A Survey on Facial Recognition System

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https://doi.org/10.26782/jmcms.2019.08.00014

Abstract

Facial recognition stands for an imperative area of interest to serve various applications such as security, verification of bank identities, identification of wanted persons at airports, etc. Therefore, it is employed for real time application. Consequently, reliability stands for significant matter for security. Facial recognition system is deal with two different application scenarios, one of which is called "identification" and the other of which is called "verification" anew face can be classifying either "known" or "unknown", after comparing it with stored identified persons. The complete process of facial recognition system done in three phase, detection the face, extraction the features of the face and recognition to recognize this face. Various techniques are then required for these three phases. Also these techniques differ from different other surrounding factors for example, face orientation, expression, illumination and background. In this review also highpoints the most frequently databases that existing as a standard to be utilized for facial recognition investigations like, AR Database, ORL, FERET, and Yale Database.

Keyword: Face detection, Features extraction, Face recognition, Face Database

I. Introduction

In the most recent three decades, facial recognition is a standout amongst the well-known research themes in computer vision in addition to pattern recognition. This interest demonstrates the need for a robust face recognition system, especially with the rise of the criminal activities and the advantages that offer such a recognition system over the other modalities as being nonintrusive and capable of recognize individual at a distance and in a covered manner despite the researches and performance improvement of facial recognition systems, there are always some challenges that need to be overcome like pose deviation, facial expression, illumination and aging[XIII]. Quality of image is critical in face recognition. The quality can be enhanced by the use of image processing techniques. Feature of interest can be extracted and improved by the use of image processing techniques. Contrast enhancement strategies is utilized in image processing to increase lucidity inside the image which are distorted because of camera movement, darkness etc. The histogram equivalence strategies are available in such situations.[XV]
A facial recognition system is formed by four primary advances: face detection, standardization, feature extraction and classification. Each step is significant however the feature extraction has a high influence on the accuracy of the recognition system. Facial recognition methods recognize individuals by their face images. It is built up the presence of an authorized individual as opposed to simply testing whether a valid legitimate (ID) or key is being used or whether the user identifies the secret individual Identification Numbers (Pins) or passwords. Individual identification is the process of associating a specific individual with an identity. Automatic by dual customary methods extensively utilized first Token-based methodologies use “something you have” to make an individual identification like passport, driver’s license, identity card, visa or master card, or keys second Knowledge-based methodologies use “something you know” to make an individual identification, such as a password or a Personal Identification Number (PIN). These two technique have drawbacks: tokens may be lost, stolen, overlooked, or inappropriate, and a PIN can be unnoticed by a valid user or speculated by an impersonator. They are unfit to separate amid an lawful individual and an impersonator who falsely gets the token or knowledge of the authorized individual [XV].

A more secure strategy has been utilized to build up individual personality is biometric technique. Biometry is the science of establishing the personality of an individual dependent on the physical or behavioral attributes of the individual. Face recognition stands fora category of biometrics system trying to capture and use the behavior or physical features for person certification or personal identification [XVI].

The facial recognition system has several advantages which are not associated in biometric strategies. The other biometric systems are difficult to use because it requires to physically contact with system and to pause for few moments to detected and recognize [XXX].

Facial features scored the highest compatibility, among the most six well known biometric systems utilized in Machine Readable Travel Documents (MRTD) system as in registration, security system, machine requirements, renewal, surveillance system and communal perception [XXX].

Figure (1) presents that face recognition have the highest weighted percentage in biometric system compared with others biometric traits based on MRTD [XIII].

![Figure (1): several biometric traits based on MRTD compatibility in 2016](image-url)
II. Related Work

- **Prasad et al., in 2011[XXI]**, presented a neural based algorithm to detect frontal views of faces. Principal Component Analysis (PCA) can be utilized for the dimensionality reeducation of face image and the recognition has prepared by the Feed Forward Neural Network (FFNN). The YALA database used and taken 50 face image from database. Neural based Face recognition achieved performance of more than 90% acceptance ratio.

- **Miry, in 2013[XVII]**, proposed a method that combines the DWT and PCA. Discrete wavelet Transform has employed to decompose the image with dissimilar levels and PCA to extract the features. The proposed method was applied on the typical database (ORL database) and non-standard database for practical result. This method achieved recognition rate of 70% for the non-standard database with two face images per person.

