Appearance-Based Approach

In appearance-based approach, the entire face region is taken into consideration as input image data to the system [15]. It processes the face image as two dimensional patterns, concept of feature in this approach is different from simple facial features such as eyes and mouth. Any extracted characteristic from the image is referred to a feature. The technique finds the best in facial feature extraction because it keeps the important information of image and rejects the redundant information. There are several techniques in appearance-based which include; Principal Component Analysis (PCA), Linear Discriminant Analysis (LDA), Local Preserving Projections (LLP), Independent Component Analysis (generalization of PCA) and Linear Discriminant Analysis (LDA) [13].

2.1.1 Linear Discriminant Analysis (LDA)

This technique is also known as fisherface [16]. LDA is a powerful technique for data reduction and feature extraction used for the development of facial recognition system [17], it produces an efficient representation that linearly transforms the original data space into a low-dimensional feature with focus on most discriminant features (perform dimensionality reduction while preserving as much of class discriminatory information as possible)[18]. The technique gives reference to feature vectors in underlying space that best represent the best discriminate features among classes rather than best describing data. LDA projects a face image from high dimensional image space to a low-dimensional image by computing transformation that maximizes the between class scatter while minimizing the within class scatter.

2.1.1 Principal Component Analysis (PCA)

PCA is usually employed for feature extraction and data representation in computer vision and pattern recognition such as face recognition [19]. It is commonly used for reducing number of facial features for face recognition [20][21]. It searches for a set of representative projection feature vectors such as that the projected samples retain most information about original samples [22]. The PCA method applies a vector space transform

to reduce the dimensionality of large database. Applying mathematical projection that transforms a number of possibly correlated variables into a smaller number of uncorrelated variables called principal components [23].

2.1.3 Local Preserving Projections (LPP)

Linearity Preserving Projection (LPP) is an approach of feature extraction in which its focus is majorly to combine the benefits of linear techniques and local nonlinear techniques of dimensionality reduction by finding a linear mapping that minimizes the cost function of Laplacian Eigenmaps [24]. LPP represents a linear approximation of the nonlinear Laplacian Eigenmaps, when high-dimensional data lies on a low dimension manifold embedded in the data space. The technique preserves the local structure of the data, this is unlike PCA and LDA that preserve the global structure of features or data [25].

2.2 Feature-Based Approach (Geometric Approach)

The feature-based method gives the key emphasis on the facial features like eyes, nose, and mouth as well as other fiducial marks to build up model based on the position and size of these characteristics to form a feature vector. Standard statistical pattern recognition methods are then applied to match faces using these measurements. Approaches under the feature-based technique include; Elastic Bunch Graph Matching (EBGM), Local Binary Pattern (LBP) and Gabor-filter [26]. The feature vector represents the face geometric relationships among facial points, thus reducing the input facial image to a vector of geometric features [27]. The distance between the features get detected which is used to represent a face image. This is the simplest and earliest technique for face recognition system. The problem with this technique is that is unable to identify faces with variations in illumination and viewpoint as well as not reliable with respect to time.

2.3 Illumination Normalization Technique

Illumination normalization is a process which involves the reduction of lighting effect in image processing. The technique of illumination normalization remains an important preprocessing step for many operations such as face tracking, face detection and face recognition. All these operations are essential for many applications including video surveillance, object-based video coding and human computer interaction. It is well known that the image gray-level (image colour) is very sensitive to the lighting variations. The same object with different illuminations may produce considerably different images [28]. Illumination normalization techniques in face recognition system include: histogram equalization (H), adaptive histogram equalization (AHE) and contrast limited adaptive histogram equalization (CLAHE)

2.3.1 Histogram Equalization

In this technique, an image contrast is adjusted or enhanced using image's histogram[29]. The equalization of histogram is used to remap gray levels of image based on probability distribution function (PDF) of input image gray level [30]. Histogram equalization (HE) flattens the histogram and stretches dynamic range of gray levels to perform overall contrast enhancement [31] [32].

