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Face Recognition Algorithms: A Review

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ABSTRACT

Due to its potential for application in various fields of face recognition, the field of research is very fast growing. In everyday life, to receive and interpret information, and to recognize familiar faces, face recognition is used. It is popular due to its simplicity and performance. In the past few years, a large number of research has been done but there are still many challenges related to face recognition. It becomes challenging to identify a mask-wearing face, especially in covid times. This paper aims to give a review of some well-known facial recognition techniques and algorithms used in the research such as Discrete Wavelet Transform, Principal Component Analysis, Linear Discriminant Analysis, Artificial Neural Network algorithms, and many others.
Keywords: *Face Recognition, Feature extraction, Person Identification, Holistic, Feature-based approaches methods.*

1. Introduction

Face recognition is a vital challenge in the field of appearance-based pattern recognition. This technology has developed as an attractive solution to meet many new requirements for identification and verification. It is the most common function of visual monitoring systems. It has received a lot of attention for decades due to its many possible applications. Some of these applications are low enforcement, national security, surveillance, and the field of public safety. There are many elements that affect the performance of facial recognition such as facial expression, lighting, cluttered background, pose, or occlusion [1][2]. Face recognition challenges in the visible spectrum include minimizing the influence of variable lightning and cover or photo detection. Many studies on facial recognition divide into two main classes feature-based and holistic features. The engineering approaches were introduced in the 1980s, using simple measurements like the distance between the eyes and the forms of lines that connect face features to face recognition. The overall methods became very common in the 1990s with the famous method of Eigen-faces [3].

Feature-based approaches initial process the input image to detect and extract characteristic facial features such as eyes, mouth, nose, etc., as well as other fiducial signs, and after that calculate the geometric relationships between those facial points, therefore minimizing the input face image to a vector of geometric features. Then standard statistical pattern recognition techniques are used to match faces using these measurements [4][5].

Holistic methods such as neural networks are more compound for the execution of their engineering counterparts; their application is more straightforward where the whole image can be minimized to limited main values compared with other kept core values. There is no need to know any precise measures such as eye positions or the attendance of mustaches [6][7].

Several well-known facial recognition techniques and algorithms used in research has been reviewed in this paper, such as PCA, LDA, DWT, and artificial neural network algorithms. The rest of paper is organized as follow. Section 2 gives an overview of Face Recognition Algorithms. Conclusion and results is given in Section 3.

2. Literature Review

The intelligence of human can be demonstrated by its capability to distinguish human faces. Over the past decades investigates continued to study this distinct visual perception of humans in automated face recognition. While dealing with challenges in face recognition, several techniques have been employed. This paper discusses some of the basic and latest face recognition techniques in the following subsections.

2.1 Principle Component Analysis PCA

PCA is an easy and effective algorithm. It works well in fewer or more pose or brilliance differences. It utilizes the concept of Euclidean distance for computing the space between two items. For the tracing of faces, it utilizes the conception of Eigenfaces [1]. It is the best effective method of dimensionality reduction and depends on multi images as an entry[8] .

PCA is the common way to select the feature and reduce the dimension of face recognition using PCA [9]. The recognition technique called the eigenface technique identifies feature space that decreases the dimensionality of the data space This area is used to decrease recognition but the weak discrimination power within the category and the large computerization are the known problems in the PCA technique This limitation is incredible by Linear Discriminant Analysis LDA is the most widely used algorithm for selecting elements in pretend based methods [10]. But many face recognition methods based on the LDA initially utilize PCA to decrease the dimensions and then LDA is utilized to maximize the discriminating power of the feature selection The reason is that the LDA has a small problem

in the size of the example where the data set should contain larger examples per chapter for distinct features to differentiate Therefore the implementation of LDA directly led to the poor removal of discriminatory features Methodology:

By using the following way, can be find the principal component

1. Contract the data: Suppose X1, X2....., XM is N x 1 vectors

$$X = 1/M \sum_{i=1}^{M} Xi \quad (1)$$

2. By Subtracting the Mean:

$$\phi_i = \overline{X_i} - X \quad (2)$$

3. Computing the covariance matrix: formula of matrix A = [Φ1, Φ2….ΦM] (N x M matrix) then calculate:

$$C = 1/M \sum_{n=1}^{M} \phi_n \phi_n = A^T A \quad (3)$$

4. Computing the eigen and eigenvector amount of the covariance matrix.

5. Selecting constituents and creating a feature vector: As soon as eigenvectors are created from the covariance matrix, the following phase is to arrange them by eigenvalue, highest to lowest. This offers the constituents an arrange of implications. The eigenvector with the maximum eigenvalue is the principal constituent of the data set. Select the maximum eigenvalue and create a feature vector [11].