- **Kadam, in 2014 [XIV]**, Hybrid combination of PCA and discrete cosine transform (DCT) is used to reduce time and high recognition rate than PCA. This methodology is used to enhancing the recognition rate of the facial recognition system. Standard databases such as Faces94 and ORL have been employed to examine the investigational consequences that shows that projected system achieves higher than 94.7%.

- **Al-Arashi et al., in 2014[II]**, investigated to enhance the system performance by relating PCA with genetic algorithm (GA) to discover optimum fundamental distribution of the training data that is appropriate for classification. They found that accuracy and classification time have been greater than PCA if used by itself.

- **Patel et al., in 2015[XXII]**, Tried to recognize face images, 2D-Principal Component Analysis (2DPCA) was employed for feature extraction. After that feature vectors are used as input to adaptive neuro-fuzzy inference system (ANFIS) classifier. The consequence specifies that ANFIS classifier has classification accuracy of 97.1%.

- **Barnouti, in 2016[V]**, presented a method which uses PCA technique and Feed forward Neural Network (FFNN) with DCT. This combination showed
improvement in face recognition. DCT has employed to compress the facial database. Faces94 and Grimace have applied in the examination. This system has recognition rate higher than 90%.

- **Sukhija et al., in 2016[XXVII]**, proposed method using Genetic Algorithm (GA) for facial recognition. The projected method distinguishes an unidentified face image by relating it with the training face stored images in the database and provides information concerning the recognized person. Then, Genetic Algorithm is compared with other identified facial recognition algorithms such as PCA and Linear Discriminate Analysis (LDA) algorithms. The proposed method was applied on the standard database (ORL, UMIST, Indbase database). This method achieved recognition rate of 92.5% for the ORL database with forty persons.

- **Abdulrahman et al., in 2017[I]**, the proposed method is to modify the method of Eigen face based on principal component analysis, through applying Eigen face on wavelet transform to get features in a hybrid scheme known as Eigen-Wavelet. The original Eigen face and Discrete Wavelet Transform (DWT) face recognition approaches have correspondingly used to extract feature for the sake of comparison. The results showed hybrid method achieved 100% recognition rate for databases involving huge quantity of training sets and variations, whereas for those databases with minor training images DWT technique got the finest recognition rate of 95% under favorite condition.

In view of previous work, it was found that the use of PCA and 2D-DWT for feature extraction alone does not give good results. Therefore, PCA is integrated with 2D-DWT in order to extract features and use intelligent algorithms to increase the recognition rate and reduce storage space database.

Proposed work presented by use of PCA and 2D-DWT for feature extraction with Back propagation Neural Network technique(BPNN) that tested on FERET Face Database.
III. Basics of facial recognition

A standout amongst the most efficacious uses utilized for image analysis and identification is facial recognition system due to the description of the issue of facial recognition, not just computer science scholars have interested in it, yet psychologists and neuroscientists are likewise interested for the same[IV].

The elementary general facial recognition system looks like the one below.

Input image identification or verification

![Figure (2): generic block diagram of facial recognition system](image)

Various methodologies of facial recognition system for static images can be characterized into three primary groups like holistic methodology, feature-based methodology, and hybrid methodology.

In holistic methodology, to perform face recognition the entire facial region has occupied as an input in face recognition system, while in feature-based methodology, the inputs to the face detection system are local features on face as in mouth, eyes, nose are segmented and at that time given to face detection to facilitate the assignment of facial recognition. Finally, in hybrid methodology, local features and the entire face is utilized as the input to the face detection system. It is highly comparable to the performance or human being to identify the face[XIX].

IV. Face detection methods

Face detection stands for the 1st step of facial recognition system. Objects are feasibly detected utilized one of the face detection approaches[VII].

Face Detection stands for procedure of identifying and discovery faces from a solitary or group of images. It’s not important that images comprise faces only they might come with multifaceted backgrounds. Human organisms are able to detect facial features and other constituents of an image promptly, nevertheless, it’s a problematic task for computers. The major purpose of the face detection is to separate faces image from non-faces[XVIII].