2.3.2 Adaptive Histogram Equalization

The technique is an enhancement of histogram equalization method. It improves the contrast of image by transforming the values in the intensity of the image [33]. These operations are performed on small data regions (tiles), instead of on the entire image. The contrast of each small data is enhanced, so that the histogram of the output region approximately matches the particular histogram. Then, the neighboring tiles are combined using bilinear interpolation so that the artificially induced boundaries are eliminated.

2.3.3 Contrast Limited Adaptive Histogram Equalization

It is an improved version of adaptive histogram equalization in which an image contrast is enhanced by applying image's histogram [29]. The equalization of histogram is used to remap gray levels of image based on Probability Distribution Function (PDF) of input image gray level [30]. Histogram equalization (HE) flattens the histogram and stretches dynamic range of gray levels to perform overall contrast enhancement. The image contrast enhancement

or improvement is a classical problem in computer vision and image processing [32].

3. RELATED WORK

Several studies have been proposed for which different feature extraction techniques employed by researchers to develop face recognition system. These studies include:

[10] conducted a comparative survey on some feature extraction techniques available in face detection. The study considered different feature extraction algorithms like Discrete Wavelet Transformation (DWT), Scale Invariant Fourier Transform (SIFT), Linear Discriminate Analysis (LDA), Principal Component Analysis (PCA). It was recommended that better results would be produced, if Discrete Wavelet Transform has been hybridized with other mentioned techniques.

[34] presented an overview of several feature extraction methods in different researches for face recognition in the field of digital image processing and also suggested an approach for using these feature extraction techniques for efficient face recognition.

[35] conducted a review on different face recognition techniques and technologies; knowledge based, feature based, template based and image based with their advantages and limitations. The study will help to provide insight and also aid the development of more effective algorithms.

[36] performed a comparative analysis on face recognition system. The study mentioned two methods; the Linear Discriminant Analysis, Elastic Bunch Graph Matching (EBGM) and Principal Component Analysis (PCA). The literature survey gave a brief comparative study between the features of face recognition techniques and also discussed the performance under different environmental conditions.

[37] presented a comparative study on various extraction of feature methods; Singular Value Decomposition (SVD), Principal Component Analysis (PCA) for facial expressions and emotion recognition. The result revealed that the recognition accuracy of combined PCA with SVD outperformed PCA approach. It was demonstrated that combination of SUSAN edge detector, edge projection analysis, and geometry distance measure are the best combination to locate for gray scale images in constrained environments. The feed forward back-propagation neural network was used to recognize the facial expression. 100% accuracy was achieved for training set and 95.26% accuracy was achieved for test set of JAFFE database.

[38] came up with an investigation to reveal the efficiency of the combination of Independent Component Analysis (ICA) with Gabor algorithm (I-Gabor) as feature extraction. The features were obtained from eye and nose of known faces using Gabor and I-Gabor. The Support Vector Machine was used for local characteristics classification of facial features regions. The performance of classification algorithms was evaluated based on the false acceptance rate, false rejection rate and accuracy. The experimental results recorded 4.4 % of FAR, 5.3 % of FRR, 87.7 % of accuracy for Gabor feature extraction method and 2.8 % of FAR, 3.9 % of FRR, 94.9 % of accuracy for Gabor-Independent Component Analysis method.

[24] applied several linear subspace techniques to perform two significant tasks; reduction of dimensionality and loss of performance in classification due to facial appearance variations. The design of experiments was carried out specifically to investigate the gain invariant to illumination and changes in facial expression. The reduction of dimensionality techniques were used to choose relevant feature vectors of face and also searched those parts that are less sensitive to intrinsic deformations due to expression or extrinsic factors like illumination. For training and testing Support Vector Machine (SVM) is selected as the classifying function. The proposed algorithm was evaluated with ORL face image database under different expressions or illumination conditions. More significant and comparative results were discovered.

4. PROPOSED METHODOLOGY

The proposed study will conduct a comparative analysis on three selected appearance-based feature extraction techniques: Linear Discriminant Analysis (LDA), Principal Component Analysis (PCA) and Locality Preserving Projection (LPP), two face image

datasets: FERET and YALE database will be employed to carry out evaluation on the proposed system. The face images normalization will be performed geometrically and photometrically in order to produce standard image data for analysis purpose. Contrast Limited Histogram Equalization (CLAHE) which is one of the main targets of the study; this will be applied to reduce lighting variations in face images. Artificial Neural Network will be used to classify the extracted facial features into matched and mismatched. The block diagram of the proposed system is shown in Figure 1.