6. Creating the new datasets: When selecting the constituents (eigenvectors) that desire to keep in the data and molded a feature vector, suggest income the transfer of the vector then multiply it by the left of the original dataset transferred.

PCA is essentially a method to present the feature vector in the minor dimensionality space. Therefore, by treating all the image pixel values as the feature vector, a superior demonstration of the image are receiving. That is the reason this method is employed superior to DCT based method even in big posture and brilliance variations [12].

2.2 Linear Discriminant Analysis (LDA)

The objective of discriminant analysis is to categorize items like people, clienteles, things, etc. into one of two or more sets depending on a group of features that define the items as gender, income, age, preference score, weight, etc. If some can suppose that the sets are linearly separable, some can use a linear discriminant model. Linearly separable proposes that the sets can be divided by a linear grouping of features that define the items. If two features, the partitions between items set will be lines. If features are three, the partition is a plane and if features are greater than three i.e. independent variables, the partitions will be a hyper-plane [13][14].

Methodology:

Here are the following steps of LDA

1. Examples for class-1 and class-2

2. Compute the mean of class-1 and class-2 as Mu-1 and Mu-2

3. Covariance Matrix of the class-1 and class-2 as C1 and C2

4. Compute within-class scatter matrix utilizing this equation

$$Sw = C_1 + C_2 \quad (4)$$

5. Compute among-class scatter matrix utilizing this equation

$$SB = (Mu1 - Mu2) * (Mu1 - Mu2) \quad (5)$$

6. Compute the all classes mean

7. The LDA plan is then gained as the resolution of the general eigenvalue issue

$$Sw^{-1} S_B W = \lambda W \quad (6)$$

$W = eig(Sw^{-1} S_b)$ where W is projection vector

2.3 Independent Component Analysis (ICA)

ICA is a method for discovering basic constituents from high-dimensional data. There is a necessity to appliance facial recognition method by using ICA for face pictures taking face locations and diverse brilliance situations, which will provide superior grades as matched with current methods. The thing that differentiates ICA from other systems is that it appears for components that are non-Gaussian and statistically separate. The ICA is alike to unsighted source parting problematic [15] that sores depressed to discovery a linear demonstration in that the constituents are statistically separate. ICA had a superior recognition level as paralleled with PCA with statistically separate base images and with statistically separate factors also. Face recognition using ICA with big turning angles with attitudes and deviations in intelligence situations. A new subspace way named sequential row-column separate constituent analysis for facial recognition. In ICA every facial image is converted into a vector beforehand computing the separate constituents.

2.4 Gabor Wavelet (GW)

For improving facial recognition, concentration characteristic vectors were removed from GW transformation of forwarding facial images joint composed with ICA. The Gabor characteristics are renowned as the finest demonstrations for facial recognition. In current years, GWs have been commonly used for facial illustration by facial recognition investigators, as the kernels of the GWs are like the 2D interested arena outlines of the creature cortical modest cells, which display necessary features of spatial locality and location choosiness. Earlier works on the Gabor characteristic have also confirmed imposing grades for facial recognition. Usual approaches contain the dynamic link architecture Gabor Fisher classifier (GFC), elastic bunch graph matching (EBGM) [12] and AdaBoost GFC (AGFC). The Gabor characteristic is also utilized for gender recognition and posture recognition lately. In prior work, authors suggested presenting facial images by using the limited Gabor binary patterns (LGBP), which associations local binary patterns (LBP) operator with Gabor magnitudes. Developed results were reached when paralleled with the GFC and the LBP.

The wavelet-based method is employed superior to the PCA-

based method and DCT-based method even in huge pose and brilliance variations.