Face detection ought to be performed before recognition system. This is done to extract relevant data for face which takes images/video sequences as input and find face areas inside these images by separating face areas from background regions then Facial feature extraction finds significant feature (eyes, mouth, nose and eye-brows) positions inside a detected face[III].

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In this section will be review existing strategies to detect faces in image. The single image detection methods classified into 3 groups. The 1\textsuperscript{st} one is Feature invariant methodologies which depends on fundamental structures that are even when the view point, pose or illumination circumstances variable extensively as in skin color. The 2\textsuperscript{nd} one is the template matching methodologies that have numerous standard outlines of a face to define face as a complete or the facial features distinctly. The 3\textsuperscript{rd} one is appearance-based methodologies that applied template matching for comparison, the face patterns are learned from a large set of training images that must cover searchable item[VI].

The related assignment of face detection has direct application of the topic of face recognition due to images should be investigated and faces recognized, before they can be acknowledged. Identifying faces in an image is assisting focus the computational properties of the face recognition system, enhancing the rapidity, accurateness and system performance [III].

\textbf{IV.i. Viola Jones Ada Boost classifier}

Researchers who are deal with the field of image processing for complex objects, often utilized pixels differing brightness to distinguish certain characteristic features of the picture just to the particular items. Researchers, Paul Viola and Michael Jones in 2001 proposed a methodology, as the utilization of simple brightness variations the characteristic features of the object is extracted.[VI]

The Viola-Jones face detector consist of three principles that make it possible to build a best successful face detector that can execute in real time: the integral image principle, classifier learning with AdaBoost, and attentional cascade structure. This method requires full view frontal upright faces [VII] The full overview of this methodology are presented in[XXVIII].

Cascade structure classifier based on Haar features are utilized to detect user's face shown in figure(3)[VI]. Haar feature are made out of two or three rectangles shape then this features are applied on face candidate to see if there is face or not. Each haar feature has a value calculated by taking the area of each rectangle and then adding the result. In easily way can find out the area of rectangle by utilizing the integral image principle.[IX]

![Figure (3): shows cascade structure classifier](image)

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Although all of the pictures were taken today are colored but most of the existing face detection methodologies rely on grayscale and only a small number of techniques deal with color images.[XVIII]

V. Feature extraction

The general efficiency of a facial recognition system is essentially reliant on the techniques utilized to facial features extraction. Facial recognition systems basically utilized two types of features namely local and global features. In the local techniques features are independently extracted from various facial regions like the eyes the mouth and the nose. These techniques are not influenced by unimportant and nonessential data that might exist in the image. In any case they do not take advantage of the general information related to the face appearance also this type of feature is sensitive to many image noise. in the other type of feature which is global feature techniques the extracted features taken from everywhere throughout the facial image and there is less sensitivity to image noise[XII].

Some popular global methods include Eigen faces (Turk & Pentland,1993; Martin, 2006; Yang, Zhang, Frangi, & Yang, 2004), Fisher faces (Belhumeur, Hespanha, &Kriegman, 1996; Liu, Huang, Lu, & Ma, 2002; Li & Yuan, 2005), Independent Component Analysis (Bartlett, Movellan, & Sejnowski, 2002; Liu et al., 2005) and orthogonal rotation invariant moments (Singh, Mittal, & Walia, 2011; Singh, Walia, & Mittal, 2012; Haddadnia, Faez, Ahmadi, 2003; Pang, Teoh, & Ngo, 2006; Foon, Pang, Jin, & Ling, 2004; Arnold, Masadu, Boles, & Yarlagadda, 2007; Singh, Walia, & Mittal, 2011).