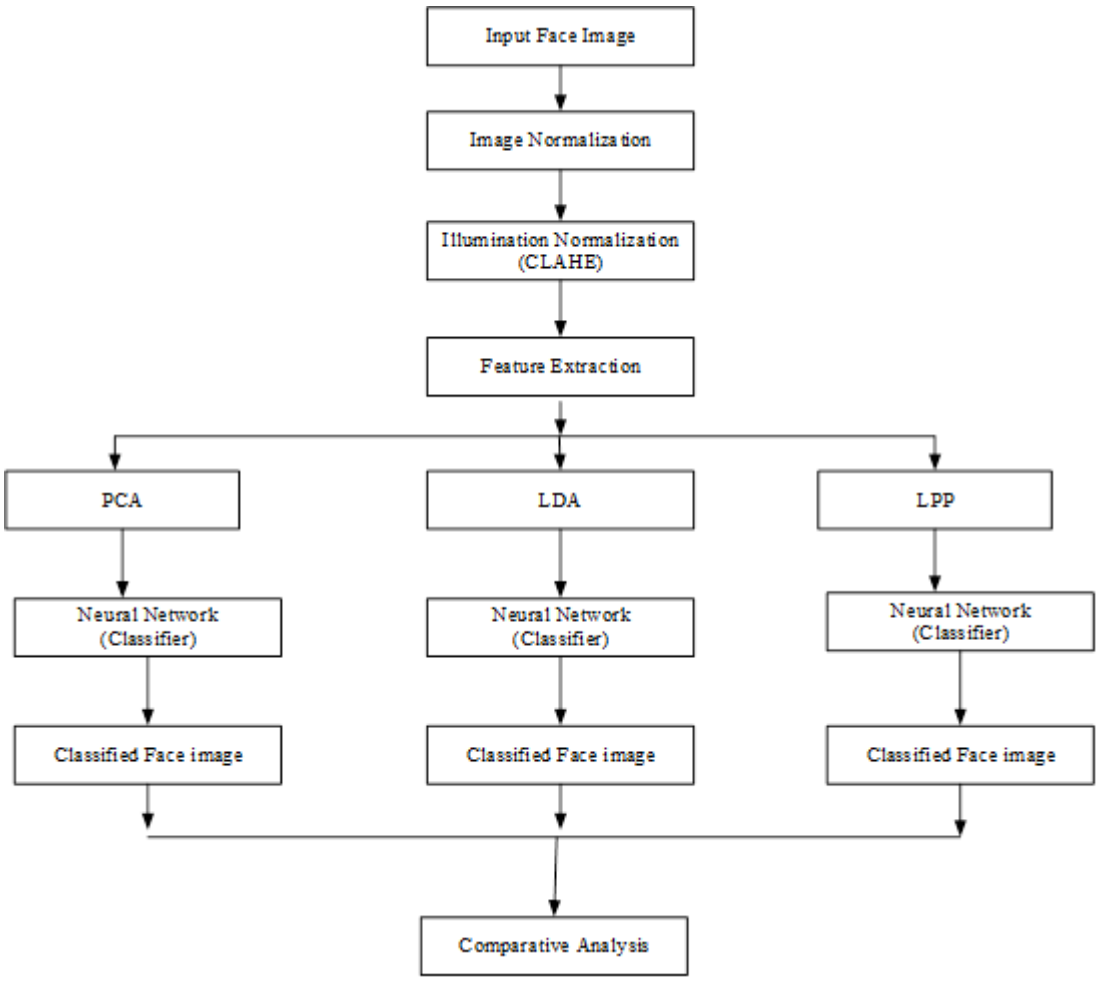

Figure 1: Block Diagram of the Proposed System

4.1 Data Image Acquisition

The study will make use of publicly available face image database: FERET and YALE image database as illustrated in Figure 2 and Figure 3 to evaluate the performance of the proposed face recognition system. The following subsections discuss briefly the structure of face image datasets.