2.5 Artificial Neural Network (ANN)

A feed-forward learning method thru Multi-Layer Perceptron was selected for the suggested scheme due to its easiness and its ability in a supervised pattern identical. It has been effectively applied to various pattern category issues. A novel method of facial recognition with feed-forward NN & Gabor wavelets was offered [11]. The technique utilizes a feed-forward neural network & Gabor wavelet transform for detecting characteristic points and mining characteristic vectors. A NN resolution was offered in which join local image exampling, a convolution NN and a self-organizing map NN. The self-organizing map (SOM) offers a quantization of the image examples into a topological area where contributions that are close to the original area are also entertaining and suitable for human life. Smart home technology can be particularly beneficial for aging or employed women who live alone in metros and for disabled people wishing to live self-sufficiently. Elderly/disabled people or women can take the benefits of smart home technologies such as dangerous kitchen appliance detection, emergency system, monitoring system, fall detection, etc.

2.6 Discrete Contourlet Transform (DCT)

It extracts texture features that can be implemented by decomposition in two main steps. The steps are Laplacian Pyramid (LP) and Directional Filter Bank (DFB), which are used in the transformed field. In the LP stage, it splits the image into the low pass, and band-pass, and confines the position of the discontinuities. The DFB stage handles band passing and shapes the linear structure by correlating the position of discontinuities [16].

2.7 Discrete Cosine Transform (DCT)

Ahmed, Natarajan, and Rao first presented the discrete cosine transform (DCT) in the seventies (1974). DCT is a very famous signal exploration mean used in compression principles due to its compacted demonstration power [6]. An invertible linear convert states a finite arrangement of data points in expressions of a calculation of cosine functions wavering at diverse frequencies and has independent nature.

DCT-based facial recognition method implements well once there are fewer pose and brilliance differences. The DCT-based recognition method is modest but is not appropriate for situations where there are huge pose or brilliance differences.

2.8 Discrete Wavelet Transform (DWT)

The complexity of facial recognition because of background differences in images utilizing the pre-processing methods suggested in this study [17] the basic static features in the image were provided for extraction. Background elimination is performed on a non-focus basis by combining both the YCbCr and HSV color models to reduce needless background features. A multiple scale merge is included to override the difference in mode. After that, the images are subjected to extraction feature utilizing two-dimensional separate wavelet conversion DWT and feature determination algorithm. The experimental results demonstrate the efficiency of the methods to identify faces on the two face database databases CMU PIE and Caltech.

2.9 LBP, LoG, and SVM

People have permanently had the inborn capability to identify and distinguish faces; current computers have presented an equivalent capability to distinguish and identify human faces. Face recognition is a biometric technique for defining an individual by matching live images or digital image data with the kept record of that individual. In this study [18], facial recognition is accomplished under diverse facial expressions. The comparison is based on Local Binary Pattern (LBP) with Laplacian of Gaussian (LoG), local binary modes, and Basic Component Analysis (PCA). Gaussian (LoG) Laplacian method is used to detect edges and extract properties using PCA and LBP methods. The Support Vector Machine Classifier is utilized to categorize images. The LoG and LBP provide improved recognition proportion than PCA and LBP approach. However, it takings more time to distinguish face matched to the other approaches.

2.10 Deformable Templates

A technique for detecting and describing facial features using deformable templates is introduced [19]. This shows the feature of interest for instance if the eye has been taken as an example and a parameter model, this template then describes that it interacts with the image by changing its parameter values. Final parameters can be applied as feature descriptors. Therefore, deformable templates are applied for features in real images. The method for extracting eye features from face images using the deformable template matching method is demonstrated. The method shows that the digital colour facial image is transformed into a binary image representing the eyes.

2.11. Back Propagation Neural Network

The backpropagation neural network algorithm is the main and most effective method for machine learning when the data includes compound sensory inputs such as images demonstrated [20]. The partial derivation of the cost function with respect to any weight or bias is an expression of backpropagation. This system illustrates how simply the cost can change with modifications in weights and biases.

Moreover, occlusion detection is suggested in [21] where objects hide from another object. The study involves four phases where the backpropagation neural network is applied to discover the age of humans in the third stage showing good performance when compared to other artificial neural networks.