The widely used local face descriptors are Gabor Filters (Struc, Gajsek, & Pavešić, 2009; Bhuiyan, & Liu, 2007), Local Binary Patterns (LBP) (Ahonen,Hadid, & Pietikainen, 2004), Histogram of Oriented Gradients (HOG), These have been well applied for the problem of human detection (Dalal, & Triggs, 2005) and only recently to face recognition where they have provided with competitive results (Tan, Yang, & Ma, 2014; Salhi, Kardouchi, & Belacel, 2012; Deniz, Bueno, Salido, & Torre, 2011; Chang, Xiaoqing, & Chi, 2011; Albiol, Monzo, Martin, & Sastre,2008), and Scale Invariant Feature Transform (SIFT) (Lowe, 2004; Soyel, & Demirel, 2010)[XXV]

Normalization of face image is a standout amongst the most critical issues in utilizing a vector of features. The extracted features must be some way normalized so as to be independent of position, scale, and rotation of the face in the image plane. The process of feature extraction includes acquiring relevant facial features from the original data and it must to be more efficient in memory usage and computing time. The output should also be optimized for the classification stage. Feature extraction also includes dimensionality reduction and feature selection. Dimensionality reduction is an essential task in any pattern recognition system. Feature selection is often performed after feature extraction. The performance of a classifier depends on the amount of sample images, number of features and classifier complexity. So, features are extracted from the face images, and then an optimum subset of these features is selected. Finally, the system should recognize the face. In an identification task, the system would reveal an identity from a database[VIII].

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VI. Face recognition methods

Face recognition methods relying on the input images, poses, edges, angles, features and appearance, these methods divided into categories such as Knowledge-based methods, Template matching methods, Feature-invariant methods, Appearance-based methods.

VI.i. Knowledge-based methods

Knowledge-based methods collect knowledge from our face and then render into set of rules which are rule-based methods. For example, in a face usually there are two eyes which symmetric eyes and the eye area is darker and differ color intensity than the cheeks forehead. Facial features could be either the distance between eyes or the color intensity differences between the eye area and the lower zone. The issue with these methods is the difficulty in building an appropriate set of rules.

VI.ii. Template Matching Methods

Template matching methods compare input images with already stored templates of face in database. Template matching methods try to define a face as a function. One can try to find a standard template. A template can be designed on the basis of features of faces like nose, eyes, face contour, and mouth. But template matching methods are limited to only frontal face images or images that purely visible, partial or any type of occlusion is not accepted. This method is simple to implement, easy to execute but its insufficient for face detection. It cannot achieve good outcomes with variations in pose, scale and shape.

VI.iii. Feature-invariant methods

Feature-invariant methods that attempt to discover invariant features of a face in spite of its position or angle. Facial recognition utilizes specific features of the face which is micro elements for instance: Mouth, Lips, Nose, Eye, Ears, Cheekbones, Chin, Forehead, the mouth sides, the position of the eyes and nose, the edge of the jaw, the distance between the eyes, and the nose length.

VI.iv. Appearance-based methods

Appearance-based methods are type of template matching methods in which the templates or patterns are learnt from training set of images from the database. These methods are dependent on the techniques of machine learning or statistical analysis to find appropriate matching templates from the images.

VI.iv.a. Principal Component Analysis – PCA Algorithm

The main approach of using PCA algorithm is it reduce the dimension of the image by compressing image and then provide the best usable low dimension structure of face. The process of dimension reduction eliminates the useless information and decomposes into components and these components are known as Eigenface. Then all the facial images are represented as weighted sum of Eigenfaces and are stored in one dimensional array. Then the test image is matched with the database.

To perform PCA several steps.
Stage 1: Subtract the Mean of the data from each variable (our adjusted data)
Stage 2: Calculate and form a covariance Matrix
Stage 3: Calculate Eigenvectors and Eigenvalues from the covariance Matrix
Stage 4: Chose a Feature Vector (a fancy name for a matrix of vectors)
Stage 5: Multiply the transposed Feature Vectors by the transposed adjusted data

VI.iv.b. Linear Discriminant Analysis – LDA Algorithm

Linear Discriminant Analysis methods also utilized for dimensionality reduction that is useful to determine combined features that do the separation of the classes. The length and complexity related with the calculations are reduced using LDA method. LDA method give small set of features which are having the appropriate data which is also known as Fisher's Discriminant Analysis. The between - class scattering matrix measure is maximizes when applied LDA while the inside - class scatter matrix measure is minimizes, which make it more reliable for classification[XXIX].

In this technique a class is represented by a block, and these blocks are having large variations within the classes. Then those vectors are searched that discriminate in between the classes. LDA makes linear combination of these independent features that gives the highest mean difference in the classes[XXIII].