4.1.1 FERET Face Image Database

The FERET database is a huge database that contains face images of over 1000 people. It was created by the FERET program, which ran from 93 through 1997. The database was assembled to support government monitored testing and evaluation of face recognition algorithms using standardized tests and procedures as shown in Figure 2.

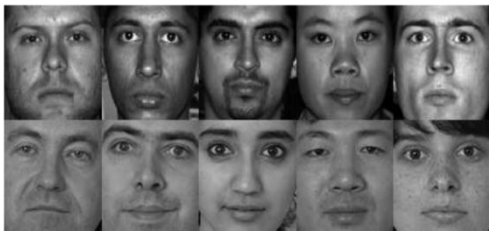

Figure 2: Sample of Face Images (FERET Database)

4.1.2 YALE Face Database

Yale Face Database contains 165 gray-scale images in GIF format of 15 individuals as shown in Figure 3. There are 11 images per subject, one per different facial expression or Configuration: center light, w/glasses, happy, left-light, w/no glasses, normal, right-light, sad sleepy, surprised and wink

Figure 3: Sample of Face Images (YALE Database)

4.2 Performance Evaluation of the Proposed System

The measurement metrics used in this study are as follows:

$$\text{Recognition Accuracy (\%)} = \frac{TP+TN}{TP+TN+FP+FN} \times 100$$

$$FAR = \frac{number\ of\ false\ acceptance}{number\ of\ identification\ attempts} = \frac{FP}{FP+TN}$$

$$FRR = \frac{False\ rejection}{number\ of\ identification\ attempts} = \frac{FN}{TP+FN}$$

Where True Positive (TP) denotes the total number of authorized face images that are correctly recognized by the system, False Positive (FP) that is the total number of unauthorized face images wrongly recognized by the system, True Negative (TN) represents the total number of authorized images correctly unrecognized and False Negative (FN) is the total number of unauthorized images that are wrongly unrecognized.

5. SUMMARY AND DISCUSSION

Despite the significant achievements of appearance-based approach for feature extraction in face recognition system, this technique suffers from some adverse conditions such as rotation, position and illumination. Among the aforementioned variations, illumination seems to be the most predominant problem in appearance-based method, which may result into poor performance of face recognition algorithm. Different studies have employed several illumination control methods such as Local Binary Pattern (LPB), Discrete Cosine Transform (DCT), Gamma Intensity Control (GIC), Histogram Equalization, Adaptive Histogram Equalization (AHE) and Contrast Limited Adaptive Histogram Equalization (CLAHE). The Contrast Limited Adaptive Histogram Equalization (CLAHE) is a powerful illumination preprocessing technique where contrast of an image is enhanced by applying Contrast Limited Histogram Equalization (CLAHE) on small data regions called tiles rather than the entire image [39]. The CLAHE represents the extension of adaptive histogram equalization, which reduces the amount of noise and also retain high level of important information or features require for recognition purpose.

Hence, it therefore necessary to carry empirical comparative analysis in order to further investigate how this illumination normalization method will affect the performance of the appearance-based feature extraction techniques for face recognition in term of accuracy, false acceptance rate, false rejection rate and error rate. The proposed study will apply the CLAHE method of illumination normalization on the three selected appearance-based techniques at the pre-process stage to get information on how this method will improve the performance of the proposed system.

6. CONCLUSION

Feature extraction technique remains a significant phase of any facial recognition algorithm. A number of feature extraction techniques such as feature-based and appearance-based method of feature extraction have been proposed. Among the two methods, appearance-based feature extraction algorithms have attracted great attention of researchers in the field of pattern recognition owing to the fact that the method represents the whole face image during recognition. One of the main challenges of appearance-based is illumination (variation in lighting conditions), thus this may influence the performance output of face recognition system. To know the effect of illumination conditions, this study will adequately carry out an in-depth comparative analysis on three selected appearance-based feature extraction approaches in order to provide result to which one performs better with respect to the CLAHE illumination control approach.

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