2.12 Radial basis function (RBF)

An effective scheme method by considering the radial basis function (RBF) neural classifier with minor training sets of high dimensionality is presented [22]. The data information is encapsulated in defining the construction and initial parameters of the RBF neural classifier before learning takes place. A

hybrid-learning algorithm trains RBF neural networks where the dimensions of the search space are greatly reduced in the gradient model. The simulation results performed on the ORL database show that the system achieves excellent performance in terms of both learning efficiency and misclassification rates[23].

2.13 Probabilistic Neural Network (PNN):

A new heuristic structure optimization approach with a radial-based probabilistic neural network is introduced, and this method achieves higher recognition rates and better classification efficiency than multiplayer perceptron networks [24]. This is a combination of both radial basis function neural networks and probabilistic neural networks.

2.14 Pairwise Approach

The proposed approach first detects faces and automatically extracts them from images. Then, the face is divided into several normal regions and the compositional features are extracted from each region to capture the local information. Features extracted from all regions are sequenced to model the entire face. A dual approach that takes into account all pairs of classes and a mixed feature selection strategy is used to reduce dimensions and to identify relevant features to distinguish between certain pairs of classes [25].

2.15 Decision Tree

The present work focuses on two points: First, a new extraction method based on the engineering approach is presented. This method consists of calculating six distances to measure the parts of the face that best describe facial expressions. Second, a supervised automatic learning method called decision tree is applied for classification [26].

2.16. Convolutional Neural Network

CNN is one of the neural network algorithms that is used for facial recognition. Same ANN, CNN has input, hidden, and output layers. Convolution layers are the layers in the hidden CNN layer. A CNN requests to have a training data set of a thousand or even more to work more accurately [27] [28]. CNN has convolution layers with corrected linear units, completely connected layers, and corrected linear units [29]. Image transformations can be performed more efficiently with functions such as weight sharing, pooling, and receptive fields [27]. [30]has been proposed to detect faces from various angles and can deal with occlusion to some extent, and it has been shown that the act of the proposed technique can be further improved by using better sampling strategies and enhancement methods. The error resilience of CNN implementations and the usefulness of Gabor filters to propose an energy-saving and fast training methodology for CNNs is suggested in [31].

3. Results

The different face recognition algorithms with a summary of the results and the accuracy achieved by the investigator are mentioned in Table 1. The seven different types of feature recognition methods seem to be more efficient compared to the rest of the other techniques as these techniques also have their own limitations. It obvious that neural network techniques, which are discussed above, are taken into consideration. Moreover, it is observed that the backpropagation neural network and the convolutional neural network are more accurate.

Table 1 Classification of face recognition techniques

No.	Author	Year	Dataset	Classifier	Accuracy
1.	Sekhon, Abhjeet [21]	2015	Create by author	Back propagation Neural network	95%
2.	Wang, Tao Wu, David J Ng, Andrew Y [21]	2012	CDAR 2003 and the Street View Text (SVT)	Convolutional Neural Network	90%
3.	Zhai, Junhai Zhao, Wenxiu [24]	2016	JAFFE, YALE, ORL and FERET	Probabilistic Neural Network	99%, 88%, 99%, 79%
4.	Cossetin, Marcelo J Nievola, Julio C Koerich, Alessandro L [25]	2016	JAFFE, CK and TFEID	Several Pairwise Classifier	99%, 98% and 99%
5.	Jadida, El [26]	2016	JAFEE and COHEN	Decision Tree	89% and 90%
6.	Karthigayani, P.Sridhar, S. [30]	2014	ORL	Decision tree C5.0 J48	95%
7.	Proceedings of the International Symposium on Low Power Electronics and Design [31]	2017	MNIST and TiCH	Convolutional Neural Network	99%, 91%

4. CONCLUSION

In this paper, the various techniques of facial recognition, which include feature-based approaches and holistic methods, have been discussed. Face recognition is one of the most significant subjects that has become an exciting part for investigators. It is a challenge in computer vision. Because of the many algorithms used in different fields, face recognition has been very interesting. The various face recognition algorithms are stated with a summary of the results and accuracy attained by the investigator. Different types of feature recognition methods look more efficient compared to the rest other techniques where these techniques also have their own limitations. Moreover, it is observed that back propagation neural network and convolutional neural network are found to be more accurate.

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