VI.iv.c. Scale Invariant Feature Transform– SIFT Algorithm

Scale Invariant Feature Transform is depending on the invariant features. These features are invariant to rotation, occlusion, and scaling of the image. In this process, first key points are detected and identify in the scale space and then after detecting the key points are located. The SIFT process done by finding the scale-space extreme the localization of key points then orientation assignment and lastly key point descriptor.

The SIFT descriptor accept 128 dimensional vector used to identify the near around pixel. SIFT extract the key points for the images, then an image is given to SIFT that extracts the key points in that image and then comparing done with the database[XXIV].

Face recognitions can likewise be possible by utilizing soft computing tools. Genetic algorithm (GA), Fuzzy logic, and Neural networks(NN) are frequently utilized soft computing strategies. Compared to all the other methods, soft computing strategies are time consuming processes[VIII].

VII. Available Databases of Faces

When a face recognition algorithm is developed, a test of the system is being made to find out its recognition rate. For testing face recognition system a database of faces is required. Using a standard database for testing purpose is highly recommended. There are numerous standard databases available and an appropriate one should be selected as per requirement.

VII.i. (AR) Database

AR database was made by Computer Vision Center (CVC), University of Alabama at Birmingham. It involves more than 4000 color images belongs to 126 individuals. Also, they are partitioned into 70 man and 56 women. Images were frontal view faces with differ in facial expressions, illumination and occlusions (sun glasses, hair styles...
VII.ii. (ORL) Database

This database was taken from the AT&T lab and contains a set of images snapped between April 1992 and April 1994 known as the ORL face dataset made out of 400 images of size 112 x 92 with (PGM format file extension). There are 40 individuals, 10 images for every individual. These images with various times, illumination and different facial expression. The facial images taken in frontal view of an upright position, with a very slight right-left rotationally level and some people use fixtures like glasses. Also there are men and women. It’s quite an easy database which makes it a good choice for initial tests.

VII.iii. (FERET) Database

This database is being utilized in facial recognition for system evaluation. The Face Recognition Technology (FERET) program is executed by joint collaboration between the National Institute of Standards and Technology (NIST) and the Defense Advanced Research Projects Agency (DARPA). This database consists of 1564 sets of 14,126 images of 1199 subjects with 365 duplicate set of images. It was formed in 11 sessions from Aug 1993 to Dec1994[XX].

FERET database developed on the basis of two rules facilitates both algorithm development and evaluation. First is that a common database of facial images is required for both development and testing for evaluation purposes. Second is that diversity of the problems defined by the images should increase.

VII.iv. (Yale) Database

Yale face database has two parts Yale face A (aka Yalefaces) and Extended Yale face database B. In this database there are 15 different subjects (14 males and 1 female)

The Yale Face Database includes 165 grayscale images in Graphical Interchange Format (GIF) of 15 individuals they are divided into 11 images/subject, each having different facial expression or configuration: center-light, with/glasses, no glasses, happy, sad, sleepy, normal, surprised, and wink. Left-light, right-light.

Extended Yale face database is a dataset of 2414 images of 38 subjects. No variation in expression and no occlusions are found in the images but more focus is on extracting feature apt to illumination and they are available in cropped version.

VIII. Conclusion

Facial recognition system is a difficult issue especially in the field of computer vision and image analysis that has gotten a great deal of regard during the last years due to many important applications of the system in different domains. detailed analysis it revealed that PCA is best suited technique when dimension of features is higher for original face images, whereas features of Eigenfaces image method work very well for frontal facial recognition. In this review attempted to
clarify steps of how the facial recognition system works and view different approaches of face recognition algorithms to implement particular applications. Present study exposes that face recognition algorithm can be improved utilizing hybrid methods for obtain better performance. Ongoing advancement in the field of face recognition is covered by conducting a review of a noteworthy number of researchers. Developed face recognition techniques could be analyzed over varying facial expression i.e. under varying illumination conditions and pose. And evaluation could be performed using benchmark and latest face databases. Currently, face recognition system has been implemented for many real-time applications, but still it suffers from several challenges that need to be addressed in order to design a well-established face recognition system with the common aim to make a system for face recognition with high accuracy rate and performance.

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